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Effect of Level and Source of Protein on Digestibility of Different Qualities of Prairie Hay by Cattle and Sheep

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EFFECT OF LEVEL AND SOURCE OF PROTEIN ON DIGESTIBILITY OF DIFFERENT QUALITIES OF PRAIRIE HAY BY CATTLE AND SHEEP

By

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This thesis is approved as a creditable independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Ralph L. Braun

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INTRODUCTION

The economy of much of our Great Plains region depends upon the efficiency with which we use its most important crop--grass. Since over 75 percent of the feed of all beef cattle and sheep is grass, anything that can be done to increase its value as a feed for livestock is of tremendous importance to the wealth and economy of the nation.

In addition to the importance of grass to the Great Plains region, it is playing an ever more important role in the economy of the southeastern states and even of many areas in the corn belt. With higher prices for livestock and the increased cost of grain farming, many farmers in the corn belt are converting more and more of their land to grassland for the production of livestock. Recent educational work to encourage planting of grass mixtures and grass and legume mixtures for building the soil, as well as getting cash return from the land as pasture or hay, has also added considerable importance to the grass and hay crop of the nation.

A number of experiments have been conducted to determine the nutritive value of hay and pasture crops and to find ways of improving their value. Several of these experiments have shown the importance of properly harvesting hay and of harvesting it at the proper time to obtain the greatest return of nutrients per acre. Some of the more important changes that occur as plants mature are discussed in the review of literature. The most serious loss of nutrients by delayed harvesting is that of protein.

Loss of nutrients that occur during the harvesting of hay and when hay is not cut at the proper time means that the crop can vary considerably in feeding value. It is not always possible to produce uniformly high quality

hay. Therefore, to get the most out of any particular quality roughage, it should be supplemented according to its deficiencies.

The study reported herein was conducted to determine the digestibility of good quality and poor quality prairie hay when supplemented with varying levels of protein. Soybean meal and urea were used to determine their comparative value at various levels with the two qualities of hay. Both cattle and sheep were used in the experiments to obtain information on their comparative ability in utilization of these hays of different quality and in the use of the various levels of the two supplements tested.

REVIEW OF LITERATURE

Effect of Stage of Maturity on Content and Digestibility of Protein in Prairie Hay and Grasses

The results of a number of experiments have shown that prairie hay and grasses decrease in nutritive value as they mature. Protein, carotene and phosphorus have shown marked decreases. Protein is generally the most expensive portion of the animal's ration and is the nutrient under study in the experiment reported herein. Therefore, some of the more significant studies on the effect of stage of maturity on protein content and digestibility of range grasses are reviewed.

Burkitt (1940) reported that beardless wheatgrass in Washington contained 20.79 percent protein on a dry basis at the 3-5 inch stage, but that it contained only 8.95 percent in the headed stage. Similar reports have been made by other workers on other kinds of prairie grasses. Sotola (1940) analyzed crested wheatgrass at various stages of growth. He found it to contain 6.13 percent protein in early May, but that it had dropped to 1.98 percent by July 15 and then rose to 3.02 on September 1. The rise again in the fall no doubt could be attributed to the fact that a characteristic of this grass is early spring and late fall growth with little growth during the hot part of the summer.

Blue grama grass, buffalo grass and Russian thistles were analyzed by McMillan et al. (1943) in Oklahoma, and they too found that the protein was high in early season and that it decreased rapidly as the plants matured. The same occurred in big and little bluestem according to Hobbs et al. (1945) in their work in Oklahoma.

Previous work in South Dakota by Nelson (1948), Jordan (1949), Staples et al. (1951), and Moxon et al. (1951), all have shown that there is a decided reduction in protein content of native grasses with maturity. The work by Moxon et al. (1951) shows that early-cut hay (cut from July 1 to 15) contained fiv etimes more digestible protein for steers and four times more for lambs than the late-cut hay (cut in late September and early October). On chemical analysis, this late-cut hay contained only 50 to 70 percent as much total protein as did the early-cut hay. Staples et al. (1951) further reported that the early-cut hay yielded 400 pounds more dry matter per acre and that its total yield was 50 pounds more protein per acre than the late-cut hay.

Several workers have reported that the digestibility of the crude protein in hay is affected materially by the stage of maturity of the grasses when harvested. This was reported by Moxon et al. (1951) on South Dakota grasses and by other workers prior to that date. Burkitt (1940), Hobbs et al. (1945) and Nelson (1948), all reported significant differences in the digestibility of the protein and stated that not only did the grasses contain more protein when cut early than when cut late but what they did contain was more digestible.

Embry (1951) compiled the results of chemical analysis on a number of samples of hay cut at three different stages of maturity in South Dakota. This compilation is shown in Table I. Both protein and phosphorus decreased decidedly with advancing maturity. The decrease in protein represents a considerable economic loss because the amount of protein supplement needed is greatly increased with the late-cut hay.

Table I. Average chemical composition and coefficients of apparent digestibility of prairie hay cut at different stages of maturity.

Stage of Maturity	Early (Heading)	Medium (Seed Ripe)	Late (Mature and Weathered)
Approx. Cutting Dates	Late June to Mid. July	Mid. to End of August	Late Sept. or Early October
	(Samples taken 1947, 1948, 1949, and 1950)		
Average percent chemical composition			
Number of Samples	36	34	35
Dry Matter	91.25	91.57	91.02
Crude Protein	7.43	6.11	4.94
Ether Extract (Fat)	2.66	3.24	3.35
Crude Fiber	29.23	29.64	30.30
Nitrogen-free Extract	43.11	43.91	43.50
Ash	8.82	8.71	8.93
Calcium	0.29	0.31	0.32
Phosphorus	0.19	0.13	0.09
Average coefficients of apparent digestibility (Each value is an average for 12 steer calves.)			
Dry Matter	47.1	43.5	39.4
Crude Protein	42.6	30.6	9.3
Ether Extract	40.0	29.3	34.7
Crude Fiber	59.1	54.8	52.9
Nitrogen-free Extract	49.4	47.4	43.2
Total Digestible Nutrients (TDN)	44.12	41.06	37.89
Digestible Protein	3.17	1.87	0.46
Calculated True Digestible Protein	5.98	4.68	3.27

A much greater loss of digestible protein than of total protein is indicated in Table I. These values represent the apparent digestible protein; the real differences are not as great.

Apparent digestion coefficients represent the percentage difference between the intake of a nutrient and the outgo in the feces. However, not all the protein appearing in the feces is undigested protein from the feed. A portion of the fecal protein is derived from the body and is known as metabolic fecal nitrogen. A thorough discussion of this is given by Maynard (1951).

The metabolic fecal nitrogen fraction is considered to be dependent upon the dry matter consumption. Blaxter and Mitchell (1948) have calculated the metabolic fecal protein from a number of experiments in which the protein content of the rations varied widely. They found it rather constant and equal to 2.811 pounds per 100 pounds of dry matter consumed.

Embry (1951) used the value calculated by Blaxter and Mitchell (1948) to correct for the metabolic fecal protein in the South Dakota digestion trials to arrive at the true digestible protein in the hays cut at the three stages of maturity. The calculated values for the true digestible protein represents the percent of the feed protein that was digested based upon the assumption that the metabolic fecal protein is equal to 2.811 pounds per 100 pounds of dry matter consumed. They are higher than the apparent digestible protein values and do not vary as widely between stages of maturity (See Table I). The decrease with advancing maturity is still evident even in the true digestible protein.

In most of the work cited previously an increase in crude fiber and a decrease in digestibility of the total dry matter has been found as plants

mature. Cellulose is a complex carbohydrate making up a large part of the crude fiber fraction (Morrison, 1948; Maynard 1951). It is not readily broken down into simple products that can be used by the animal. Thus, a high cellulose content in a feed is indicative of a low feeding value.

Lignin is another complex compound appearing in the crude fiber fraction. It is so incompletely digested that it is used as a reference material in digestion studies (Crampton and Maynard, 1938; Forbes and Garrigus, 1948). Lignin is considered not only indigestible itself, but actually lowers the digestibility of other nutrients in the ration (Maynard, 1951).

Patton and Giesaker (1942) tested five species of Montana grasses for lignin and cellulose content and found a considerable increase in these materials with maturity of the grasses. The variations found varied from 5.2 percent lignin on May 16 to between 14.0 and 17.8 percent lignin on September 4. The cellulose content likewise increased with advancing maturity from around 21 percent on May 16 to between 36.9 and 41.3 percent on September 4. These workers believed that the lignin content was of great value in predicting feeding value of forage plants because of the correlation of these figures with those of digestion trials on feeding value of grass at various stages of maturity.

It is apparent from this work that as grasses mature they increase their content of cellulose and lignin. The digestibility of the nutrients is correspondingly decreased. The greatest nutritional loss with maturity is in the amount of protein and in the digestibility of the protein there is in the grasses.

Effects of Level of Protein on Digestibility of Rations by Cattle and Sheep

The animal body does not possess enzymes capable of breaking down cellulose to simple compounds which can be absorbed from the digestive tract. In the ruminant, the breakdown of complex carbohydrates, such as cellulose, is accomplished by numerous microorganisms present in the rumen. These microorganisms have nutritional requirements which must be met for maximum activity. The idea is not new, but it has received considerable attention since the development of the artificial rumen technique for the study of bacterial digestion. (Marston, 1948; and Burroughs et al. 1950a).

Rumen microorganisms require protein and it has been shown that the level of protein in the ration influences the extent to which roughages are digested and utilized. However, the proper level of protein or proper proportion of protein to other nutrients has not been very well established.

Watson et al. (1947) reported that digestibility by cattle of rations containing a roughage, a protein concentrate, and a carbohydrate concentrate is unaffected by the nutritive ratio within the ranges of approximately 1:2 and 1:9. Total protein content of the rations fed would have varied from slightly over 9 to nearly 20 percent. The lowest level used is considerably higher than in many rations fed under range conditions.

Swift et al. (1947), in work with lambs to determine interaction of feeds as it affects digestibility, compared a basal ration of mixed timothy and alfalfa of good quality, corn meal, and linseed oil meal with this same ration plus additions of various feeds. They found that the addition of oat straw to an already balanced and adequate diet significantly decreased the digestibility of the protein in the ration. This would correlate with the

findings of workers previously cited who found that as grass increased in cellulose and lignin, the digestibility of the protein decreased. Additions of casein by Swift et al. increased the digestibility of the protein as did the addition of urea.

The protein content of native hay is a good index of the nutritive value of hay rations containing similar supplements according to Gallup and Briggs (1948). Addition of protein to hay rations even in small amounts markedly increased the consumption of feed. The digestibility of the nutrients of the hay was increased as the protein content was increased from 3 to 6 percent. Above 6 percent the amount of protein fed did not increase digestibility of other nutrients except protein.

In work on the effect of protein levels on the digestibility of corn cobs for cattle, Burroughs and Gerlaugh (1949a) fed rations of corn cobs and mineralized starch with varying amounts of dried skim milk added so that the protein level of the ration varied from 5 to 18.5 percent. The digestibility of the corn cobs increased from 48.0 to 63.5 percent with additions of protein up to the 13.5 percent level. In the first trial there was no added benefit from additions of dried skim milk that raised the protein level above 13.5, whereas in the second trial benefits were the maximum at the 18.5 percent level.

In the same report by Burroughs and Gerlaugh, it was reported that in rations consisting of clover hay and starch, there was likewise a decided improvement in the digestibility of the clover hay with additions of protein from 6 to 12 percent. Above the 12 percent level there was no added benefit from additional protein being fed.

In another series of digestion trials, these workers (Burroughs et al. 1949b) tested the effect of protein on digestibility of corn cobs when no starch was fed. Dried skim milk was used at various levels to give rations with total protein content of 4, 12, and 18 percent. There was practically no difference in corn cob digestibility between the high and low levels of protein. Digestibility of corn cobs was quite high at all levels.

These workers concluded that the protein requirements for efficient roughage digestion in cattle is extremely low when roughages are fed in the absence of starch or starchy grains. However, when starch forms a part of the ration, the need for protein supplement is increased in maintaining roughage digestion, but factors other than protein appear to be involved. They pointed out that protein fed to ruminants presumably serves two separate physiological functions. One of these functions pertains to the growth and development of rumen microorganisms necessary for roughage digestion and synthesis of amino acids and B-vitamins. The other function pertains to growth and development of the animal's body. Thus, the minimum requirements for protein depends upon which function has the greatest need.

According to these experiments, the influence of protein on digestibility of roughage would be of little, if any, practical concern when the ration consisted of roughage with no grain. These results are in general agreement with the Oklahoma studies (Gallup and Briggs, 1948). The level of protein for efficient roughage digestion in this case appears to be much lower than that required for the body needs. On the other hand, when rations containing grain are fed, a level of protein sufficient for body needs may not be high enough to maintain efficient roughage digestion. In further studies by Burroughs et al. (1950b), they concluded that with roughage and no grain, as

little as 4 or 5 percent protein is ample for good digestion. However, with a ration containing a large amount of starch, the level of protein for good digestion at times must exceed 11 percent.

Urea as a Protein Substitute for Ruminants

The results of a number of experiments have shown that urea and other non-protein, nitrogen-containing compounds may be used as a partial substitute for protein in the rations of cattle and sheep. Numerous microorganisms present in the rumen of these animals can utilize the nitrogen contained in urea for the synthesis of protein. These microorganisms are digested further down the digestive tract and thus supply protein for the needs of the host animal. Work at the Ohio station (Pounden et al. 1950) has shown that some of these bacteria are disintegrated early in the abomasum, others later in the intestinal tract, and some pass through undigested.

Several methods of experimentation have been used to show that urea nitrogen serves as a source of protein for ruminants. By use of rumen fistulas, Wisconsin workers (Wegner et al. 1941a, 1941b) have shown that the protein content of rumen ingesta of dairy cattle receiving a low-protein ration (corn, silage, timothy hay, oats and corn) was increased by the addition of urea. The rate of conversion of urea nitrogen to protein decreased when the protein level of the rumen ingesta became greater than 12 percent. When both linseed meal and urea were used to supplement the low-protein basal ration, utilization of urea decreased decidedly when the total protein content of the ration exceeded 18 percent.

Confirmation of this maximum level of protein in the ration above which urea is not efficiently utilized has been obtained by Johnson et al. (1942) using lambs as the experimental animals. These workers stated that there was no difference in the utilization of urea nitrogen and the nitrogen from common protein supplements when the level of protein in the ration did not exceed 12 percent.

A slightly lower level of total protein in the ration for efficient utilization of urea was obtained by Gallup et al. (1952). In their experiments with lambs, urea was added to a basal ration with 37 percent cottonseed hulls and containing 7 percent protein. Urea was used to increase the total protein content of the ration to 8.5, 10.1, and 12.2 percent. Maximum nitrogen retention was obtained at the 10 percent protein level with urea, but a higher retention was obtained with cottonseed meal at the 12 percent level. In these same studies, there was no difference in the utilization of urea when added to a ration containing soybean meal, cottonseed meal, or corn gluten feed.

While urea appears to be about as well digested as other sources of nitrogen up to the 12 percent level of total protein, it may not always be as well assimilated by the body. Harris and Mitchell's work (1941) comparing urea with casein as a source of nitrogen gives evidence that they were equally digestible, but that urea was only 80 percent as efficient in the replacement of the losses of endogenous nitrogen. This was confirmed by Harris et al. (1943) who noted that at higher level sof feeding urea there was considerable nitrogen given off in the urine but digestion was equal to soybean oil meal. He found the biological value of urea nitrogen to be about 34 compared to a value of soybean oil meal nitrogen of 60 even though both were about equally well digested. (Apparent digestion coefficient for urea was 74, for soybean oil meal, 78).

The greatest value from urea appears to be when it forms not all but a part of the protein source in the ration. Hamilton et al. (1948) did work which indicated that best results with urea were obtained when at least 25 percent of the total nitrogen is in the form of preformed protein. They

further found that the addition of certain amino acid materials with the urea had no appreciable beneficial effects, indicating that the bacteria are capable of making all the essential amino acids in the rumen from urea nitrogen. To learn this they fed different lots of growing lambs the same amount of nitrogen from dried skim milk, dried skim milk and cystine, corn gluten feed, casein plus cystine and urea. The nitrogen of the urea was as well utilized as was the nitrogen from the other protein sources.

With rations for wintering cattle and sheep, it appears that the maximum levels of urea feeding are lower than the level cited above. Briggs et al. (1948) found, with lambs receiving a protein supplement in the form of pellets to prairie hay, the best results were obtained where urea furnished about 25 percent of the supplemented nitrogen. Storage of nitrogen by the body decreased as the urea provided 50 to 75 percent of the nitrogen. In work with steers, Briggs (1947) had found the pellets with 25 percent of the nitrogen as urea preferable to those where urea furnished a higher percentage of nitrogen.

In the works cited above, there does not appear to be any difference between sheep and cattle in the utilization of urea. Dinning et al. (1949) added urea to a fattening ration composed of prairie hay, corn and cottonseed meal to increase the protein content from 10.0 up to 12.4 percent. They reported that lambs appeared to utilize this level of urea for fattening better than did steers. However, it has been pointed out in two recent reports (Reid, 1951; and Morrison, 1952) that urea may be unsatisfactory for sheep. Reid recommended that conventional forms of protein be fed to sheep.

The work cited on the use of urea appears to furnish ample proof that urea can be used as a partial substitute for protein in the rations of rumi-

nants. The present work also indicates that the level of total protein in the ration should not exceed 12 percent for most efficient utilization of urea and that it is utilized best when fed with conventional forms of protein. However, in view of the conflicting reports on the utilization of urea by cattle and by sheep, further work on its comparative value for these animals seem justifiable.

Comparative Digestive Powers of Sheep and Cattle

Many investigators have assumed that the efficiency with which sheep and cattle digest feeds is essentially the same. In his tables of digestible nutrients and digestion coefficients of various feeds, Morrison (1948) has combined the results of digestion trials conducted with cattle and sheep. Coefficients of digestibility for the various species of livestock for many feeds have been compiled by Schnieder (1947).

Guilbert and Loosli (1951), after a study on the comparative nutrition of farm animals, concluded that the feed capacities of various animals are proportional to the same fractional power of body weight as the maintenance requirement and basal heat production. They also concluded that there was no fundamental difference between large and small animals in efficiency of feed utilization for growth that depends upon body size as such. The authors state that at physiologically equivalent ages, the requirements for digestible protein, calcium, and phosphorus appear to be similar for the various species but the ratio of these nutrients to energy intake change with alterations in the composition of growth increments and advancing age. They further state: "Progress in all sciences has consistently demonstrated that we are living in an orderly universe and that the basic laws apply generally if one can but find the means for doing research and expressing results on a comparable basis. Progress in comparative nutrition offers ample evidence that this field is no exception, that each species is not a special creation functioning in its own peculiar manner, but rather that the similarities are far more striking than the differences."

From the above study one could conclude that there is not a basic difference between cattle and sheep in their nutritive requirements and ability to

utilize feed. This is an important problem confronting the research worker. In the determination of digestibility, metabolism, and requirements of various nutrients, sheep can be used for a fraction of the cost of cattle. The cost of animals, feed, facilities and labor required are much less with sheep than with cattle. On the other hand, a much larger percentage of our total feed is fed to cattle than to sheep.

Jennings (1949) reported the percentage of different feeds consumed by the various farm animals. Of all feeds consumed by farm animals from 1942 through 1946, beef cattle consumed 21 percent, dairy cattle 31.3 percent, and sheep only 7.1 percent. In the total roughage consumed beef cattle consumed 31.2 percent, dairy cattle 42.1 percent, and sheep only 12.3 percent. Thus, it is evident that cattle consume a far greater amount of feed than sheep, but most of the studies on the digestibility of feeds have been conducted with sheep.

Several experiments have been conducted in which direct comparisons of the digestive powers of sheep and cattle have been made. Cipolloni et al. (1951) reviewed this work and made a statistical study of digestibility of various feeds by sheep and cattle from published data. From the review of the literature they stated that it was not possible to state that sheep had better or poorer digestive powers than cattle but that differences between the two species did exist.

From published data which allowed comparisons of the digestive powers of sheep and cattle, a statistical study was made on the digestibility of organic matter, crude protein, crude fiber, nitrogen-free extract, and ether extract of dry roughages, silages, and concentrates. Cattle appeared to digest dry roughages and silages better than sheep but sheep tended to digest concentrates

better. In the case of roughages, cattle digested the protein significantly better in some feeds, but in others sheep digested the protein better. The authors concluded that greater accuracy will result if digestibility data to be used for cattle are obtained with cattle, and similarly for sheep.

Crampton et al. (1951) made comparisons of the digestive powers of rats, guinea pigs, sheep, swine and humans. They concluded that there was no large differences between these species in digestibility of diets negligible in crude fiber content. This being true for species differing considerably in anatomy of the digestive tract, it would seem that sheep and cattle should be quite similar even when a large amount of crude fiber was present in the ration.

Digestion trials are subject to errors, and considerable variation exists in reports by various workers on digestion coefficients of nutrients in similar feeds. Differences in ages of the animals, environmental conditions, and level of feeding in the species comparisons may account for some of the variation between cattle and sheep. Therefore, it was thought to be worth while to make further comparisons on the relative digestive powers of sheep and cattle when the experimental conditions would be controlled as rigidly as possible.

METHOD OF PROCEDURE

The purpose of the experiment reported herein was to determine the effect of level and source of protein on the digestibility of different qualities of prairie hay by sheep and cattle. Specifically, the objectives were:

1. To determine the effect of various levels of total protein on the digestibility of good quality (early-cut) and poor quality (late-cut) prairie hay.

2. To compare soybean meal and urea as protein sources for supplementing prairie hay.

3. To compare the digestive powers of sheep and cattle being fed different qualities of prairie hay supplemented with various levels of protein from different sources.

Twelve high-grade Hereford steer calves and twelve white-faced, western, wether, feeder lambs predominatly of Rambouillet breeding were used as the experimental animals. The steers were purchased from a local commission company in December and averaged approximately 475 pounds. They were dehorned, sprayed, and vaccinated for blackleg shortly after arrival at the college. Approximately a full feed of prairie hay and one pound of oats were fed until February 9. After this date, the experimental rations were fed.

The lambs were bought from a local commission company in early January and averaged about 90 pounds in weight. Shortly after arrival, they were sheared, dusted with rotenone for ticks, and drenched with phenothiazine for a control of internal parasites. The lambs were fed about a full feed of prairie hay and one-fourth pound of oats daily until February 9.

Both steers and lambs were assigned to the treatments on February 9, 1952, and they were fed the experimental rations after this date. All calves

remained healthy except one (No. 4) which developed lumpy jaw. This healed without any difficulty following treatment with potassium iodide. No trouble was encountered with any of the lambs.

The good quality hay used was cut in mid-July and contained about 98 percent western wheatgrass with traces of blue gramma and weeds. It was estimated to contain one percent old hay, but there was no moldy hay in it. The so-called poor quality hay was cut in mid-October. It contained about 95 percent western wheatgrass and 5 percent weeds. Two percent of the late cut hay was estimated to be moldy, but there was no old hay that could be detected.

The animals were fed twice daily during the entire experiment, equal amounts of feed being offered at the morning and afternoon feedings. In order to reduce sorting to a minimum and because of the type of feeding crates used for the lambs, the hay was chopped for both the lambs and steers.

The rate of feeding in this experiment was 454 grams of air dry matter per feed per 100 pounds of body weight based on a 1000 pound animal and calculated as being proportional to three-fourths power of body weight ($W^{0.75}$). This rate of feeding was based upon a statement by Guilbert and Loosli (1951) in which they stated that the feed capacity of an animal was proportional to the same power of body weight as the maintenance requirement. They accepted the maintenance requirement as being proportional to three-fourths power of body weight ($W^{0.75}$). It was believed that this would be the most accurate method of feeding for a comparison of the relative digestive powers of sheep and cattle and might overcome some of the variation between individuals that varied in size.

Lambs and steers 1, 2, 3, and 4 were fed the late-cut hay during all periods of the digestion trials. Their supplement was soybean meal mixed

with various proportions of ground common oats, oat groats, and oat hulls to give the desired amount of protein in the mixtures and a calculated total digestible nutrient content of about 70 percent. Lambs and steers 5, 6, 7, 8, 9, 10, 11, and 12 were fed the early-cut hay during all periods of the digestion trials. The same supplement as fed to the first four animals was fed to numbers 5, 6, 7, and 8. Numbers 9, 10, 11, and 12 were fed a supplement composed of different levels of urea to give the desired level of protein in the supplement. The urea was mixed with various proportions of ground common oats and oat groats to give a calculated total digestible nutrient content of about 70 percent. Common oats, oat groats, and oat hulls were selected as the ingredients to mix with the protein ingredients so that the energy content of the supplements could be regulated merely by changing the proportion of hulls and groats. In comparing supplements as a source of protein, it is important that they be similar in energy content and ingredients except for the major source of protein.

The amount of ingredients used in the supplements and the feeding schedule are given in Table II. In period 1, only hay was fed. The total amount of feed fed in period 2 was the same as in period 1, but 15 percent of the total was composed of the supplement. This same ratio of hay to supplement was used in periods 3, 4, and 5. Some growth occurred after period 1 and increases in feed were needed to keep the dry matter intake per unit of body weight approximately that offered initially. The sheep and cattle were weighed at the end of each collection period and the weights are given in Table III. Feed increases were based upon the average weight increase for the group during the period. The increase in feed offered amounted to 4 percent for period 3, 3 percent for period 4, and 4 percent for period 5. Only hay was fed in period

6 to check the digestibility of the hay at the end of the experiment with the beginning of the experiment.

Table II. Ingredients and protein content of concentrate mixtures fed in the digestion trials (percent).

	Digestion Period *			
	2	3	4	5
Soybean Meal Mixes				
Ground Whole Oats	98.4	62.5	32.4	
Ground Oat Hulls		5.0	9.8	15.0
Soybean Meal		31.5	57.0	84.6
Dicalcium Phosphate	1.6	1.0	.8	.4
Percent Protein	13.26	22.72	27.94	36.24
Urea Mixes				
Ground Whole Oats	98.4	79.6	68.7	54.0
Ground Oat Groats		15.6	24.1	36.0
Urea		3.1	5.5	8.2
Dicalcium Phosphate	1.6	1.7	1.7	1.8
Percent Protein	13.26	21.84	27.44	36.64

* No supplement was fed to any steers or lambs in periods 1 and 6

Table III. Weight of steers and lambs at end of each collection period (pounds).

Steer No.	Digestion Period and Date of Weighing						
	Initial	1	2	3	4	5	6
	March 14	April 3	April 22	May 12	May 31	June 19	July 7
1	408	408	422	428	435	451	479
2	465	475	485	486	514	521	527
3	482	502	495	498	531	553	565
4	467	471	469	490	516	541	522
5	520	553	575	619	639	672	697
6	500	536	562	594	617	660	672
7	432	471	491	525	552	576	594
8	490	536	549	582	623	649	663
9	505	535	550	578	585	615	647
10	430	458	476	499	522	537	555
11	443	478	505	532	551	566	589
12	560	605	636	673	701	721	740
Lamb No.							
1	71	71	80	81	86	96	85
2	74	74	81	86	89	92	83
3	83	82	91	96	99	105	100
4	79	77	81	84	92	93	91
5	78	85	93	100	104	105	109
6	87	95	101	106	115	117	118
7	79	84	93	92	98	106	108
8	91	99	107	112	113	114	123
9	79	87	94	100	105	107	114
10	86	97	101	105	111	115	114
11	86	93	100	107	110	116	116
12	88	94	97	99	106	112	113

The total feed offered was the same as during period 5.

The animals were fastened for approximately three hours for each feeding to give ample time to consume all feeds. Between feedings, both morning and evening, they were given access to an exercise area where they had free access to water and a mineral mixture. The mineral mixture consisted of dicalcium phosphate with 10 percent salt and additional salt was supplied in another container. The exercise areas for both cattle and sheep had a concrete floor well sloped so the urine would drain into a sewer. No bedding was used for the steers but sawdust was used as bedding for the sheep when they were not on collection periods.

In periods when the supplements were fed, they were fed before the hay. Ample time was given for their consumption before the hay was fed. The soybean meal supplement was consumed readily by both sheep and cattle. No difficulty was encountered in the consumption of the supplement with 3.1 percent urea in period 3. However, steers 9, 10, 11 and 12 refused small amounts of the supplement with 5.5 percent urea in period 4. No refusal was encountered with the lambs. In period 5 when the supplement contained 8.2 percent urea, larger amounts were refused by the steers than in period 4. Lamb 12 refused a small amount, but numbers 9, 10, and 11 consumed the urea supplement readily.

Any of the supplement that was not consumed was swept up and saved before feeding the hay. Hay refused was also saved. At the end of the collection period the refused feeds were weighed and samples saved for chemical analysis.

Collection periods were 7 days in length. At the end of a collection period, the rations were changed for the next period. A ten to twelve day preliminary feeding period with the new ration was allowed prior to the next

collection period. The length was believed ample time for the animals to become adjusted to the new feeds and to overcome effects of the previous rations since changes in type of rations were not great.

The total collection method was used and feces were collected by means of canvass bags fastened to the cattle and sheep by a harness. The bags were worn during the preliminary period as well as during the collection period. These bags were emptied twice daily and the total weight of feces taken at the time they were emptied. A sample of the feces was taken at this time which consisted of 2 percent of the weight for the steers and 3 percent for the lambs. This sample was placed in a glass jar for each animal and kept frozen until the end of the collection period.

At the end of the collection period, a fresh sample of the feces was analyzed by the Station Biochemistry Department for moisture, protein and ash. A sample of the hay, supplement, and orts were also analyzed for moisture, protein and ash. The total amount of nutrients refused was subtracted from the total amount offered to get the nutrients actually consumed. Nutrients excreted in the feces were deducted from the nutrients consumed to arrive at the amount that was digested. All calculations were on a moisture-free basis. Digestion coefficients were then determined for dry matter, organic matter, and protein by dividing the amount digested by the intake of these items.

RESULTS AND DISCUSSION

Effect of Level and Source of Protein and Quality of Hay on Digestibility of Protein by Sheep and Cattle.

The coefficients of apparent digestibility of protein by steers and lambs in this experiment are given in Tables IV and V. Coefficients of apparent digestibility of the organic matter are given in Tables VIII and IX. Summaries of the feed consumption and digestion coefficients for each period are presented for the steers in Appendix Tables I-VI and for lambs in Appendix Tables VII-XII.

The late-cut hay fed during the various periods contained between 3.38 and 4.15 percent crude protein while the early-cut hay contained between 8.14 and 9.73 percent. It will be seen in Tables IV and V that the digestion coefficients for protein on the unsupplemented late-cut hay were extremely low (first four animals in periods 1 and 6). In period 1, three of the lambs and one steer actually showed negative digestion coefficients for protein.

Negative digestion coefficients for protein are not surprising on this low protein hay unsupplemented with protein since the values represent apparent digestion. In such a case, metabolic fecal nitrogen composes a large part of the total fecal nitrogen which result in these apparent negative values. While they do not represent the true digestibility of the protein, they do represent the net worth of protein in the hay to the animal when fed in an unsupplemented ration. When one considers that there would be an additional loss of nitrogen in the urine, it is obvious that the animals were in serious negative nitrogen balance. These coefficients of digestibility of protein emphasize the inadequacy of such low protein rations for wintering calves and lambs.

Table IV. Coefficients of apparent digestibility of protein by steers fed late-cut or early-cut prairie hay supplemented with various levels of soybean meal or urea.

Steer No.	Digestion Period					
	1	2	3	4	5	6
Late-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, SBOM; P6, None						
1	-15.2	35.7	44.5	48.6	54.5	21.1
2	7.4	38.6	48.2	44.4	58.6	11.9
3	12.9	38.1	48.3	44.7	59.0	15.3
4	16.0	45.9	56.0	51.6	65.2	17.4
Av. 1-4	5.3	39.6	49.2	47.3	59.3	16.4
Av. protein in rations, dry basis, %	3.82	5.58	7.90	8.30	9.67	4.38
Early-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, SBOM; P6, None						
5	49.8	58.4	66.6	60.3	70.3	52.8
6	47.6	58.5	64.1	63.3	71.8	47.1
7	53.5	60.2	65.6	63.5	71.2	50.9
8	49.4	64.8	64.3	65.1	73.7	56.7
Av. 5-8	50.1	60.5	65.2	63.0	71.8	51.9
Av. protein in rations, dry basis, %	9.12	9.82	12.18	13.40	15.66	9.54
Early-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, Urea; P6, None						
9	53.4	61.0	64.2	64.7	75.0	53.3
10	52.3	59.3	68.1	62.5	72.0	47.2
11	43.7	60.9	67.8	63.2	71.8	53.4
12	47.3	59.3	61.9	63.3	73.6	51.0
Av. 9-12	49.2	60.1	65.5	63.4	73.1	51.2
Av. protein in rations, dry basis, %	9.07	9.82	12.01	12.99	14.86	9.53

Table V. Coefficients of apparent digestibility of protein by lambs fed late or early-cut hay supplemented with various levels of soybean meal or urea.

Lamb No.	Digestion Period					
	1	2	3	4	5	6
Late-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, SBOM; P6, None						
1	-1.1	42.2	58.1	56.4	59.9	19.6
2	-0.8	33.2	50.9	52.3	59.8	22.2
3	-5.9	43.8	55.0	55.4	62.7	24.9
4	3.3	39.8	55.9	54.1	59.7	20.7
Av. 1-4	-1.1	39.8	55.0	54.6	60.5	21.8
Av. protein in rations, dry basis, %	3.72	5.59	7.96	8.41	9.94	4.20
Early-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, SBOM; P6, None						
5	55.2	62.9	68.9	67.2	70.9	61.5
6	55.5	63.7	68.3	68.2	70.9	59.0
7	54.4	67.0	68.6	69.3	71.3	61.2
8	57.0	56.8	69.3	68.2	73.2	61.2
Av. 5-8	55.5	62.6	68.8	68.2	71.6	60.7
Av. protein in rations, dry basis, %	9.15	9.86	12.30	13.43	16.14	9.31
Early-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, Urea; P6, None						
9	54.7	65.8	68.6	69.7	72.9	59.8
10	62.5	65.2	68.7	71.1	75.3	60.9
11	55.0	64.3	66.2	69.9	75.0	59.5
12	56.6	61.3	69.4	71.2	76.1	63.4
Av. 9-12	57.2	64.2	68.2	70.5	74.8	60.9
Av. protein in rations, dry basis, %	8.96	9.86	12.23	13.43	16.62	9.29

In periods 3 through 5, the rations contained 15 percent concentrates with various levels of total protein. Digestibility of protein by both sheep and cattle increased with each increase in the level of protein in the total ration when the late-cut hay was fed. During period 5, digestibility of protein in the late-cut hay ration was about equal to the digestibility obtained in period 2 with the early-cut hay. Total protein in the two rations was about equal.

Digestion coefficients obtained with sheep were considerably higher than those for cattle in periods 3 and 4 on the late-cut hay ration. However, in period 5 with the highest level of protein, the coefficients were about the same.

When early-cut hay was fed, apparent digestibility of protein increased with each increase in protein level of the ration with steers except during period 4. Why the drop occurred in period 4 cannot be explained. This occurred in all groups of steers and lambs. Feed consumption was good and no unusual behavior of the animals was noted.

Lambs showed smaller increases in digestibility of protein than did the steers after period 3 when the ration contained slightly over 12 percent protein, moisture-free basis. Apparently the maximum level of protein in the ration for best digestion of protein was reached sooner with lambs than with steers. At the highest level of protein fed, period 5, the digestion coefficients obtained with steers and lambs were about equal.

It would appear from the results, with both hays, that sheep have a smaller requirement for dietary protein than do cattle. The digestible protein requirements for the two species could still be similar as indicated by Guilbert and Loosli (1951).

The coefficients for the apparent digestibility of protein by both steers and lambs were as high or slightly higher on the rations supplemented with urea (animals 9-10) as on rations supplemented with soybean meal (animals 5-8). In period 3, the level of urea was 3.1 percent. It was increased to 5.5 percent in period 4 and 8.2 percent in period 5. The lambs consumed the supplements with urea readily except lamb 12 in period 5 at the highest level of urea. This lamb refused about 3.1 percent of the supplement offered. The steers consumed all of the supplement offered when the level of urea was 3.1 percent. However all refused considerable amounts when higher levels of urea were used (Appendix Tables I-VI). The average refusal for the four steers was about 12.1 percent in period 4 and 24.1 percent in period 5. In spite of this refusal, the apparent digestibility of the protein in the rations with urea was quite similar to that of the rations with soybean meal.

Apparent digestibility of the protein in the rations with urea by lambs was also quite similar to those with soybean meal. The coefficients were slightly higher than for steers at each level of protein except at the highest level of protein, period 5, with urea as well as with soybean meal. As far as digestibility of the protein in the total ration was concerned, lambs utilized urea fully as well as steers. They consumed higher levels before refusal than did the steers.

Direct evidence that the true digestibility of the protein in the late-cut hay was less than the true digestibility of the protein in the early-cut hay was not obtained in this experiment. However, it was previously pointed out that the digestibility of the ration when late-cut hay was fed in period 5, the highest level of protein used, was about equal to the digestibility of the early-cut hay and oats fed in period 2. The two kinds of rations contained

nearly the same amount of protein, about 9.7 to 9.9 percent, moisture-free basis. Fifteen percent concentrate was used with both kinds of hay.

The average digestion coefficient of protein by the four lambs on late-cut hay in period 5 was 60.5. The two groups on the early-cut hay in period 2 had average digestion coefficients of 62.6 and 64.2. Less variation was obtained with the steers. An average digestion coefficient for protein of 59.3 was obtained on the late-cut hay in period 5. In period 2 on early-cut hay and oats, the digestibility of the protein was 60.5 percent for one group and 60.1 for the other. These values are so close as to suggest that the digestibility of the protein in the rations with either early or late-cut hay were equal when supplemented to give equal protein levels.

Coefficients of true digestibility of the protein were calculated assuming that the metabolic fecal nitrogen was equal to 2.811 pounds per 100 pounds of dry matter consumed (Blaxter and Mitchell, 1948). This was done to see how the digestibility of the rations with the two hays compared when this correction was made. The difference between sheep and cattle would still exist since digestion coefficients for both were corrected at the same rate. These calculations are presented in Tables VI and VII.

Table VI. Calculated true digestion coefficients for protein by steers.

Steer No.	Digestion Period					
	1	2	3	4	5	6
Late-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, Soybean meal mix; P6, None.						
1	57.1	86.5	80.8	82.6	83.6	83.9
2	78.7	88.6	83.8	78.7	87.9	76.4
3	86.4	89.5	84.8	79.0	88.3	81.0
4	94.0	95.3	90.2	84.6	93.8	81.3
Av. 1-4	79.0	89.9	84.9	81.2	88.4	80.7
Av. percent protein in rations (moisture free)	3.82	5.58	7.90	8.30	9.67	4.38
Early-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, Soybean meal mix; P6, None.						
5	80.8	87.1	89.7	81.3	89.9	82.3
6	78.5	87.0	87.2	84.2	91.3	76.7
7	84.3	88.8	88.7	84.5	90.7	80.3
8	80.2	93.4	87.4	86.1	93.1	86.1
Av. 5-8	80.9	89.1	88.3	84.0	91.3	81.3
Av. percent protein in rations (moisture free)	9.12	9.75	12.18	13.40	15.66	9.54
Early-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, Urea mix; P6, None.						
9	84.2	89.6	87.6	86.4	94.8	82.7
10	83.3	87.9	91.4	83.9	92.5	76.6
11	74.9	89.5	91.3	85.5	93.9	83.0
12	78.4	88.0	85.3	84.6	93.7	80.5
Av. 9-12	80.2	88.8	88.9	85.1	93.7	80.7
Av. percent protein in rations (moisture free)	9.07	9.82	12.01	12.99	14.86	9.53

Table VII. Calculated true digestion coefficients for protein by lambs.

Lamb No.	Digestion Period					
	1	2	3	4	5	6
Late-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, Soybean meal mix; P6, None.						
1	74.3	91.8	91.6	88.9	87.2	89.1
2	73.2	85.1	86.9	85.9	88.2	84.6
3	72.2	95.1	91.2	89.4	91.6	94.6
4	78.0	88.3	91.5	87.7	88.3	87.0
Av. 1-4	74.4	90.1	90.3	88.0	88.8	88.8
Av. percent protein in rations (moisture free)	3.72	5.59	7.96	8.41	9.94	4.20
Early-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, Soybean meal mix; P6, None.						
5	85.9	91.3	91.8	88.1	85.2	91.7
6	86.3	92.1	91.2	89.1	85.5	89.0
7	85.1	95.6	91.2	90.1	90.1	91.6
8	87.8	85.4	92.3	89.3	91.2	91.3
Av. 5-8	86.3	91.1	91.6	89.2	90.3	90.9
Av. percent protein in rations (moisture free)	9.15	9.86	12.30	13.43	16.14	9.31
Early-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, Urea; P6, None.						
9	85.4	94.4	92.1	90.7	91.6	90.0
10	93.2	93.9	91.4	92.0	93.0	91.7
11	85.8	92.8	89.5	91.0	93.9	89.7
12	87.4	89.6	92.0	92.1	94.5	93.4
Av. 9-12	88.0	92.7	91.2	91.4	93.2	91.2
Av. percent protein in rations (moisture free)	9.15	9.86	12.23	13.43	16.62	9.29

True digestion coefficients for protein were quite high with little differences between hays except for late-cut hay unsupplemented for sheep in period 1. Digestibility of the unsupplemented hay by steers was about the same in both periods 1 and 6 but considerably less than the rations with 15 percent concentrates, periods 2, 3, 4, and 5. Adding a more digestible protein in the concentrates to the hay could hardly account for the differences obtained since only a small amount of concentrates were used. However, it may be that the metabolic fecal fraction varies with the type of ration fed or the small amount of concentrates exerted a beneficial effect on the digestibility of the protein by supplying additional protein and/or energy. Oats alone were about as effective as the high levels of soybean meal or urea.

With sheep some increase in digestibility of protein occurred by adding oats in period 2. However, the coefficients obtained in period 6, also with hay alone, were about the same as the supplemented ration in periods 2, 3, 4, and 5. Again it is apparent that sheep digested the protein better than cattle except at the highest level used, period 5.

No consistent improvement in the calculated true digestibility of the protein occurred after period 2. In this period, the ration of late-cut hay and oats contained only 5.6 percent protein, dry basis. It would appear from this that the maximum level of protein for best digestion of protein in the roughage is low. Such values are lower than considered necessary to meet the physiological needs of the animal. This is in agreement with the work of Burroughs and Gerlaugh (1949) and Gallup and Briggs (1948).

The values for true digestible protein calculated in this way are subject to criticism since the metabolic fecal protein fraction determined by various investigators is quite variable (Lofgreen and Kleiber, 1953). It is usually

given on the basis of dry matter consumption, but it is also influenced by body size (Lofgreen and Kleiber, 1953). Even with an error in assuming a metabolic protein value, the calculated true digestibility of the protein would represent the true value of the protein in the hay better than the apparent digestion values. This statement is supported by the digestion coefficients obtained with the rations composed of the two qualities of hay when the protein contents were about the same (late-cut hay, period 5, and early-cut hay, period 2).

On the above basis, it would appear that the protein requirements of cattle and sheep would be more accurate if given on the basis of total protein. Since apparent digestibility of protein increases with increasing levels of protein at least to very high levels in this experiment, digestible protein obtained with roughages varying widely in protein content can be misleading. This would be particularly true for those roughages low in protein when fed in a ration containing enough protein.

Effect of Level and Source of Protein and Quality of Hay on Digestibility of Organic Matter by Sheep and Cattle.

The coefficients of apparent digestibility of organic matter are given in Tables VIII and IX. It is apparent that the digestibility of the organic matter was lower on the late-cut hay ration. This was true even at the highest level of protein fed (period 5). The lowering of digestibility of organic matter with advancing maturity of grasses is in agreement with several references cited in the review of literature. It apparently is due to an increase in the lignin content of the forage as it matures.

Digestibility of the organic matter in the late-cut hay ration was considerably improved when 15 percent concentrates were included. The values obtained for lambs were greater than for steers in all periods except in period 1 when no supplement was fed. Slightly higher values were obtained with the lambs with increasing levels of protein. However, the higher levels of protein had little if any effect on the digestibility of the organic matter by the steers.

When early-cut hay was fed, the highest coefficient of digestibility of organic matter was obtained when 15 percent oats was fed with the hay. High levels of protein but still with 15 percent concentrates resulted in slight decreases in the digestibility of the organic matter. This occurred with both steers and lambs. Differences in digestibility of organic matter on the early-cut hay by steers and lambs were small and inconsistent.

Even though increasing the level of protein in the late-cut hay ration brought about only slight improvement in the digestibility of the organic matter, it did greatly increase the consumption of the hay. The late-cut hay was fed at the rate the same as the early-cut hay even though it was recog-

nized that the consumption would be much lower at the lower levels of protein. This was done so that differences in consumption of the late-cut hay could be determined at different levels of protein.

Steers on unsupplemented late-cut hay in period 1 consumed from 14,672 grams to 22,531 grams of organic matter (Appendix Table I). The consumption of organic matter by these steers was increased an average of 6,000 grams per head when oats were added to the ration (Appendix Table II), and the hay refusal was cut in half. Progressive increases in consumption of organic matter were noted with each addition of protein up to and including period 5 in which the high levels were fed (Appendix Tables I-VI). The percent of hay refused by the steers is shown in Table IX. Hay consumption was good on the early-cut hay even without any supplement.

Table VIII. Coefficients of apparent digestibility of organic matter by steers fed late-cut or early-cut prairie hay supplemented with various levels of soybean meal or urea.

Steer No.	Digestion Period					
	1	2	3	4	5	6
Late-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, SBOM; P6, None.						
1	38.8	45.0	47.9	48.0	51.1	38.7
2	43.5	48.4	43.4	46.0	46.1	40.4
3	48.0	48.8	50.5	48.4	48.4	45.1
4	53.3	56.0	53.0	50.7	49.3	56.9
Av. 1-4	45.9	49.6	48.7	48.3	48.7	45.3
Av. percent protein in rations (moisture free)	3.82	5.58	7.90	8.30	9.67	4.38
Early-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, SBOM; P6, None.						
5	61.5	66.5	61.9	58.4	57.0	61.4
6	60.3	63.9	59.2	60.0	59.9	59.6
7	61.6	65.1	62.4	61.9	59.2	60.7
8	61.0	67.4	61.5	63.8	61.8	63.1
Av. 5-8	61.1	65.7	61.2	61.0	59.5	61.2
Av. percent protein in rations (moisture free)	9.12	9.75	12.18	13.40	15.66	9.54
Early-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, Urea; P6, None.						
9	58.6	62.6	55.1	59.8	59.3	57.6
10	61.2	63.1	64.0	60.4	58.9	59.7
11	57.4	61.5	60.8	58.6	58.4	59.3
12	57.9	65.3	60.0	62.4	59.5	60.5
Av. 9-12	58.8	63.1	60.0	60.3	59.0	59.3
Av. percent protein in rations (moisture free)	9.07	9.82	12.01	12.99	14.86	9.53

Table IX. Coefficients of apparent digestibility of organic matter by lambs fed late-cut or early-cut prairie hay supplemented with various levels of soybean meal or urea.

Lamb No.	Digestion Period					
	1	2	3	4	5	6
Late-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, SBOM; P6, None.						
1	45.6	53.7	55.2	52.5	54.3	50.2
2	43.0	48.0	47.3	50.3	50.8	44.1
3	39.3	51.7	51.4	51.6	51.4	48.6
4	41.1	49.2	53.7	48.6	48.3	45.5
Av. 1-4	42.2	50.6	51.9	50.8	51.2	47.1
Av. percent protein in rations (moisture free)	3.72	5.59	7.96	8.41	9.94	4.20
Early-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, SBOM; P6, None.						
5	59.1	62.4	59.8	60.7	58.3	63.2
6	60.0	64.1	62.9	63.1	61.7	62.2
7	57.2	62.5	60.8	62.5	60.2	61.6
8	59.6	61.7	63.0	61.8	59.2	60.6
Av. 5-8	59.0	62.7	61.6	62.0	59.9	61.9
Av. percent protein in rations (moisture free)	9.15	9.86	12.30	13.43	16.14	9.31
Early-cut hay, supplement, P1, none; P2, oats; P3, 4 & 5, Urea; P6, None.						
9	58.7	64.3	63.0	63.2	61.4	62.0
10	63.3	64.1	59.0	61.8	57.8	63.0
11	61.8	64.0	60.8	63.3	63.5	61.6
12	60.6	61.9	61.8	63.9	62.6	62.2
Av. 9-12	61.1	63.6	61.2	63.0	61.3	62.2
Av. percent protein in rations (moisture free)	9.15	9.86	12.23	13.43	16.62	9.29

Table X. Percentage of hay refused by steers.

Steer No.	Digestion Period					
	1	2	3	4	5	6
Late-cut hay						
1	43.7	14.0	6.6	3.8	2.8	28.5
2	40.3	16.9	11.8	2.5	1.3	18.9
3	21.2	6.3	4.6	2.0	1.5	24.6
4	29.6	28.4	24.3	16.6	9.6	46.8
Av. 1-4	33.7	16.4	11.8	6.2	3.8	29.7
Early-cut hay						
5	1.8	2.8	1.6	0.7	2.2	4.0
6	1.4	1.5	0.6	0.2	1.8	4.6
7	0.7	1.6	1.1	0.7	1.8	1.7
8	0.3	0.7	0.3	0.4	0.4	0.7
Av. 5-8	1.0	1.6	0.9	0.5	1.6	2.8
Early-cut hay						
9	1.5	0.9	1.4	3.0	1.0	1.1
10	2.6	2.8	2.4	1.9	3.8	2.3
11	3.8	2.9	2.6	3.6	5.8	5.4
12	3.7	3.3	0.8	1.1	2.2	2.7
Av. 9-12	2.9	2.5	1.8	2.4	3.2	2.9

Lambs, likewise, showed considerable increase in consumption of dry matter from hay on rations with the late-cut hay and greater amounts of protein (Appendix Tables VII-XII). They consumed approximately 3,000 grams more of hay dry matter on the late-cut hay ration with supplement than when fed the late-cut hay alone. The percent of hay refused by the lambs is shown in Table XI. When late-cut hay was fed there was a progressive increase in consumption of hay with increasing levels of protein. They were quite similar to the steers in their consumption of late-cut hay that was offered. However, the steers consumed a greater percentage of the early-cut hay offered than did the lambs. It appears that either the lambs did not have the same feed capacity per unit of weight as the steers or that the hay was not as palatable to lambs as to steers.

In comparing the ability of the two species to digest organic matter, it should be noted that the steers exceeded the lambs only three times in eighteen in their coefficients of apparent digestibility. These were on the unsupplemented late-cut hay, unsupplemented early-cut hay and with oats. It would appear from these studies that lambs digest organic matter in these types of rations better than do steers but the difference is only slight.

There was no difference in the digestibility of organic matter by either steers or lambs when fed either supplements with urea or soybean meal. Increasing the level of urea had no effect on digestibility of organic matter. Lambs had slightly higher digestion coefficients of organic matter digestibility at all levels of urea than did the steers. Comparisons on the basis of digestibility of organic matter shows that urea was as good as soybean meal and that the lambs utilized it fully as well as steers.

Table XI. Percentage of hay refused by lambs.

Lamb No.	Digestion Period					
	1	2	3	4	5	6
Late-cut hay						
1	41.5	31.0	30.7	18.6	17.3	46.5
2	14.9	5.0	6.5	5.4	7.6	30.6
3	32.1	13.9	7.3	4.1	5.4	31.1
4	33.0	30.8	8.5	7.2	6.9	42.7
Av. 1-4	30.4	20.2	13.2	8.8	9.3	37.7
Early-cut hay						
5	2.9	3.0	1.9	3.9	15.9	15.1
6	6.4	2.4	4.2	0.9	9.8	17.5
7	2.6	4.4	11.6	6.1	19.1	18.6
8	1.0	1.1	4.6	4.6	23.8	13.6
Av. 5-8	3.2	2.7	5.6	3.9	17.2	16.2
Early-cut hay						
9	0.9	1.8	0.4	0.8	13.2	11.6
10	4.8	8.0	14.5	7.9	26.8	24.1
11	1.6	1.8	4.8	1.1	9.1	18.2
12	4.8	17.0	18.6	10.9	17.8	16.6
Av. 9-12	3.0	7.2	9.6	5.2	16.7	17.6

SUMMARY AND CONCLUSIONS

Digestion trials have been conducted with 12 calves weighing about 475 pounds initially and 12 wethers weighing about 90 pounds. Comparisons were made of the effect of level and source of protein on the digestibility of good and poor quality prairie hay. Comparisons of the digestive powers of sheep and cattle were made on all rations tested.

In this experiment lambs had slight but consistently higher digestion coefficients for protein than did steers when fed rations varying from about 3.7 to about 13.4 percent protein, dry basis. Steers and wethers digested the protein equally well at the highest level tested, 15 to 16.6 percent protein. Apparent digestibility of the protein increased with both steers and lambs with each increase in protein in the ration.

Calculated true digestion coefficients were about the same for the poor quality hay (late-cut) and the good quality hay (early-cut). The apparent digestibility of the late-cut hay ration, supplemented with 15 percent of a protein supplement to give about 9.9 percent total protein, was nearly the same as the early-cut ration supplemented with the same amount of oats and containing about the same level of total protein.

Digestibility of protein in rations containing 0.47, 0.82 and 1.23 percent urea (3.1, 5.5 and 8.2 percent urea in the protein supplement) was equal to those containing the same level of total protein but with soybean meal as the major source of nitrogen. Thus urea had no effect on the apparent digestibility of the protein in the ration and sheep appeared to utilize it fully as well as cattle. However, lambs were found to consume higher levels of urea supplement than would steers. Supplements with 5.5 percent

urea were unpalatable to steers but only one lamb out of four left any supplement when it contained 8.2 percent urea.

Increasing the level of protein in the supplement had no effect on the digestibility of the organic matter in either the early-cut or late-cut hay ration. Digestibility of organic matter in the late-cut hay ration was lower than for the early-cut hay at all levels of protein tested. Lambs tended to digest the organic matter in these rations better than steers but the differences were small. Increasing the level of protein did greatly increase consumption of hay. Thus when the higher levels of protein were fed, both sheep and cattle consumed more hay and digested it fully as well as they did the lower intakes. This indicates that at the higher levels of protein the rations with late-cut hay were digested at a faster rate but not more completely.

Organic matter in rations containing the various levels of urea was digested as completely as it was with soybean meal. Increasing the level of urea had no effect on the digestibility of organic matter.

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Appendix Table I

FEED CONSUMPTION AND COEFFICIENTS OF DIGESTIBILITY FOR STEERS DURING PERIOD I

Steer No.	Dry Matter Fed		Dry Matter Refused			Nutrients Consumed			Coefficient of Apparent Digestibility		
	Hay Gms	Concentrates Gms	Hay Gms	Hay %	Concentrates Gms	Dry Matter Gms	Protein Gms	Organic Matter Gms	Dry Matter %	Protein %	Organic Matter %
Late-cut hay, 3.81% protein, dry basis, unsupplemented											
1	28539		12462	43.7		16077	625	14672	34.2	-15.2	38.8
2	30422		12245	40.3		18177	717	16560	39.1	7.4	43.5
3	31363		6646	21.2		24717	946	22531	44.6	12.9	48.0
4	31226		9234	29.6		21992	793	20115	49.1	16.0	53.3
Early-cut hay, 9.15% protein, dry basis, unsupplemented											
5	32811		596	1.8		32215	2927	29503	57.8	49.8	61.5
6	32337		437	1.4		31900	2903	29209	56.4	47.6	60.3
7	28651		196	.7		28455	2598	26038	57.8	53.5	61.6
8	31033		99	.3		30934	2829	28289	57.0	49.4	61.0
9	31389		466	1.5		30923	2823	28295	55.0	53.4	58.6
10	28378		740	2.6		27638	2509	25321	57.3	52.3	61.2
11	29765		1141	3.8		28624	2584	26263	53.4	43.7	57.4
12	35858		1326	3.7		34532	3116	31676	54.0	47.3	57.9

Appendix Table II

FEED CONSUMPTION AND COEFFICIENTS OF DIGESTIBILITY FOR STEERS DURING PERIOD II

Steer No.	Dry Matter Fed		Dry Matter Refused			Nutrients Consumed			Coefficient of Apparent Digestibility		
	Hay Gms	Concentrates Gms	Hay Gms	Hay %	Concentrates Gms	Dry Matter Gms	Protein Gms	Organic Matter Gms	Dry Matter %	Protein %	Organic Matter %
Late-cut hay, 3.38% protein, dry basis, supplemented with common oats											
1	25047	4479	3505	14.0		26021	1441	23888	40.9	35.7	45.0
2	26695	4779	4504	16.9		26970	1519	24777	44.5	38.6	48.4
3	27525	4923	1732	6.3		30716	1680	28131	45.0	38.1	48.8
4	27406	4899	7789	28.4		24516	1395	22586	51.5	45.9	56.0
Early-cut hay, 8.14% protein, dry basis, supplemented with common oats											
5	28330	4983	789	2.8		32524	3192	29958	62.7	58.4	66.5
6	27921	4911	413	1.5		32419	3188	29852	60.2	58.5	63.9
7	24730	4359	[illegible]	1.6		28694	2820	26423	61.2	60.2	65.1
8	26789	4719	199	.7		31309	3076	28834	63.7	64.8	67.4
[illegible]	27102	4767	243	.9		31626	3110	29122	58.9	61.0	62.6
10	24501	4311	697	2.8		28115	2760	25900	58.4	59.3	63.1
11	25705	4515	752	2.9		29468	2890	27144	57.8	60.9	61.5
12	30955	5452	1036	3.3		35371	3468	32579	61.3	59.3	65.3

Appendix Table III

FEED CONSUMPTION AND COEFFICIENTS OF DIGESTIBILITY FOR STEERS DURING PERIOD III

Steer No.	Dry Matter Fed		Dry Matter Refused			Nutrients Consumed			Coefficient of Apparent Digestibility		
	Hay Gms	Concentrates Gms	Hay Gms	Hay %	Concentrates Gms	Dry Matter Gms	Protein Gms	Organic Matter Gms	Dry Matter %	Protein %	Organic Matter %
Late-cut hay, 4.15% protein, dry basis, supplemented with SBOM mix											
1	26658	4782	1770	6.6		29670	2302	26860	43.8	44.5	47.9
2	28429	5090	3354	11.8		30165	2377	27350	39.5	48.2	43.4
3	29303	5250	1340	4.6		33213	2561	30060	46.5	48.3	50.5
4	29182	5225	7093	24.3		27314	2247	24843	48.1	56.0	53.0
Early-cut hay, 9.19% prptein, dry basis, supplemented with SBOM mix											
5	30147	5324	476	1.6		34995	4260	31982	57.9	66.6	61.9
6	29704	5250	173	.6		34781	4238	31770	55.9	64.1	59.2
7	26328	4646	279	1.1		30695	3738	28046	58.7	65.6	62.4
8	28520	5028	92	.3		33456	4075	30551	57.9	64.3	61.5
Early-cut hay, 9.19% protein, dry basis, supplemented with urea mix											
9	28841	5029	413	1.4		33457	4023	30583	51.8	64.2	55.1
10	26069	4554	617	2.4		30006	3607	27443	61.2	68.1	64.0
11	27338	4773	722	2.6		31389	3766	28721	57.6	67.8	60.8
12	32944	5747	278	.8		38413	4717	35118	55.8	61.9	60.0

Appendix Table IV

FEED CONSUMPTION AND COEFFICIENTS OF DIGESTIBILITY FOR STEERS DURING PERIOD IV

Steer No.	Dry Matter Fed		Dry Matter Refused			Nutrients Consumed			Coefficient of Apparent Digestibility		
	Ham Gms	Concentrates Gms	Hay Gms	Hay %	Concentrates Gms	Dry Matter Gms	Protein Gms	Organic Matter Gms	Dry Matter %	Protein %	Organic Matter %
Late-cut hay, 3.62% protein, dry basis, supplemented with SBOM											
1	27086	4960	1033	3.8		31013	2567	28072	43.6	48.6	48.0
2	28876	5293	716	2.5		33453	2744	30291	41.2	44.4	46.0
3	29777	5453	598	2.0		34632	2841	31335	44.0	44.7	48.4
4	29646	5428	4931	16.6		30143	2566	27420	46.6	51.6	50.7
Early-cut hay, 9.38% protein, dry basis, supplemented with SBOM											
5	31116	5527	203	.7		36440	4882	33396	53.1	60.3	58.4
6	30663	5440	66	.2		36037	4833	33019	54.8	63.3	60.0
7	27179	4825	195	.7		31809	4261	29156	56.7	63.5	61.9
8	29428	5231	113	.4		34546	4630	31652	59.4	65.1	63.8
Early-cut hay 9.38% protein, dry basis, supplemented with urea											
9	29759	5257	881	3.0	835	33300	4313	30581	54.8	64.7	59.8
10	26922	4744	510	1.9	266	30890	4059	28406	55.5	62.5	60.4
11	28218	4976	992	3.6	1113	31089	3933	28582	55.1	63.2	58.6
12	34001	6003	369	1.1	323	39312	5192	36114	57.8	63.3	62.4

Appendix Table V

FEED CONSUMPTION AND COEFFICIENTS OF DIGESTIBILITY FOR STEERS DURING PERIOD V

Steer No.	Dry Matter Fed		Dry Matter Refused			Nutrients Consumed			Coefficient of Apparent Digestibility		
	Hay Gms	Concentrates Gms	Hay Gms	Hay %	Concentrates Gms	Dry Matter Gms	Protein Gms	Organic Matter Gms	Dry Matter %	Protein %	Organic Matter %
Late-cut hay, 8.57% protein, dry basis, supplemented with SBOM											
1	27840	5206	827	2.8		32219	3113	29172	47.2	54.5	51.1
2	29679	5554	401	1.3		34832	3341	31531	41.6	58.6	46.1
3	30593	5728	479	1.5		35842	3447	32436	44.0	59.0	48.4
4	30464	5703	2714	9.6		33453	3284	30384	45.3	65.2	49.3
Early-cut hay, 9.72% protein, dry basis, supplemented with SBOM											
5	28950	5802	816	2.5		33936	5453	30553	52.2	70.3	57.0
6	28523	5716	586	1.8		33653	5401	30379	55.8	71.8	59.9
7	25286	5069	509	1.8		29846	4780	26887	54.4	71.2	59.2
8	27375	5492	137	.4		32730	5222	29420	57.9	73.7	61.8
Early-cut hay, 9.72% protein, dry basis, supplemented with urea											
9	27692	5543	317	1.0	799	32119	5024	28987	54.7	75.0	59.3
10	25045	5010	1041	3.8	1211	27803	4263	25170	54.0	72.0	58.9
11	26248	5258	1623	5.8	2333	27550	3920	24911	54.0	71.8	58.4
12	31640	6324	786	2.2	985	36193	5597	32758	54.4	73.6	59.5

Appendix Table VI

FEED CONSUMPTION AND COEFFICIENTS OF DIGESTIBILITY FOR STEERS DURING PERIOD VI

Steer No.	Dry Matter Fed		Dry Matter Refused			Nutrients Consumed			Coefficient of Apparent Digestibility		
	Hay Gms	Concentrates Gms	Hay Gms	Hay %	Concentrates	Dry Matter Gms	Protein Gms	Organic Matter Gms	Dry Matter %	Protein %	Organic Matter %
Late-cut hay, 3.93% protein, dry basis, unsupplemented											
1	34184		8251	28.5		25933	1161	23205	34.8	21.1	38.7
2	36446		6344	18.9		30102	1311	27012	35.8	11.9	40.4
3	37571		8523	24.6		29048	1244	26049	41.5	15.3	45.1
4	37412		16052	46.8		21360	938	19185	51.6	17.4	56.9
Early-cut hay, 8.64% protein, dry basis, unsupplemented											
5	38364		1441	4.0		36923	3518	33386	56.6	52.8	61.4
6	37798		1603	4.6		36195	3434	32772	55.2	47.1	59.6
7	33510		554	1.7		32956	5153	29805	56.4	50.9	60.7
8	36282		258	.7		36024	3450	32505	58.2	56.7	63.1
9	36701		378	1.1		36323	3474	32775	53.4	53.3	57.6
10	33190		699	2.3		32491	3098	29364	55.5	47.2	59.7
11	34792		1721	5.4		33071	3143	29941	55.0	53.4	59.3
12	41925		1065	2.7		40860	3897	36969	56.1	51.0	60.5

Appendix Table VII

FEED CONSUMPTION AND COEFFICIENTS OF DIGESTIBILITY FOR LAMBS DURING PERIOD I

Lamb No.	Dry Matter Fed		Dry Matter Refused			Nutrients Consumed			Coefficient of Apparent Digestibility		
	Hay Gms	Concentrates Gms	Hay Gms	Hay %	Concentrates Gms	Dry Matter Gms	Protein Gms	Organic Matter Gms	Dry Matter %	Protein %	Organic Matter %
Late-cut hay 3.81% protein, dry basis, unsupplemented											
1	8208		3408	41.5		4800	179	4386	41.1	-1.1	45.6
2	7629		1135	14.9		6488	246	5906	38.7	-0.8	43.0
3	8633		2771	32.1		6072	219	5351	37.4	-5.9	39.3
4	8495		2803	33.0		5692	214	5204	37.2	3.3	41.1
Early-cut hay 9.15% protein, dry basis, unsupplemented											
5	8167		240	2.9		7927	725	7278	55.7	55.2	59.1
6	8701		557	6.4		8144	744	7452	56.6	55.5	60.0
7	8096		210	2.6		7886	723	7221	53.6	54.4	57.2
8	8985		92	1.0		8893	812	8137	56.2	57.0	59.6
9	8096		75	.9		8021	733	7340	55.2	54.7	58.7
10	8843		421	4.8		8422	770	7728	60.2	62.5	63.3
11	8701		137	1.6		8564	783	7852	58.0	55.0	61.8
12	8701		416	4.8		8285	759	7581	57.3	56.7	60.6

Appendix Table VIII

FEED CONSUMPTION AND COEFFICIENTS OF DIGESTIBILITY FOR LAMBS DURING PERIOD II

Lamb No.	Dry Matter Fed		Dry Matter Refused			Nutrients Consumed			Coefficient of Apparent Digestibility		
	Hay Gms	Concentrates Gms	Hay Gms	Hay %	Concentrates Gms	Dry Matter Gms	Protein Gms	Organic Matter Gms	Dry Matter %	Protein %	Organic Matter %
Late-cut hay 3.38% protein, dry basis, supplemented with common oats											
1	7207	1285	2233	31.0		6259	355	5769	49.2	42.2	53.7
2	6721	1165	336	5.0		7550	409	6916	44.0	33.2	48.0
3	7575	1357	1050	13.9		7882	432	7233	47.7	43.8	51.7
4	7456	1333	2294	30.8		6495	377	5990	44.8	39.8	49.2
Early-cut hay 8.14% protein, dry basis, supplemented with common oats											
5	7055	1237	212	3.0		8080	797	7442	59.2	62.9	62.4
6	7513	1321	181	2.4		8653	856	7968	60.7	63.7	64.1
7	6995	1225	307	4.4		7913	777	7296	59.3	67.0	62.5
8	7754	1369	83	1.1		9040	890	8324	58.4	56.8	61.7
9	6995	1225	128	1.8		8092	796	7450	61.0	65.8	64.3
10	7633	1345	609	8.0		8369	819	7724	61.0	65.2	64.1
11	7513	1321	135	1.8		8699	860	8006	60.5	64.3	64.0
12	7513	1321	1280	17.0		7554	750	6985	58.2	61.3	61.9

Appendix Table IX

FEED CONSUMPTION AND COEFFICIENTS OF DIGESTIBILITY FOR LAMBS DURING PERIOD III

Lamb No.	Dry Matter Fed		Dry Matter Refused			Nutrients Consumed			Coefficient of Apparent Digestibility		
	Hay Gms	Concentrates Gms	Hay Gms	Hay %	Concentrates Gms	Dry Matter Gms	Protein Gms	Organic Matter Gms	Dry Matter %	Protein %	Organic Matter %
Late-cut hay 4.15% protein, dry basis, supplemented with SBOM											
1	7669	1380	2357	30.7		6692	561	6072	51.5	58.1	55.2
2	7123	1282	464	6.5		7941	619	7175	43.8	50.9	47.3
3	8069	1442	581	7.3		8930	694	8080	48.0	55.0	51.4
4	7936	1430	672	8.5		8694	685	7866	50.8	55.9	53.7
Early-cut hay 9.19% protein, dry basis, supplemented with SBOM											
5	7503	1331	145	1.9		8689	1063	7936	57.1	68.9	59.8
6	7996	1405	339	4.2		9062	1114	8275	60.0	68.3	62.9
7	7441	1306	862	11.6		7885	982	7203	58.0	68.6	60.8
8	8254	1454	379	4.6		9329	1141	8527	60.2	69.3	63.0
Early-cut hay 9.19% protein, dry basis, supplemented with urea											
9	7441	1291	31	.4		8701	1046	7951	60.1	68.6	63.0
10	8131	1412	1181	14.5		8362	1034	7647	56.2	68.7	59.0
11	7996	1388	385	4.8		8999	1087	8227	58.1	66.2	60.8
12	7996	1388	1487	18.6		7897	983	7221	58.6	69.4	61.8

Appendix Table X

FEED CONSUMPTION AND COEFFICIENTS OF DIGESTIBILITY FOR LAMBS DURING PERIOD IV

Lamb No.	Dry Matter Fed		Dry Matter Refused			Nutrients Consumed			Coefficient of Apparent Digestibility		
	Hay Gms	Concentrates Gms	Hay Gms	Hay %	Concentrates Gms	Dry Matter Gms	Protein Gms	Organic Matter Gms	Dry Matter %	Protein %	Organic Matter %
Late-cut hay 3.62% protein, dry basis, supplemented with SBOM											
1	7800	1428	1446	18.6		7782	674	7058	48.8	56.4	52.5
2	7243	1329	391	5.4		8181	683	7394	46.8	52.3	50.3
3	8191	1502	336	4.1		9357	774	8469	48.2	55.4	51.6
4	8072	1477	578	7.2		8971	750	8119	45.4	54.1	48.6
Early-cut hay 9.38% protein, dry basis, supplemented with SBOM											
5	7751	1379	303	3.9		8827	1187	8095	57.6	67.2	60.7
6	8253	1465	71	.9		9647	1297	8839	59.8	68.2	63.1
7	7666	1366	468	6.1		8564	1156	7856	59.3	69.3	62.5
8	8522	1514	391	4.6		9645	1285	8845	58.5	68.2	61.8
Early-cut hay 9.38% protein, dry basis, supplemented with urea											
9	7666	1357	61	.8		8962	1198	8235	60.0	69.7	63.2
10	8387	1479	661	7.9		9205	1243	8471	58.5	71.1	61.8
11	8253	1455	91	1.1		9617	1284	8839	60.1	69.9	63.3
12	8253	1455	898	10.9		8810	1189	8110	60.4	71.2	63.9

Appendix Table XI

FEED CONSUMPTION AND COEFFICIENTS OF DIGESTIBILITY FOR LAMBS DURING PERIOD V

Lamb No.	Dry Matter Fed		Dry Matter Refused			Nutrients Consumed			Coefficient of Apparent Digestibility		
	Hay Gms	Concentrates Gms	Hay Gms	Hay %	Concentrates Gms	Dry Matter Gms	Protein Gms	Organic Matter Gms	Dry Matter %	Protein %	Organic Matter %
Late-cut hay 3.57% protein, dry basis, supplemented with SBOM											
1	8011	1503	1301	17.3		8213	845	7444	50.2	59.9	54.3
2	7449	1392	515	7.6		8326	824	7529	46.8	59.8	50.8
3	8421	1578	411	5.4		9588	935	8683	47.3	62.7	51.4
4	8292	1553	524	6.9		9321	916	8462	44.7	59.7	48.3
Early-cut hay 9.72% protein, dry basis, supplemented with SBOM											
5	7218	1441	1153	15.9		7506	1259	6824	55.0	70.9	58.3
6	7678	1541	724	9.8		8495	1403	7662	58.1	70.9	61.7
7	7142	1429	1353	19.1		7218	1231	6530	57.0	71.7	60.2
8	7918	1603	1975	23.8		7546	1315	6821	55.9	73.2	59.2
Early-cut hay 9.72% protein, dry basis, supplemented with urea											
9	7142	1426	945	13.2		7623	1283	6926	57.7	72.9	61.4
10	7798	1562	2126	26.8		7234	1305	6561	54.4	75.3	57.8
11	7678	1538	642	9.1		8574	1414	7786	59.7	75.0	63.5
12	7678	1538	1364	17.8	48	7804	1339	7082	58.8	76.1	62.6

Appendix Table XII

FEED CONSUMPTION AND COEFFICIENTS OF DIGESTIBILITY FOR LAMBS DURING PERIOD VI

Lamb No.	Dry Matter Fed		Dry Matter Refused			Nutrients Consumed			Coefficient of Apparent Digestibility		
	Hay Gms	Concentrates Gms	Hay Gms	Hay %	Concentrates Gms	Dry Matter Gms	Protein Gms	Organic Matter Gms	Dry Matter %	Protein %	Organic Matter %
Late-cut hay 3.93% protein, dry basis, unsupplemented											
1	9842		4155	46.5		5687	230	5097	46.5	19.6	50.2
2	9145		2518	30.6		6627	298	5899	40.9	22.2	44.1
3	10343		2968	31.1		7375	297	6620	45.5	24.9	48.6
4	10184		4020	42.7		6164	261	5507	43.0	20.7	45.5
Early-cut hay 8.64% protein, dry basis, unsupplemented											
5	9560		1271	15.1		8289	771	7545	59.7	61.5	63.2
6	10176		1579	17.5		8597	804	7794	58.5	59.0	62.2
7	9462		1536	18.6		7926	734	7224	58.3	61.2	61.6
8	10509		1292	13.6		9217	861	8389	57.6	61.2	60.6
9	9462		919	11.6		8543	797	7784	59.4	59.8	62.0
10	10336		2191	24.1		8145	744	7456	59.7	60.9	63.0
11	10176		1368	18.2		8808	819	8020	58.0	59.5	61.6
12	10176		1476	16.6		8700	816	7896	59.0	63.4	62.2