



Studies on fecal analyses for determining forage species and protein in the diet of range ewes
by Mark McKinney

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree
of Master of Science in Range Management

Montana State University

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Abstract:

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STUDIES ON FECAL ANALYSES FOR DETERMINING FORAGE SPECIES
AND PROTEIN IN THE DIET OF RANGE EWES

by

Mark McKinney

A THESIS

Submitted to the Graduate Faculty

in

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Montana State College

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ABSTRACT

The problem of determining the forage plant composition of the diet, and the protein in the diet, of livestock on the range has long eluded answer, except with very intensive, expensive, and tedious sampling. The objective of this study was to find more usable and simply applied methods for determining plant species and protein in the diet of range ewes. A study was made of cell patterns and crude protein of certain forage plants eaten, and of fecal material voided, by hand-fed wethers and by range ewes.

A direct relation was shown between dietary protein and fecal protein. Undetermined factors other than the protein supplement fed to range ewes were more significant, however, in altering fecal protein than was the protein level of supplementation.

In cell pattern studies, some cell patterns were found to be present in grasses and sedges which could be found in fecal material of sheep eating that forage. Some other plants were studied, but no cell patterns were found in them which could be reproduced in fecal material.

INTRODUCTION

The range livestock industry of the West has been built with native range as its foundation. If this industry is to continue to command its place in agriculture as it has in the past, the range must remain in a productive condition. The more productive the range the higher the position the industry will command.

Involved in maintaining or improving this resource are technical, educational, economic, social, and psychological problems. Research leading to this thesis was principally concerned with only two of the innumerable technical problems that we face today. The first was that of finding a simple and accurate method of determining what forage was taken by range stock. The second was that of determining what protein the range stock obtained from the native forage during winter grazing.

It is important to know what stock eat. This knowledge is elemental to management leading toward maintaining and increasing those plant species which are most productive of stock feed. The value of a range cannot be adequately judged if the species most desired by stock and most productive of stock feed are not known. Forage species which are high in protein in the winter are important because they may greatly decrease the necessary feeding of concentrates.

In the past several years there have been innumerable efforts to determine what forage stock take from their ranges, and to what extent this forage supplies a nutritionally adequate diet. Most of the methods for securing data on preference and use of range plants

have been indirect. The only direct method now used consists of observing animals while they are grazing. Since this entails close watch of animals at all hours of day or night when they might graze, and through all kinds of weather, the task is extremely tedious, and accuracy is not assured.

For summer grazing, there are indirect methods which seem to be adequate though they are tedious. In winter grazing, on the other hand, these methods may not be adequate. There is reason to suspect that there may be a small amount of forage taken from plants high in protein or other specific nutrients (50). This small amount could be very important in the animal diet, as range grasses are very low in protein during the winter months. Indirect methods may not adequately sample this type of utilization.

It is apparent that there is an urgent need for accurate and simply applied methods of determining the extent to which forage species are utilized and what special nutrients any of these plants supply to livestock.

A specific example of the need for determining the amount of protein which stock get from the range is found at Montana Agricultural Experiment Station. This Station is trying to determine the most profitable level of supplementing range sheep with protein in the winter time. The results of this protein experiment can probably be more accurately applied to other ranges if the amount of protein received by the sheep from each range can be determined.

In this study, these problems have been attacked through analyses

of fecal materials, first for the species composition of the diet, and second for protein in the diet without regard for the species from which it came. Comparison of these analyses with range forage analyses was then made.

REVIEW OF LITERATURE

Fecal Nitrogen

There are many methods of determining the digestion coefficients of feeds and approximately what nutrients animals obtain from the feed they eat. These methods require, however, that the feeds be chemically analyzed before being consumed, and the residue, or undigested portions be analyzed after being voided. Two of these methods are the lignin ratio technique as used by Ellis and others (24) and the chromogen method as used by Reid and co-workers (54).

Klosterman and co-workers (40) showed that a low protein diet in pregnant ewes caused a small, but significant decrease in the serum albumins and the oxyhemoglobins. Oxyhemoglobins were shown to be so different in different ewes, however, that ewes had to be allotted to test on the basis of their blood oxyhemoglobin content before a significant decrease in oxyhemoglobin could be shown to accompany a lowered protein diet. The differences in serum albumins were so small as to render their use difficult. However, the significance of the differences seemed to warrant further study of the method in determining the actual state of protein nutrition of stock on the range.

Hobbs, et. al. (35) indicated that fecal nitrogen was more closely related to dry matter intake than to the percent protein in the diet. Gallup and Briggs (32) suggested that fecal nitrogen be used as an indicator of dry matter intake. Several other experiments (3,28,29) have been made on fecal nitrogen as affected by the dry matter intake and the protein content.

Blaxter and Mitchell (3) and Forbs (28) showed an increase in total fecal nitrogen per 100 grams dry matter intake as the percent of dietary protein was increased. In the works of Gallup and Briggs (32) and Forbs (29) an increase in total digestible nutrients was shown as the percent of protein was increased. Forbs (29), on the other hand, showed that the digestion was more affected by lignin than by protein.

Any methods based on the digestibility of feed appear to be equally applicable to both cattle and sheep since several workers report that cattle and sheep digest most feeds about equally well (11, 29, 38, 57).

Although Forbs (29) and Cipolloni (11) report that sheep digest the protein of some forages differently than do cattle, these differences do not seem to obscure the general rule.

Cell Patterns For Species Identification

Volumes of work (1, 6, 7, 8, 9, 12, 17, 18, 19, 20, 30, 33, 34, 36, 37, 38, 41, 42, 45, 47, 48, 49, 51, 52, 53, 58) have been done in trying to perfect methods to determine the degree of use of range plants. Measurement methods include weight, length, height of stubble, list counts of grazed and ungrazed parts, percentage estimates, volume estimates, and weight estimates. Some measurement standards include only an estimate of whether or not use has been too heavy. These methods are primarily based on what the animal has left ungrazed rather than what it has eaten.

Cory (16) in 1930 suggested close observation of stock to determine

the amount of time spent on grazing different plants. The time spent on each species was then used as an index to the portion of the diet which each plant supplied. In 1940 Fraps and Cory (31) followed stock and attempted to collect representative amounts of the different species on which they grazed. This collection was then supposed to represent both the species and chemical composition of the diet.

Cassady (10) suggested clipping samples before and after grazing to determine both species and chemical composition of the diet. C. J. Cook, C. W. Cook, and Harris (14,15) later developed this method and used it in determining species and chemical composition of the diets of range sheep. Everson (27) indicated that the time required to get a statistically adequate sample by this method seemed to prohibit its use under most conditions. He estimated the minimum time necessary to collect a representative sample would be 19 hours before grazing and 97 hours after grazing. This would be a total of 21 working days. Some of the areas studied required nearly six times as long to get a representative sample, while in the case of individual species even more time would be required. From Everson's conclusions then, it appears that the full time of two workers would be required to adequately sample a sheep band's diet once every two weeks. The use of this method to sample the diet of livestock which are not herded seems even more impractical. The method depends on sampling a short time before and after grazing. With unherded stock, the area in which to take the pre-grazing sample would not be known.

De Nio (21) and Norris (46) have used stomach analyses as a

method of studying the diet of grazing animals. Norris reported the method valuable in determining the species consumed by sheep, but of no value in determining either the proportions of the different species in the diet or the chemical composition of the diet.

Baumgartner and Martin (2) and Dusi (23) used microscopic histological studies as aids in determining the diets of squirrels and cottontail rabbits respectively. Dusi used photographs of epidermal cell structures while Baumgartner and Martin used prepared slides showing cell wall patterns, stomata, pubescence, and conductive tissue elements. The feces were then examined in an apparently successful attempt to determine the species composition of the diet.

Booth (4) demonstrated several histological differences between two species of Mentzelia. Characteristic differences in sizes, and shapes of cells were noted. Subsidiary hair cells were shown to hold their original shape after burning. It appeared, from this work, that differences in the cell patterns of ashed material of these species were of such nature that they might be used, through fecal observation, to detect those species as having been part of the diet. The abundance of, and differences in, hairs and cells subsidiary to the hairs appear to make these characters especially well suited to use.

Metcalf and Chalk (43) recently have published books on the anatomy of dicotyledonous plants. They studied differences in hairs, stomata, epidermal cells, veins, petioles, crystals, starch, crystalloids, lactiferous systems, secretory glands, cork, endodermis, vascular bundles, wood rays, fibers, growth rings, phloem, chemical contents of cells, and

other plant parts and properties. Combinations of characters were found to be far better than single characters in identification. Such factors as cell dimensions or hair density were usually of little value. Qualitative differences were found to be far superior to quantitative differences. The method was of no consequence in distinguishing species in the same genus because the differences between species were not usually qualitative. The value of the method seems to lie in providing evidence concerning the interrelationships of families; and to which families questionable genera belong. This observation on the merits of distinguishing species when the whole plant is present would seem to throw doubt on the validity of identification of plants from the histology of the small portions which can be found in the feces of grazing animals.

CONDITIONS OF STUDY

This study was conducted with the range ewes on a nutrition experiment five miles northeast of Livingston. Groups within a band of 1083 head were fed different levels of protein supplement during the winter on this test. All ewes were kept together in one band at all times during the experimental period except that they were separated into groups each morning through a five way cutting chute for supplemental feeding.

The levels of supplement fed during the winter of 1950-51 were as follows:

Group	No. Sheep on Expt.	Protein Supplement
0	55	None
1	246	1/3 lb. 10.8% pellets
2	242	1/3 lb. 19.8% pellets
3	242	1/3 lb. 28.7% pellets
4	242	1/3 lb. 37.7% pellets
5	56	1/3 lb. 20% pellets; 1/3 lb. dehydrated alfalfa; and full feed alfalfa hay.

Group 5 was designed to be a second control. They were kept at Ft. Ellis near Bozeman, Montana, and fed hay and concentrate. Climatic, forage, and feeding conditions there were different than those on the range.

Groups 0 through 4 grazed on the range during the day. They were bedded near the feed pens at night, and then were separated into feeding groups the following morning. After feeding they again went together

into a single band.

The range land on which the sheep grazed during the winter was mostly foothill grassland type. Precipitation is approximately fifteen inches annually, over 60% of which falls in the seasonal period of April through September. The area offers little protection from wind. Snow covers the range feed for short periods but wind usually sweeps the ridges clear in a few days.

Vegetation on the area is comparatively simple. There is a small amount of big sagebrush (Artemisia tridentata) and a very small amount of rabbitbrush (Chrysothamnus sp). Fringed sagewort (Artemisia frigida) is sparsely scattered over most of the range and a little phlox (Phlox sp.) and clubmoss (Selaginella sp.) can be found in most places. The principal forage species found are bluebunch wheatgrass (Agropyron spicatum), western wheatgrass (A. Smithii), needle-and-thread grass (Stipa comata), junegrass (Koeleria cristata), and a little Sandberg bluegrass (Poa secunda). Cheatgrass (Bromus tectorum) is prevalent on previously plowed areas while crested wheatgrass (Agropyron cristatum) furnishes a little feed in some places.

A little green feed was available in the fall, with cheatgrass remaining green and available through December and into January. Sheep went into the home ranch for lambing before spring growth had started. During the winter fringed sagewort, rabbitbrush, clubmoss, and phlox remained more or less green. These plants are relatively scarce however, and seemed not to have been heavily used.

Grass hay was the only other forage available to the sheep. This

hay was fed only when snow made the range forage unavailable.

More detailed data concerning the weather and forage on the sampling dates are as follows:

December 29: The first forage sample was taken. There was no snow. There were only a very few green shoots in the centers of perennial grasses. Young cheatgrass was green, but small.

January 15: The first fecal samples were taken. A little cheatgrass had been available while perennial grasses had a very few green leaves on them. There was no snow, and the weather was relatively warm.

January 29: The second fecal and second grass samples were taken. It was very cold, snow had all but the tops of grasses covered in most areas, and no green material was available.

February 12: Snow had covered the ground the night before this third fecal sample. Range had been clear of snow and weather not excessively cold. The sheep had been moved to fresh range at a different camp about a week before.

February 26: The area was partly covered with snow from the February 12th fall. Sufficient ground was clear so that there was little interference with grazing. It was not very cold at this time. Grass samples were collected on this date for protein analysis.

March 12: Snow had covered all forage for several days. Hay was being fed to the ewes.

March 26: The last fecal and grass samples were taken. The whole area was clear of snow, ground was fairly well thawed out, and a few green shoots were noted on some of the perennial grasses, especially junegrass.

EXPERIMENTAL PROCEDURE

The literature previously reviewed seemed to indicate that when the percent of feed protein was increased, both digestible dry matter of the feed and total fecal protein were increased. Lignin was shown however, to be more effective in altering the digestion of feeds than was the percent feed protein. From these works then, a hypothesis was developed that the percent fecal protein would increase as the percent feed protein increased provided the lignin content remained relatively constant.

In order to obtain more information regarding this hypothesis, further data were calculated from digestion trials as reported by Schneider (55) and Morrison (44). In these calculations the feed protein which was not apparently digestible was determined by subtracting the apparent digestible protein from the total crude protein in the feed. The amount of feed voided as fecal dry matter was similarly determined. The percentage of fecal nitrogen was then calculated for comparison with the feed protein. In Table I, fecal protein percentages are given which were calculated from digestion coefficients given by Schneider (55). Table II was calculated from Morrison (44) and Table III from the work of Gallup and Briggs (34). These calculations tended to bear out the original hypothesis.

Fecal Protein Studies

Before studying fecal protein of the range ewes, it was deemed advisable to first study the effect of varying levels of protein supplementation under more closely controlled conditions. A preliminary

Table I. FEED PROTEIN AND CALCULATED FECAL PROTEIN
(From Schneider (55))

Feed	% Feed Protein	% Apparent Digestible Protein	Calculated % Fecal Protein
Soft brome, Fescue, and oat mixed hay	3.6	-0.9	8.8
Soft brome weathered hay	3.7	-0.3	9.0
Bluebunch wheatgrass hay-overripe	3.0	0.2	5.0
Barley hay mature	6.2	3.4	8.4
Barley hay milk stage	7.1	3.5	9.0
Bermuda grass hay	7.2	3.7	7.1
Timothy hay-full bloom	7.2	3.9	8.4
Barley hay	7.9	4.4	9.6
Bentgrass mixed hay	8.1	4.7	9.6
Timothy hay-1/2 bloom	9.2	5.6	9.9
Acacia pods	11.8	6.1	16.6
Bluegrass hay	10.0	6.3	11.5
Alfalfa hay under 13% protein	12.1	8.0	9.4
Alfalfa hay-overripe	12.4	8.8	9.0
" " low ash	14.2	10.0	10.4
" " 31-34% fiber	14.1	10.1	9.6
" " full bloom	13.9	10.4	8.8
" " all experiment	15.0	10.8	10.2
" " under 25% fiber	16.4	12.1	12.1
" " high ash	16.6	12.3	10.8
" " early bloom	16.6	13.0	9.9
" " last cutting- very immature	21.8	15.7	16.3

Table II.

FEED PROTEIN AND CALCULATED FECAL PROTEIN
(From Morrison (43))

Feed	% Feed Protein	% Apparent Digestible Protein	Calculated % Protein Not Apparent Digestible	Calculated % Feed Voided as Fecal Dry Matter	Calculated % Fecal Protein
Alfalfa hay black	17.5	0.4	17.1	66.0	25.91
Barley straw	3.7	0.7	3.0	49.8	6.02
Grass straw	4.5	1.8	2.7	47.2	5.72
Bermuda grass, poor	5.8	2.3	3.5	50.1	7.00
Bent grass hay	6.6	2.8	3.8	43.2	8.80
Johnson grass hay	6.5	2.9	3.6	42.4	8.49
Bermuda grass hay	7.2	3.7	3.5	48.6	7.20
Barley hay	7.3	4.0	3.3	41.2	8.01
Slender wheatgrass hay	8.0	4.6	3.4	41.4	8.21
Bromegrass hay, all analysis	9.9	5.0	4.9	41.8	11.72
Crested wheatgrass hay, cut early	9.2	6.5	2.7	41.7	6.47
Alfalfa hay stemmy	12.1	8.1	4.0	46.1	8.68
" " past bloom	12.8	9.2	3.6	45.5	7.91
" " brown	17.3	9.2	8.1	45.9	17.65
" " fair	13.5	9.7	3.8	42.8	8.88
Alfalfa meal stemmy	13.6	9.8	3.8	44.5	8.54
Alfalfa hay 3/4 to full bloom	14.1	10.3	3.8	42.8	8.88
Alfalfa hay good	14.3	10.3	4.0	42.3	9.46
" " all analysis	14.8	10.5	4.3	42.7	10.07
" " 1/10 to 1/2 bloom	15.3	11.2	4.1	40.8	10.05
" " dehydrated	16.1	11.3	4.8	39.6	12.12
" " leafy	15.8	11.7	4.1	41.8	9.81
Alfalfa meal good	16.1	11.8	4.3	41.9	10.26
Alfalfa hay very leafy	17.2	12.6	4.6	41.0	11.22
" " before bloom	19.0	13.7	5.3	47.5	13.09
Alfalfa leaves	22.3	17.4	5.1	36.4	13.46

Table III:

FEED PROTEIN AND CALCULATED FECAL PROTEIN
IN PRAIRIE HAY AND PRAIRIE HAY SUPPLEMENTED WITH COTTONSEED MEAL
(From Gallup and Briggs (31))

Grams Dry Matter Con- sumed Daily	% Crude Protein	Calculated Fecal Percentage		Calculated Fecal Dry Matter		Calculated Total Fecal Nitrogen (grams)	Fecal Nitrogen % of Dry Matter Intake
		Nitrogen	Protein	% of Feed	Total Grams		
Prairie Hay							
3684	3.01	1.017	6.36	53.1	1956	19.89	.54
3216	3.20	1.000	6.25	52.0	1672	16.72	.32
3576	3.81	1.070	6.69	54.2	1938	20.74	.58
2907	3.93	1.093	6.83	49.4	1436	15.70	.54
3100	4.00	1.046	6.54	45.9	1423	14.88	.48
4204	4.18	1.253	7.83	46.3	1946	24.38	.58
3945	4.64	1.195	7.47	43.5	1716	20.51	.52
3359	4.71	1.256	7.85	42.2	1417	17.80	.53
4038	5.50	1.356	8.48	45.0	1817	24.63	.61
3542	5.85	1.392	8.70	39.5	1399	19.48	.55
Prairie Hay Supplemented With Cottonseed Meal							
4396	5.48	1.303	8.14	45.3	1991	25.94	.59
4448	6.22	1.407	8.79	46.2	2055	28.91	.65
4495	7.65	1.441	9.01	46.5	2090	30.12	.67
4565	8.67	1.545	9.66	46.6	2127	32.87	.72
5093	10.83	1.597	9.98	45.7	2328	37.18	.73
5071	10.85	1.746	10.91	41.8	2120	37.02	.73
4945	11.33	1.678	10.49	43.5	2152	36.10	.73
4918	12.00	1.994	12.46	35.6	1751	34.92	.71
5466	13.42	2.129	13.31	40.4	2208	47.01	.86

test, therefore, was carried out.

In this test, 3 groups of 4 wethers each were fed in individual crates for a period of 16 days (Tables IV and V).

Table IV. DAILY RATION OF WETHERS ON PRELIMINARY TEST

Group no.	Grams Barley	Grams Linseed Oil Meal	Hay	% Protein in Supplement
I		152	Free Choice	37.1
II	59	93	Free Choice	20.0
III			Free Choice	

Table V. PROTEINS IN FEEDS USED TO
FORMULATE RATIONS FOR WETHERS ON PRELIMINARY TEST

Feed	% Protein (Dry Wt. Basis)
Linseed Oil Meal	37.1
Barley	9.2
Hay	8.0

The first group was fed a supplement of 152 grams (1/3 lb) per day of 37.1% linseed oil meal. The second group received 1/3 lb. per day of a 20% supplement made up of 93 grams of barley plus 59 grams of linseed oil meal. The third group received no supplement.

The supplement was fed each morning about eight o'clock

followed by an unlimited feeding of hay containing approximately 8% protein. The sheep were turned out in the corral before noon where water and a commercial salt-mineral mixture was available. They were put in their stalls again about 4:30 P. M. and allowed to eat hay until approximately 8:30 P. M. when they were turned out in the corral for the night. There was no straw or other bedding material in the corral upon which they could feed.

Fecal collection bags were used to collect a 12 hour supply of feces at the beginning of the experiment, and at the end of 12, and 16 days. This material was then dried in open pans over a steam radiator. Individual fecal samples, and a composite sample of the hay fed were then ground and analyzed for crude protein. Uneaten portions of hay were collected each morning and were weighed at the end of 5, 10, and 16 days. The total amount of feed consumed was determined, and percent of crude protein in the diet was then calculated for each wether. Feed protein and fecal protein were then compared (Table VI). The results of this preliminary test appeared sufficiently promising to warrant going ahead with the test of this method on a larger scale with the range ewes.

On January 15 the first fecal sampling was made on the range ewes. Sampling was done at two week intervals after that until March 26. The ewes went to the lambing sheds shortly after this date and were not available for further sampling.

Twenty ewes randomly selected from each feeding level group were taken as the basis of each test. After the groups had been separated

Table VI. CALCULATED FEED PROTEIN
 FOR LAST SIX DAYS AND DETERMINED FECAL PROTEIN OF LAST
 SAMPLE FOR WETHERS ON PRELIMINARY TEST

Wether No.	Calculated % Feed Protein	% Fecal Protein
<u>Group I</u>		
1	11.35	9.7
2	11.36	10.9
3	11.39	9.6
4	11.58	10.3
Mean	11.42	10.1
<u>Group II</u>		
5	9.52	9.8
6	9.29	8.6
7	9.36	9.8
8	9.33	9.1
Mean	9.34	9.3
<u>Group III</u>		
9	8.0	9.2
10	8.0	9.1
11	8.0	8.9
12	8.0	8.6
Mean	8.0	9.0

for their daily supplemental feeding, moveable panels were set up as a small corral into which about twenty-five sheep were driven or lured with hay. One person would then hold the head of a sheep and mark it with chalk so that it would not be sampled again. A second person would hold the rear of the sheep against a fence panel and take, by inserting the index finger in the rectum, a sample of at least 8 fecal pellets, or an equivalent amount of unpelleted material. This sample was then put into a small clean bottle. Individual bottles were used so that an equal portion of dry material from each ewe could later go into a composite sample for the entire group. A rubber glove was used to protect the sheep and to keep the hands relatively clean.

A band of purebred sheep was also on a nutrition experiment during the winter of 1950-51. Two samples were taken from each of the four feeding groups into which this band was divided. The first sample was taken on March 12, and the second on March 26.

These samples were not kept individually as were the range ewe samples, due to a lack of suitable containers. An effort was made however, to get approximately the same amount of material from each of 20 sheep in each feeding group.

All fecal samples were dried over a steam radiator for a period of one week, then ground and analyzed for crude protein (Kjeldahl Method) and moisture. Unground portions of samples from the range ewes were saved for cell pattern studies.

Cell Pattern Studies

Before cell patterns could be used in species identification work,

a method had to be developed by which both forage species and fecal material could be treated to show the cells clearly without excessive maceration of the material. Numerous methods were investigated in an attempt to find a suitable one.

Concentrated sulfuric acid was used on fecal and plant material, both burned and unburned. The material turned black with this procedure and failed to clear up either upon boiling or standing for a period of one week. The Kieldahl digestion mixture was similarly tried with only a little better success. No clear cell pattern groups could be seen. Ashed and unburned fecal material were both boiled and soaked in perchloric acid. The material remained black and cell patterns indistinguishable. Ashed material was both boiled and soaked in hydrogen peroxide, chloral hydrate solution, and hydrogen peroxide with ammonia. Black material still remained among the cell pattern groups. Chromic acid, either alone or in combination with other reagents, caused a deep staining of the material, making cell pattern groups indiscernible. Nitric acid failed to clear black portions in ashed material.

Burning in a low flame, or in a tube through which air, or oxygen was passing, were not found superior to burning with an ordinary flame. Burning with air or oxygen passing over the material might have been a good procedure except that as soon as any particle became thoroughly ashed it was so light that it would blow away before other particles were sufficiently ashed for study.

Treatment of grasses by burning, nevertheless, gave some good cell patterns. Treatment of fecal material with nitric acid to macerate

it followed by burning with direct flame on slides occasionally gave good patterns. Most slides, however, had black portions in them after burning.

Treatment with nitric acid without burning was found to be the best method of treating material to obtain clearly visible cell pattern groups. Some problems involved in the use of this method were: 1. acid fumes etched and damaged microscope lenses; 2. addition of a base to neutralize the acid caused salt crystals to form which interfered with distinguishing the cell patterns; 3. use of too weak acid or too short a time failed to clear the material sufficiently to see the cell patterns; 4. if treatment was a little too long or acid a little too strong, the material became macerated and broken apart too much to see any cell pattern groups.

The Nitric Acid Method

In preparing fecal material for examination a concentrated or 72% nitric acid was used. First the fecal material was mashed and put into a small beaker. Enough acid to cover the material was added and then it was boiled for about thirty to forty-five seconds. Water was added over a sink until the overflow had taken away the foam. After the material had settled a short time it was stirred lightly with a glass tube and then allowed to enter the tube from the bottom of the beaker. The material was withdrawn by keeping one end of the glass tube closed with a finger. The first drop was allowed to go back into the beaker as it usually contained a small portion of sand which the sheep had eaten along with its food. Then, without removing the finger from the glass tube,

two drops of material were put on a glass slide. This slide was dried, than washed by dripping several droppers full of xylene onto it and letting the xylene run off slowly. Canada balsam mounting oil was added while the material was still wet with xylene. A cover slip was added, and the slide then set aside to dry. If temporary slides were desired, glycerin was used in place of the mounting oil.

In preparing reference material for examination, slides were made from the leaves and sheaths of grasses and sedges. Stems were not used as they supplied very few distinguishable cell patterns and very much undifferentiated material.

The reference material was cut into pieces about 1/8 inch long, placed in a small beaker, covered with 20 to 30% nitric acid and boiled two to three minutes or until most of the material appeared clear. Cool water was then added to stop the action. Some of the material was then removed from the beaker and placed on a slide. Four to five droppers full of 95% alcohol were dripped onto the slide to wash off the water and acid. Care was taken to see that the treated material was not washed from the slide. In a similar manner, four to five droppers full of xylene were used to wash off the alcohol. Canada balsam mounting oil was added while the material was still wet with xylene, a cover slip added, and the slide set aside to dry. If cloudiness appeared, it indicated that water was still mixed with the material.

Camera-lucida drawings of cells and cell groups were unsuccessfully attempted. Microprojector drawings were made of many types of cells and cell group patterns, but all drawings were abandoned in favor of the use

of two microscopes. One scope was used to view the fecal material to locate cell pattern groups, the other to view reference slides to aid in identification. Familiarity with the different cell pattern groups of different species seemed very essential in any identification work. Even short interruptions of a few days seemed to make refamiliarization studies necessary. A number of reference slides were found to be needed for each species studied in order to include the variation of cell group patterns that occurred.

Range Forage Sampling

Range forage samples were taken monthly for crude protein analyses. The forage sampling areas were marked with a post from which sampling transects started. The locations of the sampling areas in relation to the feeding camps are shown in Figure 1. Areas 1 through 5 were sampled while the sheep were grazing out of the first feeding camp. Areas 6 through 9 were sampled while the sheep were grazing out of the second feeding camp.

In sampling cheatgrass, five plots approximately 14 inches in diameter and ten paces apart along a paced transect were used. Old stems of cheatgrass were removed first and discarded and then the living plants clipped with a pair of scissors.

Bluebunch wheatgrass was sampled by clipping approximately one fourth of each individual bunch nearest the toe on every tenth step along a paced transect. These transects started at the sampling area marking posts and were 100 paces long. The height of clipping was approximately 2 inches from the ground. Needle-and-thread was sampled in the same

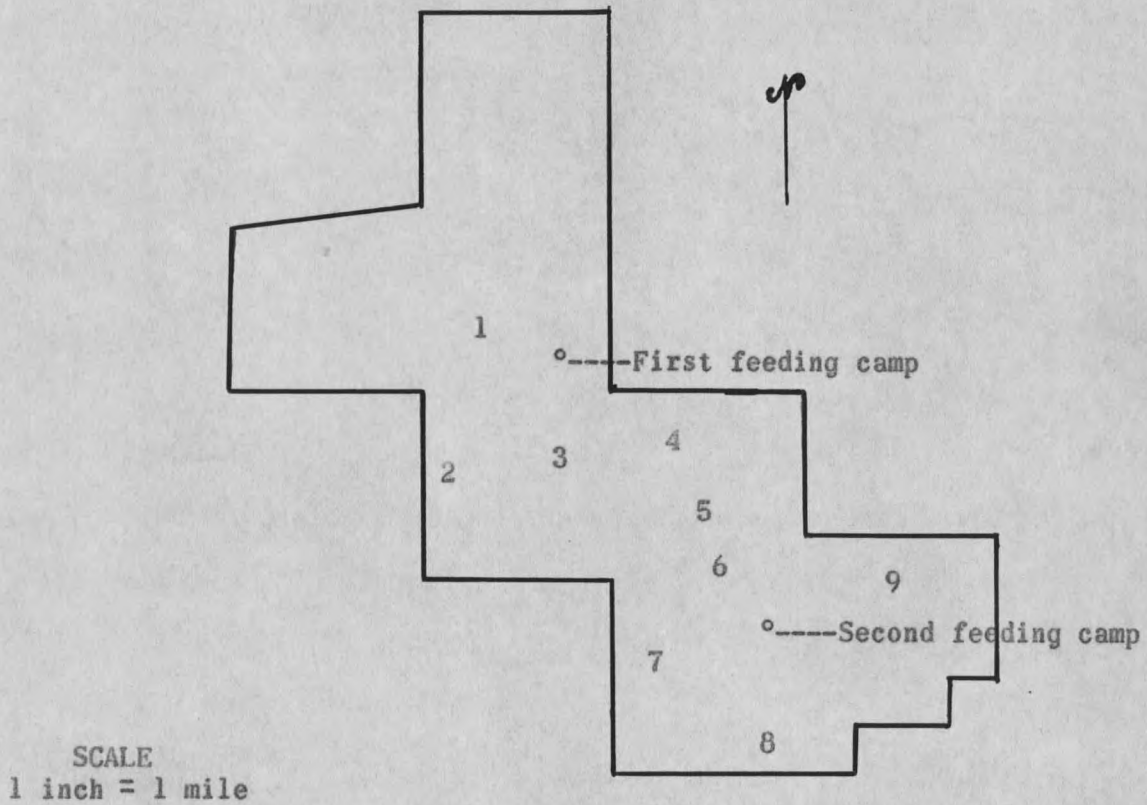


Figure 1. Sketch Of Winter Range Showing Grass Sampling Areas, And Winter Feeding Camps Where Fecal Samples Were Taken From Range Ewes.

manner as bluebunch wheatgrass except that a bunch was selected at the end of every five steps along the transects, and the entire bunch was clipped to a 1/2 inch stubble height. Other species were sampled, one at a time, by taking all individuals encountered along transects at least 100 paces long. Additional length was added to the transects when less than 15 grams of material was secured along the first 100 paces. 15 grams was considered a minimum amount of material necessary to use in preparing a sample for chemical analysis. Grasses (other than bluebunch wheatgrass) and sedges were clipped to within 1/2 inch of the ground while fringed sagewort and phlox were sampled by clipping the green material and the small stems to which the green material was attached.

RESULTS AND DISCUSSION

Fecal Protein

In a study of the calculated fecal protein percentages (Tables I, II, and III), it is noticeable that the fecal protein and digestible protein percentages are not well correlated in several cases. The general trend, however, is a corresponding variation of feed and fecal protein. Obviously, the use of fecal protein to indicate the level of dietary digestible protein cannot work if the apparent digestibility of the protein in the forage from the experimental range, as compared to the digestibility of the other nutrients, is largely different than in the forage from the range which is to be tested. There is reason to believe that the relative digestibility of forage from one range may not differ greatly from that of another. The time of testing would be in the winter when forage is either browse or cured and dried stems of grasses and forbs. Most ranges have a variety of forage available, and stock are selective (13,15,22,56,62) in their grazing. From the variability shown in Tables I, II, and III, however, it seems safe to assume that the relative digestibilities of the protein and the dry matter would not be identical. These processed feeds vary greatly in their digestibility. Even these data, however, show a definite trend toward increase in fecal protein as the feed protein increased. Feeds which were unusually high or low in digestible dry matter, as compared to the protein content, gave fecal protein values which tended to be contrary to the general trend.

In the preliminary experimental work with wethers, the initial fecal protein values between the groups were calculated to be signifi-

cantly different* (Table VII). The reason for this difference is not known. The wethers were all in the same band at Fort Ellis prior to test, and their feed was supposed to have been the same. Even if some of them had had access to some unusual feed, it seems strange that sheep with a high initial fecal protein value should have been concentrated in group 2. The individuals were thought to have been properly randomized within the groups.

The high significance shown in Table VIII indicates that fecal protein percentages were positively correlated with the feed protein.

Figures 2 and 3, which were taken from Table VI, tend to show this relationship more clearly. Fecal protein did not increase in the same proportion as the feed protein. The range of feed protein was from 8.0% to 11.6% while the fecal protein ranged from 8.6% to 10.9%. The group means ranged from 8.0% to 11.4% and 9.0% to 10.1% respectively. By charting means (Figure 3), the feed and fecal proteins were equal at 9.3%. Feed protein values above and below 9.3% coincided with a corresponding but smaller change in the fecal protein values.

Wethers which received no supplement were found to have eaten more hay than the supplemented groups in the last six day period. This difference was significant to the 5% level (Table IX). Differences in total feed consumed were negligible. Differences in fecal protein, therefore, are not considered to have been affected by differences in the dry matter intake.

*Statistical analyses are according to methods presented in the following book: Snedecor, G. W., 1946. Statistical Methods. 4th Edition. The Iowa State College Press. Ames, Iowa.

Table VII.

FECAL PROTEIN PERCENTAGES
OF WETHERS ON PRELIMINARY TEST
(Dry Weight Basis)

Wether No.	Initial	After 12 Days	After 16 Days
<u>Group I</u>			
1	8.7	10.8	9.7
2	8.8	9.6	10.9
3	8.4	9.8	9.6
4	8.2	9.5	10.3
Total	34.1	39.7	40.5
Average	8.5	9.9	10.1
<u>Group II</u>			
5	8.9	9.0	9.8
6	10.4	8.9	8.6
7	9.6	10.7	9.8
8	10.0	9.3	9.1
Total	38.9	37.9	37.3
Average	9.7	9.5	9.3
<u>Group III</u>			
9	8.6	9.3	9.2
10	8.4	8.7	9.1
11		7.9	8.9
12	9.7	8.3	8.6
Total	26.7	34.2	35.8
Average	8.9	8.6	9.0

Analysis of Variance
(Initial Protein Values)

Variation	D. F.	S. S.	M. S.	F. Ratio
Treatment	2	2.99	1.49	4.96*
Error	8	2.44	.30	
Total	10	5.43		

*Significant F. at 5% level = 4.46

Table VIII. FECAL PROTEIN OF WETHERS
ON PRELIMINARY TEST AFTER 12 AND 16 DAYS ON FEED

	Group I		Group II		Group III	
	Dec. 11	Dec. 17	Dec. 11	Dec. 17	Dec. 11	Dec. 17
	10.8	9.7	9.0	9.8	9.3	9.2
	9.6	10.9	8.9	8.6	8.7	9.1
	9.8	9.6	10.7	9.8	7.9	8.9
	9.5	10.3	9.3	9.1	8.3	8.6
Sub total	39.7	40.5	37.9	37.3	34.2	35.8
Total	80.2		75.2		70.0	

Analysis of Variance

Variance Due	D. F.	S. S.	M. S.	F. Ratio
Treatment	2	6.50	3.25	9.85**
Error	21	7.0	.33	
Total	23	13.50		

Significant F at 1% level = 5.78

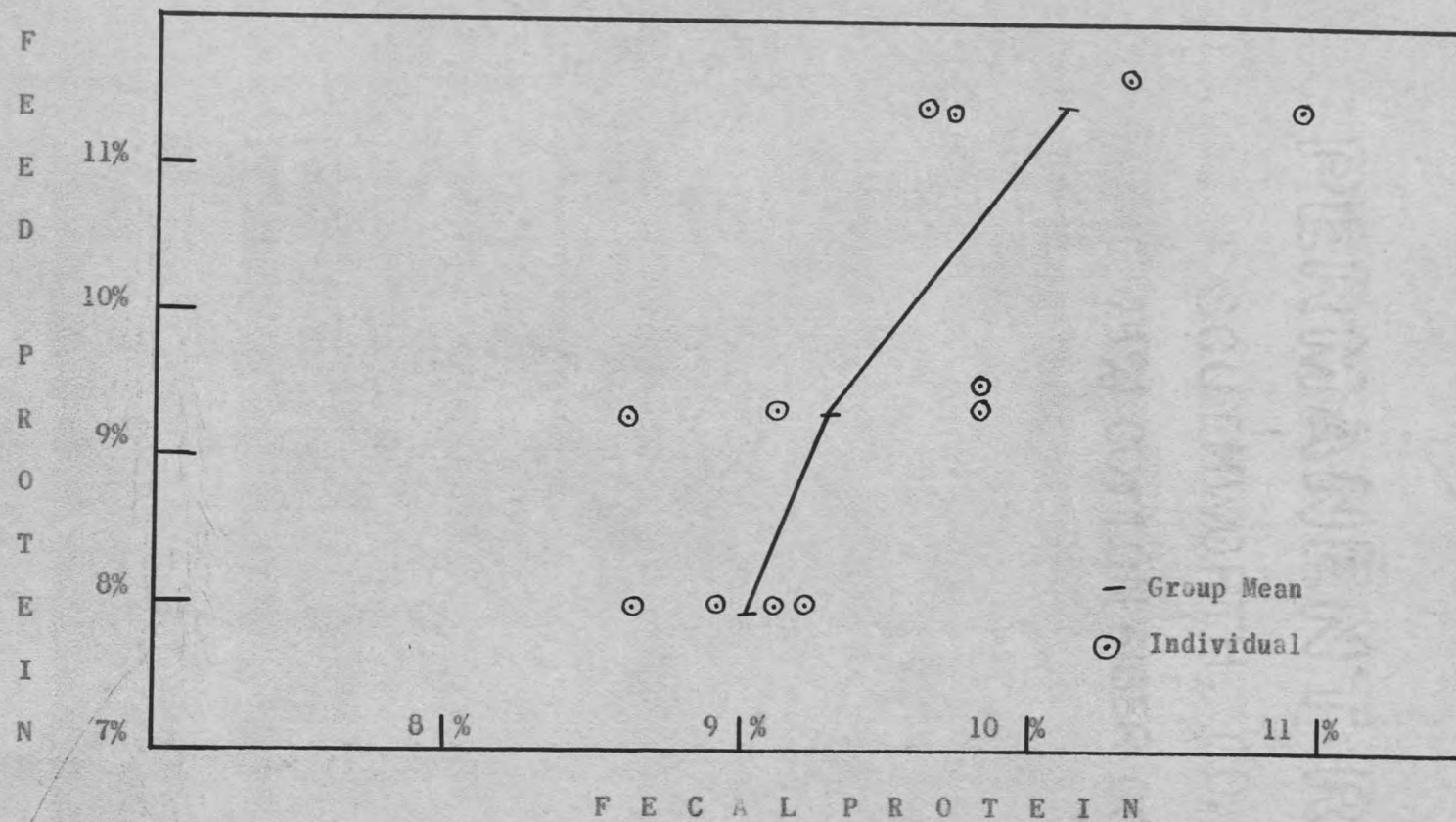


Figure 2. Individual And Group Mean Values Of Feed Protein Vs. Fecal Protein Of Wethers On Preliminary Test

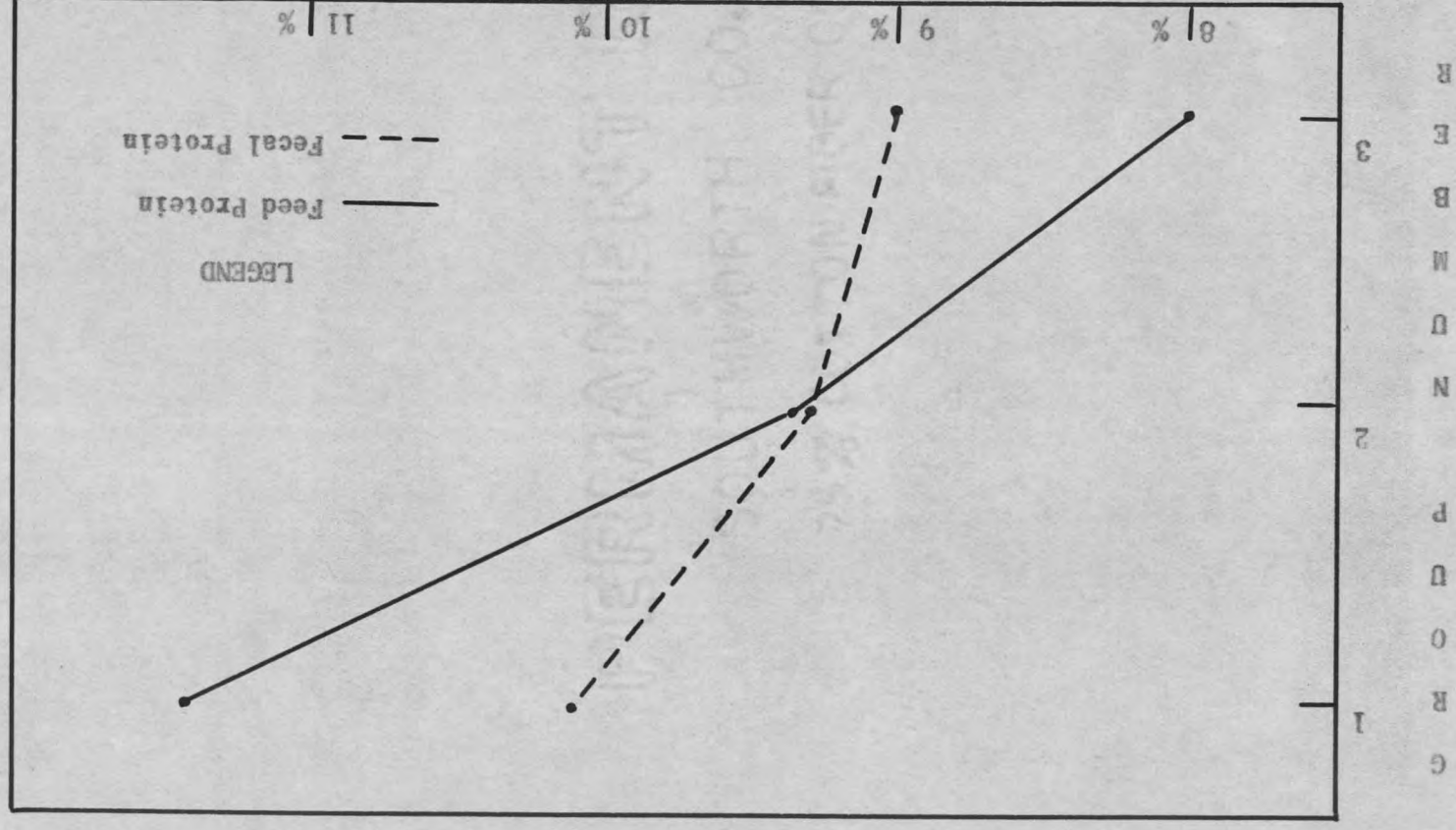


Figure 3.
Group Means Of Feed and Fecal Protein
Of Wethers On Preliminary Test.

Table IX.

GRAMS HAY CONSUMED
BY WETHERS ON PRELIMINARY TEST

Wether No.	First 5 Days	Second 5 Days	Last 6 Days	Total
<u>Group No. 1</u>				
1	5910	5475	7275	18660
2	5700	6330	7245	19275
3	7150	6900	7535	21585
4	5735	5440	6755	17930
Total	24495	24145	28810	77450
Average	6124	6036	7202	19362
<u>Group No. 2</u>				
5	7120	6065	6440	19625
6	5885	6635	7770	20290
7	6135	6340	7320	19795
8	6805	6695	7485	20985
Total	25945	25735	29015	80695
Average	6486	6434	7254	20174
<u>Group No. 3</u>				
9	6185	6840	8215	21240
10	7255	7540	8875	23670
11	6415	6320	7600	20335
12	5905	6920	8040	20865
Total	25760	27620	32730	86110
Average	6440	6905	8182	21528

Analysis of Variance For Last Six Day Period

Source of Variation	D. F.	S. S.	M. S.	F. Ratio
Treatment or Group	2	2434137	121706	5.11*
Error	9	2144669	238297	
Total	11	4578806		

*Significant F. at the 5% level = 4.26

Before discussing the fecal proteins from the range ewes, it may be desirable to examine the forage analyses (Table X). These data show no great differences in the crude protein percentages throughout the winter. In general, slight decreases from December to January and slight increases from February to March were noted.

From analyses of the data secured from the grade ewes (Tables XI and XII) it seems evident that the fecal protein percentage is a very good indicator of differences in the dietary protein of groups of sheep when they are under the same environmental and forage conditions. The high significance by dates of sampling of ewes under range conditions (Table XII) indicates that factors other than the protein supplement affected the fecal protein more than did the supplement itself. The factors which might effect a change in fecal protein levels are: 1. snow cover; 2. temperature; 3. wind; 4. freshness of the range; 5. fetal growth; and 6. other factors.

If the weather reports (59) are studied as they correspond to the dates of sampling it is seen that the first sampling date on January 15 was clear and relatively warm with no snow. There had been no precipitation since the .03 inches which came on January 2. The fecal nitrogen was high at this time. By January 29, cold had set in. Snow had been on the ground since the 23rd with as especially heavy cover after the 27th. The fecal nitrogen was low. High fecal nitrogen on February 12th corresponded to clear and warmer weather before this date. Snow fell during the night before this sample was taken, however. February 26th was also preceded by fair weather and not enough

Table X.

CRUDE PROTEIN VALUE IN GRASS SAMPLES TAKEN ON THE SHEEP RANGE, 1950-51

Species Sampled	Sample Area and Date																	
	1		2		3		4		5		6		7		8		9	
	Dec 29	Jan 29	Dec 29	Jan 29	Dec 29	Jan 29	Dec 29	Jan 29	Dec 29	Jan 29	Feb 26	Mar 26	Feb 26	Mar 26	Feb 26	Mar 26	Feb 26	Mar 26
Phlox					4.5													
Cheatgrass	11.9	12.1					10.3	7.2										
Western																		
wheatgrass			2.7	3.2					2.1	3.2			3.5	3.2				
Bluebunch																		
wheatgrass			3.1	2.8	3.7	2.5			2.7	2.9	2.9	2.9	2.6	2.8	2.9	3.2	2.6	3.4
Needle-and-																		
thread grass			3.1	2.9	2.8	2.3			2.7	2.9	2.6	2.9	2.4	2.5	2.3	2.7	2.0	3.3
Blue grama ¹			3.8								3.6	2.4					3.1	3.2
Junegrass			4.3	2.1	3.7	3.3					2.4	2.6	3.2	3.5	2.9	3.0		
Sheep fescue ²			2.2	1.9														
Bluejoint																		
reedgrass ³			2.6	1.9	1.8	2.3			2.0	2.6			2.0	2.9			3.3	2.4
Threadleaf																		
sedge ⁴					4.3	3.9									5.4	4.5	3.5	3.4
Fringed																		
sagewort					6.7						6.9	7.7						
Sandberg																		
bluegrass											2.4	1.0						
Slender																		
wheatgrass ⁵											2.6	3.2						

1. *Bouteloa gracilis*2. *Festuca ovina*3. *Calamagrostis montanensis*4. *Carex filifolia*5. *Agropyron
trachycaulum*

Table XI. FECAL PROTEIN LEVELS OF COMPOSITE SAMPLES TAKEN FROM GRADE EWES ON PROTEIN NUTRITION TEST, 1950-51

Protein Supplement Fed Per Day	Group	Jan. 15	Jan. 29	Feb. 12	Feb. 26	Mar. 12	Mar. 26	Total	Mean
None	0	9.8	8.1	10.0	8.2	9.5	8.8	54.4	9.1
1/3 lb. 10.8%	1	9.6	8.5	10.2	8.7	10.7	9.3	57.0	9.5
1/3 lb. 19.8%	2	10.1	8.6	10.1	8.7	11.1	9.5	58.1	9.7
1/3 lb. 28.7%	3	10.6	8.7	10.3	9.1	11.0	9.2	58.9	9.8
1/3 lb. 37.7%	4	10.8	8.4	10.7	9.0	11.3	9.5	59.7	10.0
1/3 lb. 20% 1/3 lb. dehyd. alfalfa-full feed alf. hay.	5	13.1	12.6	12.6	15.1	13.0	11.6	78.1	13.0
Total		64.0	54.9	63.9	58.9	66.6	57.9	366.2	61.1
Mean		10.7	9.2	10.6	9.8	11.1	9.6	61.0	10.2

Analysis of Variance

Variance Due To	D. F.	S. S.	M. S.	F. Ratio
Dates	5	16.6	3.30	6.346**
Treatment	5	61.0	12.20	23.462**
Error	25	13.1	.52	
Total	35	90.7		

**Significant F at 1% level = 3.86

L. S. D. = .684

Table XII.

FECAL PROTEIN LEVELS
OF COMPOSITE SAMPLES TAKEN FROM RANGE EWES ON PROTEIN NUTRITION TEST, 1950-51
(Same as Table XI except that group 5 is deleted)

Group	Jan. 15	Jan. 29	Feb. 12	Feb. 26	Mar. 12	Mar. 26	Total	Mean
0	9.8	8.1	10.0	8.2	9.5	8.8	54.4	9.1
1	9.6	8.5	10.2	8.7	10.7	9.3	57.0	9.5
2	10.1	8.6	10.1	8.7	11.1	9.5	58.1	9.7
3	10.6	8.7	10.3	9.1	11.0	9.2	58.9	9.8
4	10.8	8.4	10.7	9.0	11.3	9.5	59.7	10.0
Total	50.9	42.3	51.4	43.7	53.6	46.3	288.1	48.1
Mean	10.2	8.5	10.3	8.7	10.7	9.3	57.6	9.6

Analysis of Variance

Variance Due To:	D. F.	S. S.	M. S.	F. Ratio	Significant F. Ratios	
					5% level	1% level
Dates	5	20.9	4.2	52.50**	2.71	4.10
Treatment	4	2.8	.7	8.75**	2.87	4.43
Error	20	1.6	.08			
Total	29	25.3				

L. S. D. by Dates = .34

L. S. D. by Treatment = .38

snow to prohibit grazing but a highly significant drop in the fecal protein was noted. By March 12 the fecal protein was up, but this was apparently due to hay which was being fed. Weather reports show a 4 inch snow cover at that time and for several days preceeding that date. Snow had gone by March 26. The weather was warm and a little green material was noted, yet fecal protein, though higher than on January 29 or February 26, was still considerably lower than on January 15 or February 12. Snow cover or temperature as noted in this study, therefore, do not seem to have been major factors in affecting fecal protein levels.

Data on wind are not sufficient to determine its effect on fecal protein.

No general trend is noted in the values over the winter. Since fetal growth would, in all probability, have either a steadily increasing or decreasing effect, it can be listed as of doubtful effect on the fecal protein levels.

Freshness of range is the other factor listed which might affect fecal protein values. The first sampling on January 15 was on fresh range. Green cheatgrass was available at this time and fecal protein was high. By January 29, the range was no longer fresh. Snow and cold had set in, and fecal protein was low. On February 12 the sheep were on fresh range and fecal protein was high. By February 26 the entire range had been lightly grazed. Fecal protein was low again. Hay was fed before March 12 and the fecal protein was rather high. The sheep were on this range through the March 26 sampling. In this last sampling, fecal protein was significantly higher than at the February 26 sampling.

The few green shoots noted in some of the grasses may have been enough to cause this rise in fecal protein, since the sheep would select any green grass available to them at that time of year.

The relationship between fecal protein and range freshness appears to be quite close. Further work will be needed to test the accuracy of this apparent relationship.

Evidence is not sufficient to discard any factors, either singly or in combination. Snow cover may well be a factor in lowering the fecal protein because it covers up the lower portions of larger plants and nearly all of the smaller ones. The feed that would then be most available would be the old seed stalks of grass, which observation shows not to be ordinarily taken by sheep when softer forage is available. On a shrub range, snow cover might have a different effect.

There are probably other climatic factors, and possibly physiological factors, which alter the fecal protein, either directly, or indirectly by effecting a change in the diet.

Some of the problems involved in using fecal protein as an indicator of dietary digestible protein should be studied before the method can be recommended for use. Feeds with relatively indigestible protein will give a high fecal protein value. Feeds relatively high in digestible protein will give a low fecal protein. Manufactured or processed feeds are variable in digestibility.

When manufactured or processed feeds are fed, a standard feed digestion test is probably far superior to the fecal protein method.

Another problem is that fecal protein will not give the level

of the other feed nutrients, nor will it indicate whether or not the animal has sufficient energy in its diet.

Probably the most important problem is to find out if the percentage yield of fecal protein, due to the relative digestibility of protein and other nutrients, is sufficiently similar on different range areas within a given range type, and at different times of the winter, to allow the method to be used with confidence. To test the method further, ranges of other vegetative types should be studied. If the percentage yield of fecal protein is found to be relatively similar, one single fecal standard might be set as optimum. If other vegetative types were found to supply forage not similar in relative fecal protein yields, protein fecal standards might be set up for each separate major range type.

Suggestions for some of the first tests that should now be undertaken in further study of the method are to take composite samples from some of the groups of range ewes on the protein nutrition experiment. The purpose of this type of sampling would be to determine the approximate number of sheep which should be sampled from a band to get a statistically adequate sample. Four composite samples from each of three groups of ewes should be sufficient to get this data. Sampling of five ewes for each composite sample is suggested until the number necessary to sample has been determined. This testing probably need not be done on more than 3 groups, one of which should be group 0 (control).

An additional group fed according to the fecal protein level is recommended in order to study the advisability of the use of the method.

From observing the data (Table XII), an arbitrary minimum of 8.7% is proposed for fecal protein in this study. Tests made weekly would indicate how much concentrate to feed the sheep the following week. Results would be measured in lamb and wool production the same as the other lots of ewes on the protein nutrition test. This proposed weekly sample would be a composite sample from twenty ewes.

Some tests of samples collected from sheep on other ranches might reveal valuable information. A duplicate sample from each band sampled is recommended. It is suggested that twenty sheep be used in making each composite sample. Samples may be collected as previously described, or it may be possible to follow a band of sheep and collect the material immediately after it has been voided. Care must be used to prevent contamination with dirt or other fecal material if this "follow and collect" method is used.

Grass Sampling

The protein in grass samples (Table X) did not show any corresponding variation with the fecal protein levels observed. This might indicate that the range forage sampling system used in this experiment is an inadequate indicator of the protein obtained from the forage by livestock.

Purebred Ewe Sampling

The purebred ewes which were on dehydrated alfalfa nutrition test at the Chadbourne Ranch were tested in an effort to determine what differences would be caused by the different supplements fed. The rations and fecal protein percentages for these ewes are shown in Table

XIII. Group 1 had not been receiving supplement earlier in the winter, but had been put on the same ration as group 2 about ten days before the first fecal samples were taken.

The comparatively low protein percentage shown for group 2 on March 26 is inconsistent with the other values. If this is the actual fecal protein percentage value, it indicates a serious lack or reliability in the test. In view of the consistent relationship found in the other experiments, some external factor or factors can be suspected of causing this discrepancy. An error in the chemical analysis might have occurred. A more plausible explanation may be that the composite samples, being much larger than the individual samples, dried rather slowly, allowing organisms to grow in the material and decrease the nitrogen content of the samples. In any case, future samples should be spread out so that they will dry before microbial action can alter the crude protein values.

Further analysis of these tests was not attempted due to the limited data.

Cell Pattern Studies

Results of studies on cell patterns as a method of identifying forage species consumed by grazing animals consisted principally of the development of methods previously described under "Experimental Procedure".

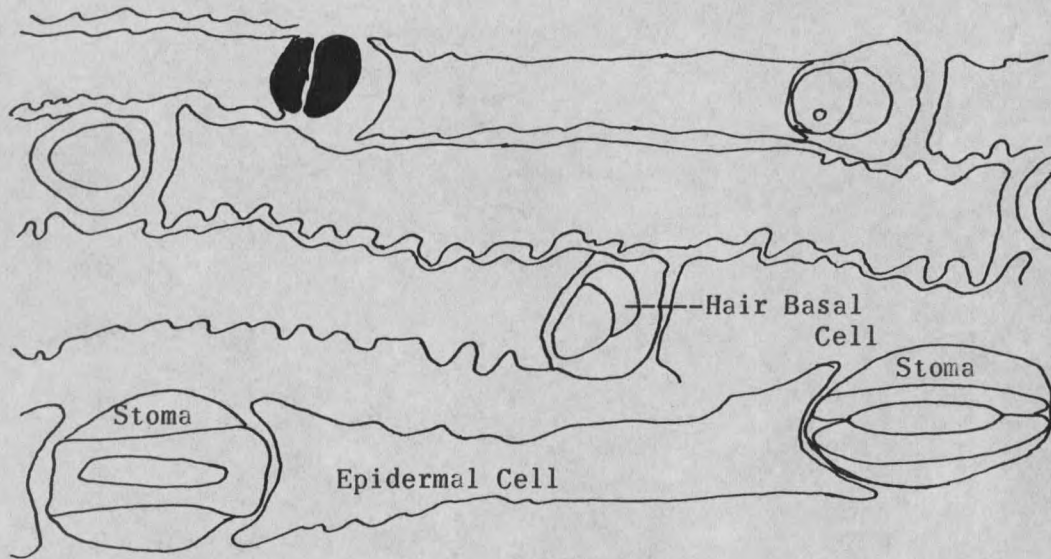
Drawings of some of the cell group patterns are shown in Figures 4, 5, 6, 7, and 8. Only a few of the cell group patterns for each species are shown. Numerous drawings would be required to show the cell

Table XIII. FECAL PROTEIN VALUES OF COMPOSITE SAMPLES TAKEN
FROM PUREBRED EWES ON DEHYDRATED ALFALFA NUTRITION TEST AT
CHADBOURNE RANCH

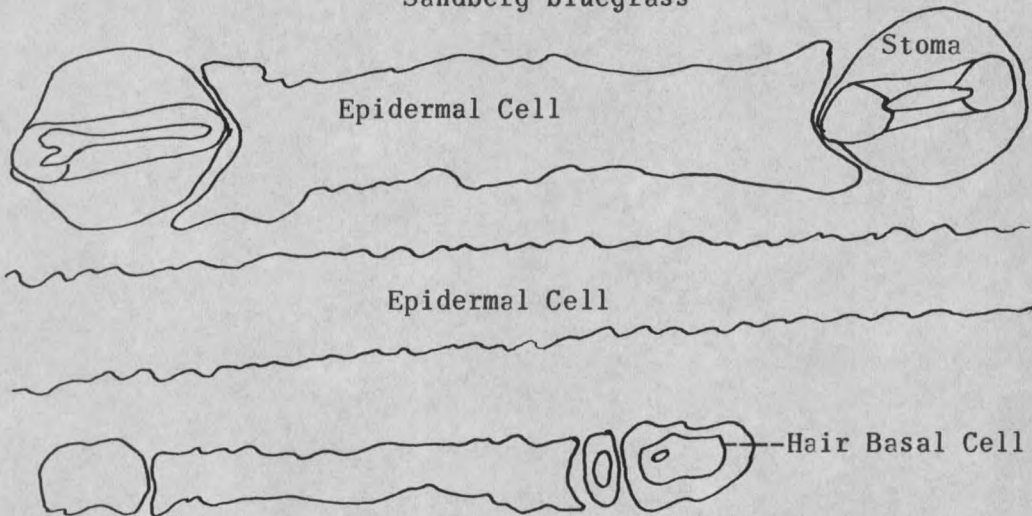
Group	Hay*	Supplement Fed	Fecal Protein	
			Mar. 12	Mar. 26
1	Free choice	1/3# 20% pellets	11.8	11.8
2	Free choice	1/3# 20% pellets	11.4	8.6
3	Free choice	1/3# 1/2 20% pellets and 1/2 Dehyd. alf.**	11.8	11.6
4	Free choice	1/3# Dehyd. Alf.	12.0	11.1

*The hay was mixed grass-alfalfa.

**Dehydrated alfalfa contained approximately 17-19% crude protein.



240X
Sandberg bluegrass



240X
Green needlegrass

Figure 4. Cell Pattern drawings from grasses.

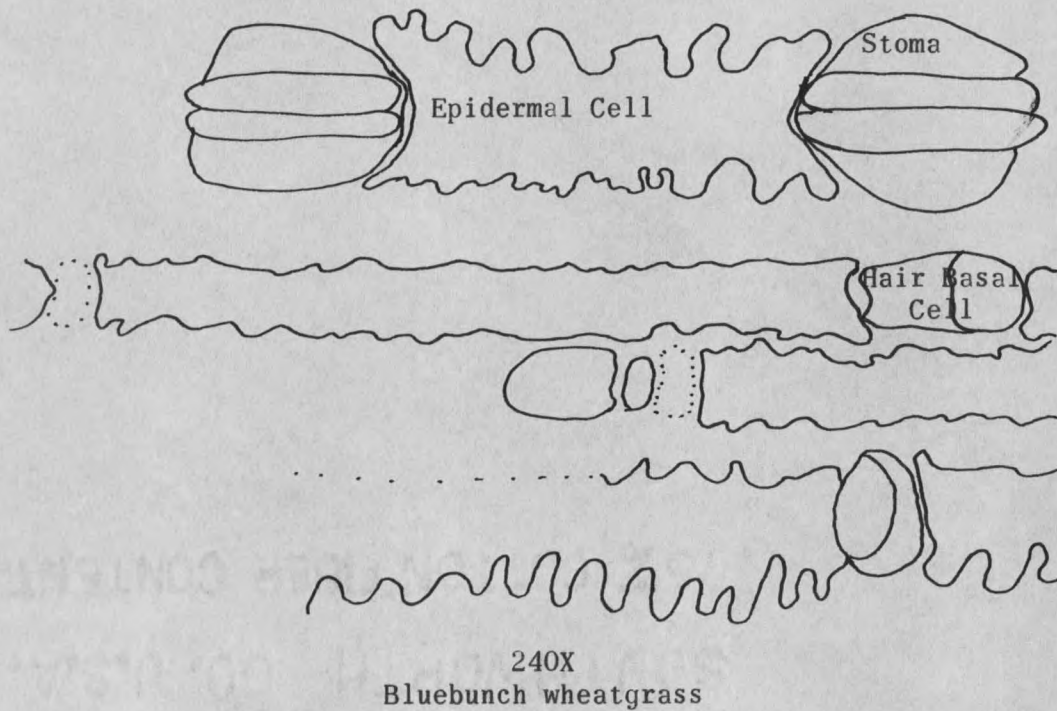
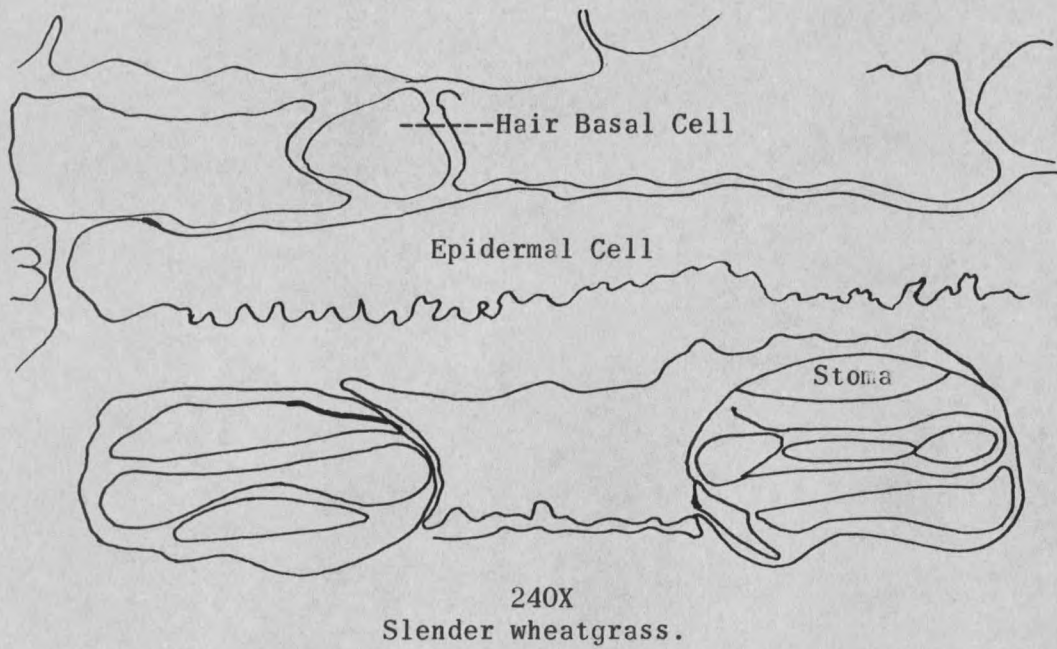


Figure 5. Cell pattern drawings from grasses.

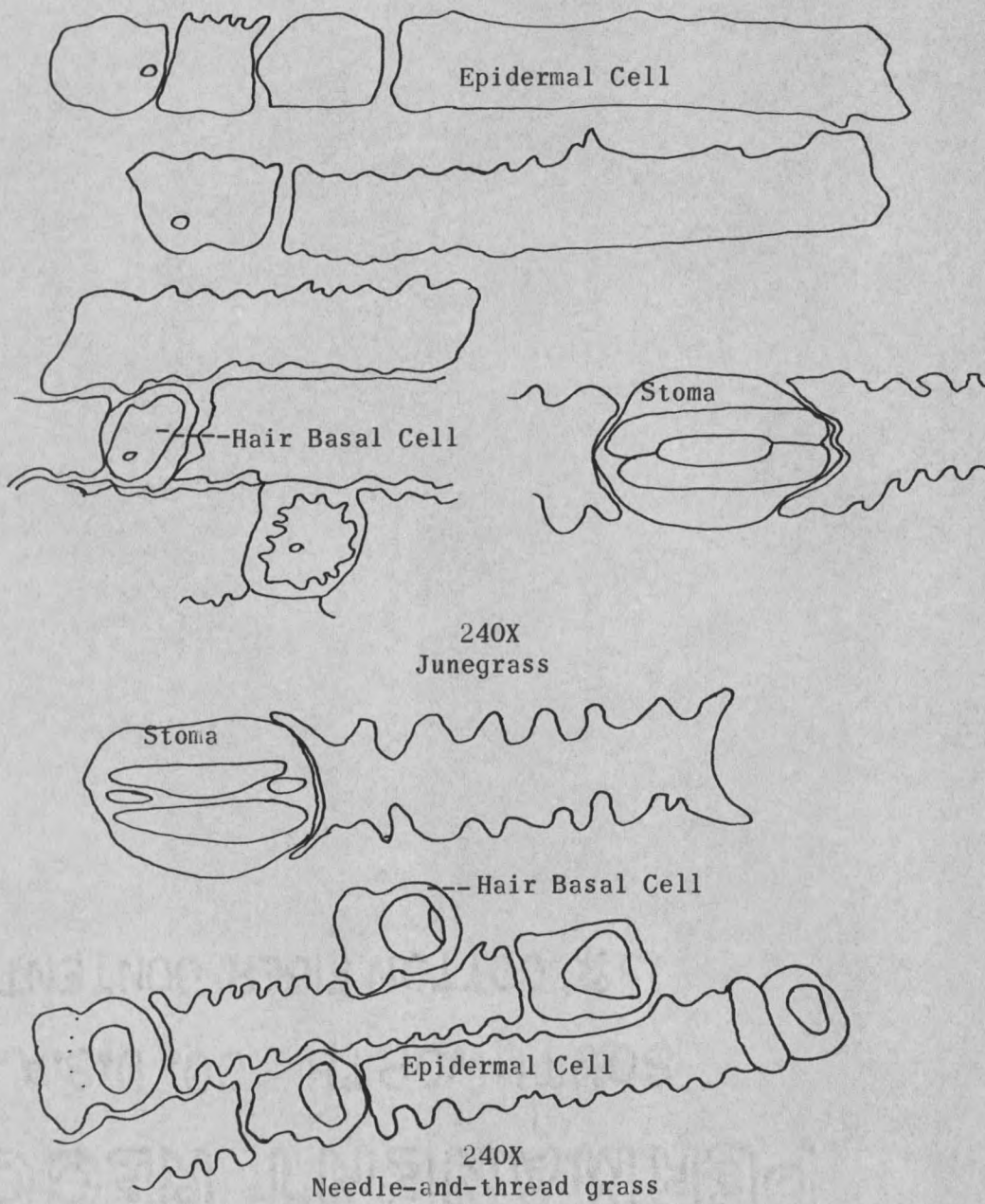


Figure 6. Cell pattern drawings from grasses.

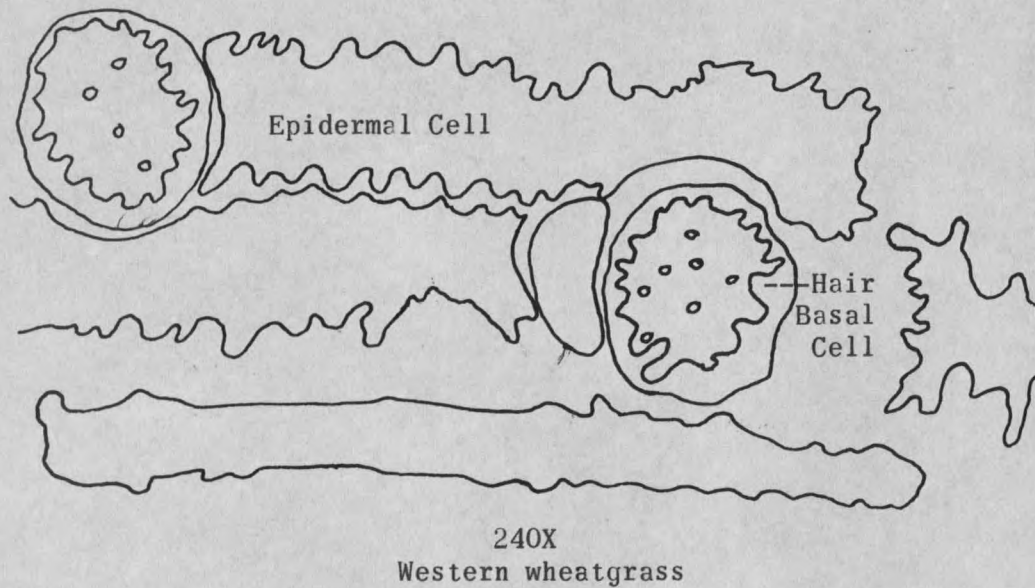
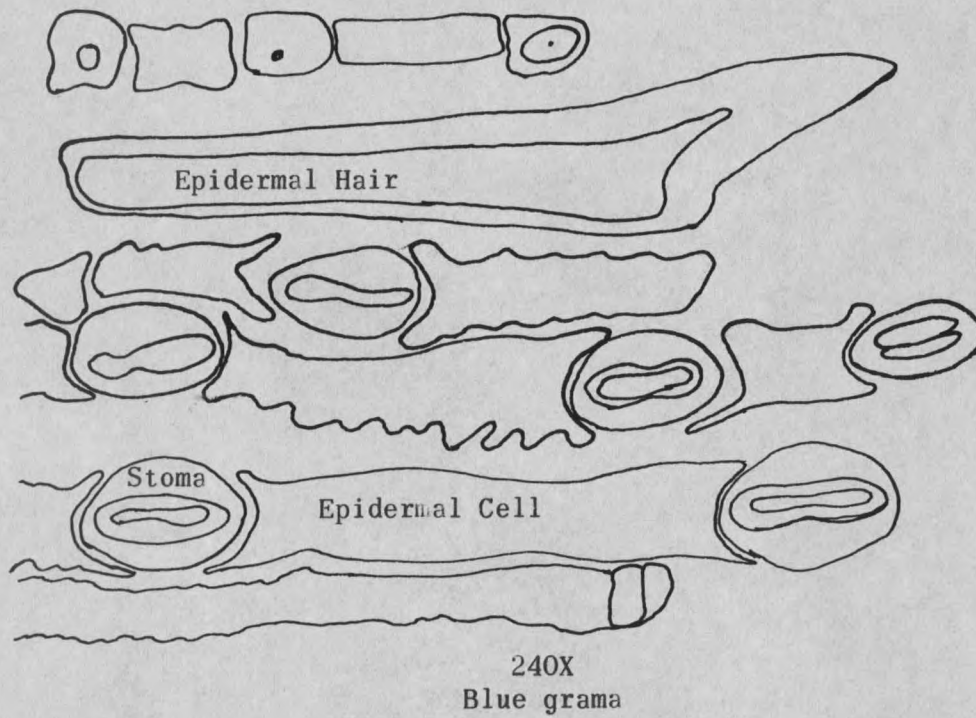


Figure 7. Cell pattern drawings from grasses.

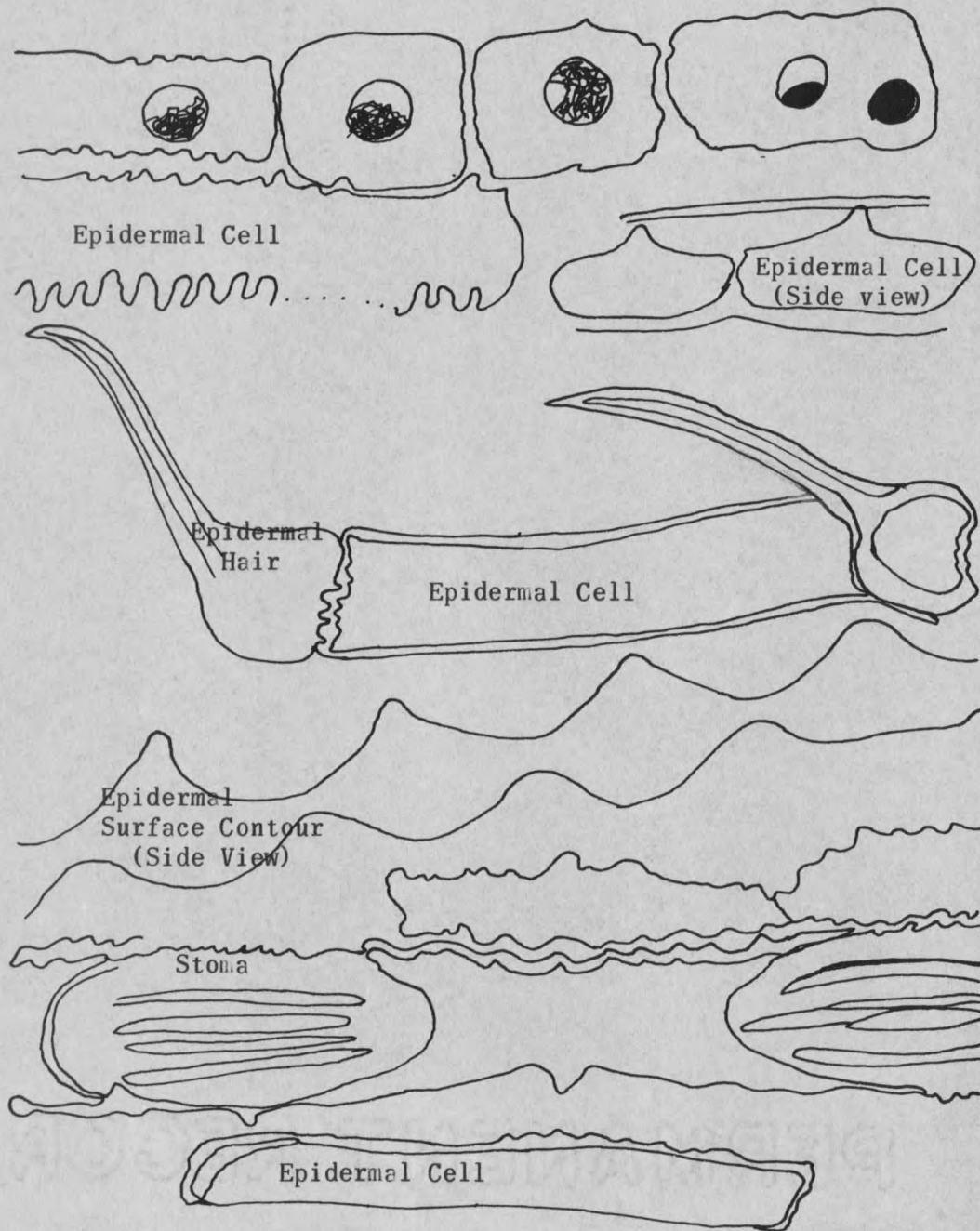


Figure 8. Cell pattern drawings from threadleaf sedge.

group pattern variation within any one species.

Of the plants studied, distinctive cell patterns were noted for four species. Western wheatgrass had numerous basal hair cells resembling a cogwheel with large irregular teeth. Some patterns very similar to these were noted in other species, but were not so abundant. Blue grama grass patterns were characteristically small celled with numerous stomata in some parts. Junegrass had more smooth margined cells than other species studied. Threadleaf sedge had some areas in which the cells appeared similar to the surface of a green pine cone. Each species however, had large areas of cells which were indistinguishable from those produced by other species. Needle-and-thread grass gave many patterns in which the cell edges were more uniform than any other species studied, yet no certain identification of this species was made in any of the fecal material.

Other species studied in which no particular identifying character could be noted in any of the reference slides included blue-bunch wheatgrass, slender wheatgrass, green needlegrass, and Sandberg bluegrass. A few patterns of these species were tentatively identified in fecal material by close comparison with reference slides, but no positive identification was made.

Microscopic study of fecal material from the range ewes gave species list counts which could not be accurately repeated on subsequent examinations of the same fecal material. This was due primarily to the very small percent of cell pattern groups which could be identified.

Difficulty was experienced in determining species from cell pat-

terns even when reference slides were kept under microscopic view. Without reference slides, accurate identification of species by cell patterns was not achieved. A few species have some distinctive characteristics, but all species studied have cells so variable that single cells could not be used in identification work. Even large groups of cells did not always have a character or group of characters that could definitely serve to identify them.

In future work with cell patterns as a means of identification of plants it should be kept in mind that, on the basis of this work, where a separate leaf or more of a grass or sedge is available, it can probably be identified. Where appreciable portions of the diet of sheep are made up of a particular grass or sedge, it could probably be detected in the fecal material. Due to the cell variation within species however, it appears that no good estimate could be made of the relative amount contributed to the diet by this species. Furthermore, many non-grass-like plants did not yield cell patterns which could be used to identify these plants in the fecal material.

The method may prove valuable in the science of botany in cases when only small portions of a plant are available and identification is desired.

CONCLUSIONS

Significance in the analysis of variance shows that, under similar conditions, a change in dietary protein percentage will cause a corresponding but smaller change in the fecal protein percentage. The possibilities, therefore, seem to be good that fecal protein standards can be developed to aid in determining the amount of protein supplement to feed range ewes under winter conditions.

Under the conditions of the experiment, some factor, or factors, other than the level of protein supplementation was the most important in changing the level of fecal protein. This is shown by the highly significant difference in fecal protein values on different dates of sampling.

Cell pattern studies lead to the deduction that cell patterns could be used as an aid in species identification where only portions of grasses or sedges are procurable and identification is desired. It appears, however, that identification of species in fecal material can be expected only when similar cell patterns of that species can be seen in both the species and fecal material, and when that species makes up a major portion of the diet.

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