The cool-season pastures will use late summer and fall moisture to produce forage for fall grazing. The winter and early spring moisture will be used in the production of early growth for spring grazing. At the same time, the fall, winter and early spring precipitation may be stored in the soil under the warm-season pastures to insure maximum production of forage for summer grazing.

In the Flint Hill Region, where most of the desirable forage species are warm-season grasses, the greatest production of beef cattle was obtained when grazing was deferred until mid-June each year (Anderson, 1940). Such deferment is not practical unless the stockman has some cool-season pasture for the stock during the spring. If the two kinds of grasses are grown in mixture in the same pasture and the grazing animals have free choice of plants to eat, it is impossible to obtain full use of each grass in its proper season. Where the two kinds of grasses are grown in separate pastures, each can be grazed in its proper season and a relatively uniform carrying capacity can be maintained throughout a long grazing season each year.

Summary

Amounts of water in the soil to a depth of five feet under cool-season and warm-season grass pastures were determined several times each year, 1956 to 1961, inclusive. The results are reported in terms of inches of "available water." Soil moisture in excess of 85% of the amount held by the soil at 15 bars tension was considered to be available to the grasses used in this study.

Six warm-season pastures in the study included one each of big bluestem, side-oats grama, and switchgrass in pure stands and one pasture of each of these grasses in mixture with sand lovegrass. Six cool-season pastures included two each of smooth bromegrass, intermediate wheatgrass, and tall wheatgrass.

There was less water in the soil under the cool-season than under the warm-season grasses in midspring each year. The amounts under the warm-season grasses ranged from 25% to 240% more than under the cool-season grasses. Consequently, the cool-season pastures suffered from midsummer drought more often than did the warm-season pastures.

LITERATURE CITED


Dietary Chemical Composition of Cattle and Sheep Grazing in Common on a Dry Annual Range

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Highlight

Significant differences among animals were found in chemical composition of dietary samples collected with esophageal fistulated cattle and sheep grazing in common on a dry annual range. Diets from sheep and in early summer were higher quality than from cattle or in late summer. Six or fewer animals would suffice to sample most dietary constituents within 10% of the mean with 95% confidence.

On California foothill annual ranges herbage generally is adequate in quality, if not quantity, during late fall and winter; but the annual vegetation matures rapidly in late spring or early summer and is greatly reduced in quality. The summer and early fall are the periods of low nutritional forage value. Supplementation of livestock on such ranges is a common practice but knowledge of dietary composition is inadequate.

California studies concerning the diet of grazing animals began over 60 years ago (Mackie, 1903). Chemical composition of herbage from different habitat and plant conditions has been investigated (Guilbert et al., 1931; Hart et al., 1932; Gordon and Sampson, 1939; Sampson et al., 1951; and Heady et al., 1963), and harvested range plants have been fed in production or digestion trials (Guilbert, 1929; Guilbert and Mead, 1931; Guilbert and Goss, 1944; Bissell and Weir, 1957; and Wagnon, 1960). Still other workers made inferences about the composition of the diet from observations of the grazing animal and of the forage crop remaining after grazing (Talbot and Biswell, 1942; Wagnon et al., 1959).

Recently, better estimates of the nutrients actually grazed have been obtained by sampling with esophageal fistulated sheep in two California range investigations (Weir and Torell, 1958; Torell and Weir, 1959). Valuable

1Support from the U.S.D.A., Western Regional Project W-34 and from National Institute of Health Grant (FR-00009) is gratefully acknowledged. Appreciation is extended to G. P. Lofgreen, J. H. Meyer, and W. C. Weir for their helpful suggestions.

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information was obtained in these studies, but animals were confined to small plots during grazing so normal flock behavior was lacking, animals were fasted overnight prior to sampling, which in many instances was of only 10 to 15 minutes duration, and sample size was small as only two or three animals were grazed on a single day. Time of day, day to day, and among animal variability in chemical and botanical composition of livestock diets on California rangeland have not been evaluated. Esophageal fistulated cattle have not been used on California annual foothill ranges except for preliminary investigation as a part of this study (Van Dyne, 1962).

The experiment reported herein was designed: (1) to determine dietary chemical composition of cattle and sheep grazing together on a dry annual range; (2) to evaluate changes in dietary composition with changes in herbage availability; and (3) to assess variability and differences in the chemical composition of diets from early morning and late afternoon grazing, among consecutive days in a sampling period, and among animals throughout the summer.

The Experiment
This study was conducted on the Hopland Field Station, Mendocino County, in northern California during the summer of 1961 in a 100-acre pasture of open oak-grassland. The herbaceous vegetation was mature before the first samples were collected. Seedheads were not shattered from many species during the first one-third of the summer, but they were shattered from almost all species by late summer. Botanical composition of the experimental range is discussed in detail by Van Dyne and Heady (1965).

Grade Hereford steers and crossbred wethers (whiteface x Suffolk) about 1.5 years old which were raised on foothill annual ranges were used. Fistulas installed by the procedure of Van Dyne and Torell (1964) were healed prior to placing the animals on the range for a two-week presampling period. The experimental animals made small weight losses or gains similar to unfistulated animal responses on dry annual-type range. Five steers and seven sheep were used throughout the summer and two other sheep for part of the experiment. Eighteen ruminal fistulated steers and wethers grazed with the esophageal fistulated animals summerlong, and between the three sampling periods, additional sheep were placed in the pasture to equalize the grazing pressure by cattle and to reduce available herbage. No supplementary feed, except salt, was given.

Forage samples were collected from the animals during early morning and early evening for five consecutive days in three sampling periods—early in July, August, and September, designated as periods I, II, and III. The animals were corralled at daybreak to remove fistula plugs and to attach forage collection bags. After grazing for 0.5 to 2 hours, the animals were gathered, collection bags were removed, and plugs were replaced. Animals were allowed to graze during the remainder of the day. The sampling process was repeated in the evening. When the animals were turned out for sampling, they were driven to the location in which they were found before corralling.

Herbage was sampled by randomly locating five plots in each of 20 cluster areas per period. Each 1 ft² plot was clipped to ground level and herbage was composited by shade or open location. Samples of 10 important plants were clipped to ground level in each cluster and composited for the entire pasture at the beginning of each period. These samples for period II were separated into (1) heads and (2) stems + leaves for determination of relative weight and chemical composition.

Herbage and forage samples were dried at ≤85°C and analyzed in duplicate by AOAC (1960) procedures for crude protein, ether extract, ash, and silica. Cellulose was determined by the procedure of Crampton and Maynard (1938), lignin by the method of Ellis et al. (1946), other carbohydrates were calculated by difference, and gross energy determinations were made by combustion. The results are expressed on three bases, i.e., dry matter, silica-free content, and total organic matter, to evaluate soil and salivary contaminations.

Factors in analysis of variance for dietary chemical composition, i.e., three periods of grazing, five days in a period, two times of day, and two classes of stock, were considered fixed and crossed. Sixty mean values used in these analyses were for four to five for cattle and six to eight for sheep. All 2- and 3-way interactions were evaluated, and the 4-way interaction was used as the error term.

Individual animal differences were analyzed in a design comparing among animal and within animal variances for data from 4 cattle and 5 sheep from which 80% or more of the attempted collections were successful. Means were compared by Tukey's test (1953). Further detail of methods, design, and results are given by Van Dyne (1965).

Herbage Analyses
More silica was found in the July herbage samples than those collected later in the summer. Individual workers gathered different amounts of soil in harvesting current herbage growth; therefore, most data are presented on a silica-free basis.

There were no large differences in chemical composition of plants from the shade or the open. Shade plants were, however, slightly higher in ash and lignin (Figure 1). The total available herbage decreased in crude protein, silica, and silica-free ash and increased slightly in cellulose, other carbohydrates, and energy from July to September, while ether extract and lignin were relatively uniform. Crude protein varied from 3.4 to 5.2%, lignin from 11.2 to 15.0%, cellulose from 36.1 to 40.0%, and other carbohydrates from 34.8 to 39.0%, which are similar to data reported for other areas of California annual range (Hart et al., 1932; Gordon and Sampson, 1939).

Sizeable differences in chemical composition of some species were found within and between
periods (Figure 2). Crude protein content of most species varied from about 2 to 9%. Spanish moss (Ranatina reticulata) contained 0.4% crude protein. This lichen was grazed during late summer. Some forbs, such as Navarretia, were also relatively high in crude protein all summer. More species were below the average crude protein value than were above it (compare Figures 1 and 2). A few species may raise the average, or differences may be due to clipping techniques. There was a greater tendency to leave stubble in plot clipping and probably more shattered leaves were held between the stems than when individual species were harvested.

Navarretia contained from 10 to 12% ether extract, while most other species and the composite samples (Figure 1) had less than 2% (Figure 2). Lignin content varied between 8 and 13%, except in Spanish moss which was very low. The grasses and a few forbs had 8 to 9% lignin, but most forbs were 10% or more lignin. Other carbohydrates were 63% and 82% in acorns and in Spanish moss in contrast to the 35 to 45% for most grasses and forbs (Figure 2). Ash content for most species ranged from 2 to 7%. Reasons for high or low contents in August in comparison with July and September, e.g., ash and other carbohydrates in Daucus pusillus, are unknown.

Chemical composition and percentage weight in the heads and stems + leaves differed widely among species and are discussed further by Van Dyne (1965). As low as 9% of the weight was in heads in Avena barbata and as much as 73% in Navarretia. Crude protein and other carbohydrates in heads were consistently higher than in stems + leaves, ether extract was usually higher for heads but the difference was not as great as in crude protein, lignin and cellulose were lower in the heads, and ash did not vary widely. In some species heads were higher than stems + leaves, while in other species the reverse was true.

These chemical composition data for individual plants and plant parts show that the grazing animals could easily alter or balance dietary chemical composition. This was true for the whole summer even though herbage decreased considerably from early to late summer:

<table>
<thead>
<tr>
<th></th>
<th>July</th>
<th>August</th>
<th>Sept.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>1790±100</td>
<td>1440±130</td>
<td>520±60</td>
</tr>
<tr>
<td>Shaded</td>
<td>780±110</td>
<td>700±90</td>
<td>210±60</td>
</tr>
<tr>
<td>Weighted</td>
<td>1490</td>
<td>1230</td>
<td>420</td>
</tr>
</tbody>
</table>

The average is weighted for 70% of the plots in the open and 30% in shaded areas. Herbage utilization summerlong, due to consumption, trampling, and weathering, was about 75%.

**Dietary Chemical Composition**

Average diets were significantly different between summer periods, between cattle and sheep, and, in several instances, cattle and sheep did not change
equally in their dietary selectivity as herbage became limited (Table 1). No significant difference was found between morning and evening diets when averaged over both classes of stock although cattle tended to show differences in time of day grazing. Cellulose contents in the diets were different (P < .05) for more factors than any other individual constituent. Dietary lignin content was remarkably uniform. Ether extract changed free basis eliminates differences due to salivary cellulose and for other carbohydrates SF 

Table 1. Pattern of important differences in dietary chemical components.

<table>
<thead>
<tr>
<th>Dietary chemical component</th>
<th>Basis</th>
<th>Period</th>
<th>Day</th>
<th>Class of stock</th>
<th>x</th>
<th>Period</th>
<th>Among all animals</th>
<th>Among</th>
<th>Among sheep</th>
<th>Among cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>DM</td>
<td>**</td>
<td>*</td>
<td>*</td>
<td>**</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Ash</td>
<td>DM</td>
<td>*</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Crude protein</td>
<td>SF</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
<td>*</td>
<td>**</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Ether extract</td>
<td>SF</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
<td>**</td>
<td>NS</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Cellulose</td>
<td>SF</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
<td>**</td>
<td>NS</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Lignin</td>
<td>SF</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Ash</td>
<td>SF</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>SF</td>
<td>*</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Gross energy</td>
<td>DM</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

1 NS, *, and ** respectively refer to non-significant, significant, and highly significant.

2 DM = dry matter basis; SF = silica-free basis; OM = organic matter basis.

those of the succeeding four days (Table 1). This result is unexplainable. Generally, cattle consumed more silica than sheep, 4.5 vs. 3.3%. In early summer, sheep diets contained more silica than cattle diets, but in middle and late summer with less herbage available the converse occurred. Silica content of cattle diets in the latter two-thirds of the summer was almost twice as high as that in sheep diets. In late summer, with limited herbage available, cattle were seen consuming mouthfuls of trampled forage which was dust- and soil-laden. Sheep selected seedheads from the ground surface in early summer (Van Dyne and Heady, 1965).

Crude Protein.—Diets varied in crude protein content during the summer, between cattle and sheep, and the two changed at different rates as the summer progressed (Table 1). Averaged for both species, dietary crude protein contents decreased from 9.5 to 6.9% from early to late summer.

![Figure 3. Chemical composition on a percentage silica-free basis of sheep and cattle diets early in July (I), August (II), and September (III). The forage samples were collected by esophageal fistulated animals freely grazing a mature annual range.](image-url)
summer (Figure 3). This decrease was expected because the amount of available herbage and its crude protein content decreased throughout the summer. These changes are most pronounced when the data are reported on a silica-free or organic matter basis (Figures 1 and 2). That cattle and sheep dietary crude protein levels exceeded those in the available herbage all summer shows that animals exert considerable selection for herbage of high quality (compare Figure 3 to 1 and 2).

Sheep selected diets with more crude protein than cattle in all periods and especially so during period I (Figure 3). Middle summer sheep diets were only about 70% as high in crude protein content as in early summer; whereas, middle summer cattle diets were more than 80% of their early summer values. Cattle grazed less selectively than sheep as their dietary crude protein levels were closer than those of sheep to the level in the available herbage.

Ether Extract. — Independent of the method of expression, dietary ether extract declined regularly during the summer (Figure 3). Middle summer levels were about 80% of early summer contents and a similar percentage decrease occurred from middle to late summer. Ether extract levels in available herbage also declined through the summer. Although morning samples and sheep diets were highest in ether extract, the differences were not significant.

Lignin. — Dietary lignin content was remarkably uniform between cattle and sheep throughout the summer (Table 1 and Figure 3). Yet, there were considerable differences in the lignin content of individual species available in the pasture (Figure 2), in gross available herbage in early and late summer (Figure 1), and in the different plant parts (Van Dyne, 1965). The highest dietary lignin values were found for cattle in late summer when herbage was limited.

Lignin varied less than any other dietary chemical constituent. If lignin is indigestible in this herbage, the low variability makes it especially valuable as an indicator for calculating digestibility and intake, but calculations made from microdigestion data show about 4% of the lignin was digestible (Van Dyne and Lofgreen, 1964).

Cellulose. — Although actual differences were small, dietary cellulose was different (P < .01) between periods and classes of stock with all methods of calculation (Table 1 and Figure 4). On a dry matter basis, there were also highly significant interactions in cellulose contents of the diets for periods by days and periods by classes of stock. Dietary cellulose levels varied between days, and cattle and sheep diets did not contain the same concentration of cellulose on the same day and time of day as the summer progressed. Some of the interactions were also significant on silica-free and organic matter bases of calculation.

Period means for dietary cellulose on a dry matter basis were 34.5, 36.7, and 35.6% from early to late summer (Figure 4). Cattle diets had a small but significantly greater amount of cellulose than sheep diets when averaged over the summer. Detected cellulose differences of 1% illustrate the high uniformity of this compound in the diets.

That many interactions were significant on a dry matter basis and not with the other calculations is cause for speculation. Perhaps early summer sheep diets were significantly lower in cellulose because of silica contamination. When expressed on a silica-free basis, the cellulose values are increased considerably (Figure 4). In middle summer, sheep dietary silica was 2.3%, while cattle levels were 3.7%. Dietary silica levels changed differentially through the summer and could have contributed to significant interactions for other dietary components.

Other Carbohydrates. — Other carbohydrates composed about 31% of the dry matter and include various soluble and insoluble carbohydrates such as starches, sugars, xylans and other hemicelluloses, and pectins. Sheep had about 1% more dietary other carbohydrates than cattle when averaged over all periods (Figure 4), and both sheep and cattle selected more other carbohydrates in late than in early summer. This is probably the result of increasing amounts of acorns and Spanish moss in the diets (Van Dyne and Heady, 1965). Acorns were about 63% and Spanish moss about 82% other carbohydrates.

Gross Energy. — Cattle and sheep had similar average dietary gross energy contents, and both showed a slight decrease from early to late summer in contrast to increases in energy content in the available herbage (Figure 1). The mean dietary...
gross energy contents on a dry matter basis were as follows:

<table>
<thead>
<tr>
<th></th>
<th>July</th>
<th>August</th>
<th>Sept.</th>
<th>Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep</td>
<td>4220</td>
<td>4130</td>
<td>4120</td>
<td>4160</td>
</tr>
<tr>
<td>Cattle</td>
<td>4240</td>
<td>4180</td>
<td>4040</td>
<td>4160</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Avg.</th>
<th>kcal/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep</td>
<td>4220</td>
</tr>
<tr>
<td>Cattle</td>
<td>4240</td>
</tr>
<tr>
<td></td>
<td>4160</td>
</tr>
</tbody>
</table>

**Individual Animal Variation In Dietary Composition**

Average individual animal dietary chemical composition over the entire summer was used to evaluate differences in animal selectivity (Table 1). Differences for dietary lignin, cellulose, and other carbohydrates among individual animals did not occur when data were expressed on a dry matter basis, but those differences were significant when data were expressed on a silica-free basis (Table 1). Animal differences in soil or salivary contamination of diets, or both, masked true differences in dietary composition. However, individual animals differed in dietary crude protein even on dry matter basis. Summerlong means, on a silica-free basis, are given for four steers and five wethers from which 24 or more samples were collected (Figure 5).

Variations among animals in dietary crude protein were found between cattle and sheep (Table 1 and Figure 5) but not among sheep nor among cattle. Dietary ether extract levels differed among all individual animals but not within a class of stock nor between classes of stock. About 0.4% difference in dietary ether extract would have been required for a highly significant difference among either cattle or sheep. Lignin, a relatively uniform dietary constituent, differed between cattle and sheep and among individual sheep. Variations existed among sheep than among steers. One steer grazed less cellulose than two others and two wethers were different from another pair. A wide range in dietary other carbohydrates is shown among sheep but not among cattle. Dietary ash, including salivary contamination, differed among all animals because one sheep had more ash in fistula forage samples than others. Individual animals differ either in dietary intake of ash, salivary contamination, or both. Energy content of diets differed among animals due to a small but significant difference among sheep.

**Numbers of Animals Required for Sampling**

Variation in mean dietary composition for animals in each class for each period was used to calculate the numbers of animals required for estimating chemical composition of the diet within 10% of the mean with 95% confidence by the procedure of Stein (1945). Each mean was based on from eight to ten samples for a given period for each animal. Thus, numbers required (Table 2) are not for single samples but they are numbers of individual animal means. Variation in gross energy was less than for chemical constituents and numbers required for estimating chemical composition of the diet on a dry matter basis within 10% of the mean with 95% confidence.

**Table 2. Numbers of animals required for estimating chemical composition of the diet on a dry matter basis within 10% of the mean with 95% confidence.**

<table>
<thead>
<tr>
<th>Dietary constituent</th>
<th>Sheep</th>
<th>Cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Period</td>
<td>Period</td>
</tr>
<tr>
<td>Total ash</td>
<td>3 6 2 1</td>
<td>1 1 1 1</td>
</tr>
<tr>
<td>Silica</td>
<td>7 12 14</td>
<td>5 5 15</td>
</tr>
<tr>
<td>Crude protein</td>
<td>5 2 1 6</td>
<td>4 3 3 3</td>
</tr>
<tr>
<td>Ether extract</td>
<td>8 1 1 3</td>
<td>3 3 3 3</td>
</tr>
<tr>
<td>Lignin</td>
<td>5 1 1 2</td>
<td>1 1 1 1</td>
</tr>
<tr>
<td>Cellulose</td>
<td>2 1 1 1</td>
<td>1 1 1 1</td>
</tr>
<tr>
<td>Other carbohydrates</td>
<td>6 1 1 1</td>
<td>1 1 1 1</td>
</tr>
<tr>
<td>Silica-free ash</td>
<td>5 10 3</td>
<td>2 1 5</td>
</tr>
</tbody>
</table>
quired for sampling gross energy are not given. Silica-free and organic matter bases required only slightly fewer animals than the dry matter analysis.

More sheep than cattle generally would be required to sample dietary chemical constituents. Early summer diets were more variable for both classes of stock than middle and late summer diets although the animals were on the range two weeks prior to sampling; thus, more animals would be required with high than with low herbage availability.

Silica usually was the most variable dietary constituent and would require up to 15 animals for estimation in certain periods. Cellulose and energy were the least variable and only one or two animals would be required. Lignin and other carbohydrates were also low in variability and generally would require only a few animals, except in early summer for sheep when five or six animals would be required. Ether extract, ash, and crude protein could be sampled adequately with six or fewer animals.

Dietary composition should be expressed on a silica-free basis to decrease the variability between classes of stock and among grazing periods. Fewer animals are required to estimate dietary chemical constituents than are required to estimate many botanical constituents to the same accuracy (Van Dyne and Heady, 1965).

Discussion

Esophageal fistulated animals have been used to collect forage samples for dietary composition analysis in several range investigations but often with inadequate procedures (Van Dyne and Torell, 1964). For results to have greatest inferential value, the animals should be handled as "normally" as possible during sampling. Fasting, confinement of movement, and sampling during times of day when normal grazing would not take place may lead to biased results. Although several investigators have used esophageal fistulated animals, little has been reported on factors affecting diet variability.

Torell and Weir (1959) used two or three sheep and made one collection per sheep in 30 by 30 ft fenced exclosures on annual range at monthly intervals. Weir and Torell (1959) sampled annual range at various times during the year but only once when forage was dry and mature. They used six sheep at different times to collect samples but do not indicate how many were used in middle summer sampling, and individual animal variation was not evaluated. Interpretation of their graphic data indicates that their samples were reasonably comparable to those collected with sheep in August in this study.

Edlefsen et al. (1960) used two esophageal fistulated sheep in seven 6-day trials in 4-acre areas on desert shrub range. They fasted sheep overnight prior to early morning collection of samples. Over the seven trials there were no significant differences between sheep in dietary chemical composition, but within trials there were significant differences. Morris et al. (1965) grazed six esophageal fistulated wethers with 35 sheep in a 160-acre salt desert shrub pasture in Utah and sampled morning (8 to 10 am) and afternoon (2 to 3 pm) diets on seven consecutive days. They found that sheep were the greatest source of variation for sample weight, gross energy, and phosphorus; but days were most important sources of variation in nitrogen, cellulose, and lignin contents. They considered time of day to be unimportant although analysis of variance indicates a difference, but averages were not given to show the magnitude of differences.

Heifers and ewes were used during three winter months to collect forage samples on a Montana foothill bunchgrass range (Van Dyne et al., 1964). No significant difference was found in the protein, lignin, and chromogen content between morning and evening sheep diets. The Montana and Utah sheep grazed throughout the day in contrast to the grazing pattern of sheep on summer California annual foothill range. Day length was shorter on the winter ranges than on summer range in the current study, and sheep on winter range were probably somewhat hungry all day so perhaps no difference would be expected in dietary composition between morning and afternoon. In the current study, the sheep were able to graze at night as well as during a longer day period, but still there were not large overall differences in time of day dietary chemical composition; yet, many differences between morning and evening samples were found in botanical composition (Van Dyne and Heady, 1965). There were no significant differences among animals for chromogen, crude protein, cellulose, ether extract, and lignin content of forage samples in the Montana studies. Differences were found among dates due to climatic variations during the sampling period. In the current study the climate was uniformly hot during the sampling periods.

Cook et al. (1963) used eight sheep and two steers for sampling summer mountain range. The animals were fasted prior to sampling and one-half were used each in the morning and afternoon sampling. No estimate was given for within day, within period, and among animal variation in dietary composition. Their only noticeable differences in diets were for total protein and phosphorus, but determination of phosphorus content of fistula forage samples without
used of radioisotopes is subject to considerable error (Van Dyne and Torell, 1964). In their work, as also was found in this study, cattle grazed diets higher in cellulose than sheep.

Arnold et al. (1964) used esophageal fistulated ewes and wethers in Australian grazing studies. Their fasted sheep or sheep unaccustomed to the pasture selected atypical diets. In data pooled from various experiments for dietary nitrogen and soluble carbohydrate content, variance was separated into sheep, day, time of day, and sheep by day components (numbers of samples are not given). Generally, variation between sheep was greater than within day or among day variation. Nitrogen content of the diet was more variable than soluble carbohydrate content. It is impossible to further compare their results with the current study because they do not specify clearly the number of animals, dates of collection, and most dietary constituents.

The lack of time of day differences when averaged over the entire summer in this study merits further consideration. For dietary crude protein on an organic matter basis, cattle and sheep responded differently during the day:

<table>
<thead>
<tr>
<th>Time of day</th>
<th>Sheep</th>
<th>Cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>12.0</td>
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<tr>
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In two of three periods for sheep there was more crude protein in morning than afternoon diets, but for cattle, afternoon diets always had more crude protein than morning. However, when averaged over both classes, there was no time of day difference. Proportionate to metabolic body size, cattle were grazing more forage than sheep (Van Dyne and Meyer, 1964) and presumably would be less hungry and would be more selective in late afternoon than sheep. Sheep may not have grazed as freely in the late afternoon heat as cattle. These data show that a biased sample could be obtained in many instances by only morning sampling.

**Summary and Conclusions**

Cattle and sheep equipped with esophageal fistulas were used to secure samples of dietary forage from a dry annual range in early morning and late afternoon on five consecutive days early in July, August, and September. Dietary chemical composition was compared on dry matter, silica-free, and organic matter bases. Herbage availability varied from about 1490 to 420 lb/acre from early to late summer.

Diets had more crude protein and gross energy but less silica and total ash in early than in late summer. Lignin content of the diet did not change significantly during the summer. Some dietary constituents were higher in middle than in early or late summer. There were differences in diets among days within a sampling period for silica and cellulose. Averaged over both cattle and sheep for the entire summer, there was no significant difference between chemical constituents in morning and afternoon diets. However, afternoon cattle diets were higher in crude protein than morning diets.

Crude protein, other carbohydrates, and silica-free ash were higher in sheep than in cattle diets. Silica and cellulose were higher in cattle than in sheep diets. Cattle and sheep did not respond the same way to decreased available herbage, so significant period by class of stock interactions occurred for several constituents.

Differences in dietary chemical composition among animals of either class could not be shown if composition was calculated on a dry matter basis, but important differences existed when dietary composition was expressed on a silica-free or organic matter basis. When comparing main effects and their interactions, i.e., periods, days, times of day, and classes of stock, the basis of calculation was not as important as with individual animals.

Except for other extract, six or fewer animals would be sufficient to sample all dietary chemical constituents within 10% of the mean with 95% confidence. Four or fewer animals would be adequate for sampling in most period by class of stock combinations.

**LITERATURE CITED**


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An effective adult extension program in range management must consider first the extent and breadth of the art and science of range management. Range management is the managed use of range for maximum sustained production of livestock; the final measure of a range program must be practical, efficient, and economic conversion of range forage into livestock. Conservation of the soil resources and production of the right kinds and amounts of forage largely determine the principal end product—livestock.

Developing helpful adult educational programs in range management is the primary responsibility of the agricultural extension services in the various states. These programs are serviced by county agents, county and area specialists, state specialists, and teaching and research personnel. The agricultural extension service in each state is both a federal and a state organization. It is the educational arm of the U.S.D.A. in that state but also functions as a segment of the land grant university in carrying out off-campus educational programs.

A range management extension program must be directed towards application of sound practices on range. If effective, it will help the stockman provide a better living for himself and his family through developing, maintaining, and efficiently using his forage resources. This includes the management and coordinated use of both his private and his public grazing lands.

Range Research

The prime source of information for an extension range management program is range research. Research data and its application are the bases of solving