Crude Protein in Rumen Contents and in Forage[1]

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Highlight

Rumen-fistulated steers consistently selected a diet higher in crude protein than hand-clipped samples of the major available perennial grasses. The excess of rumen protein over grass protein depended on the availability of higher-protein shrubs and annual forbs that supplemented the perennial grasses, and on selection of high-protein parts of the grasses. Since the abundance of these high-protein forages varied greatly with time, the protein content of grass clippings did not reliably indicate the protein level in the steer's diet.

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[1] *Conducted in cooperation with Western Regional Research Project W-34, Range Livestock Nutrition. Approved as Ariz. Agr. Exp. Sta. J. Article No. 1033.*

[2] *Research accomplished while author was on sabbatical leave with the Animal Science Department, University of Arizona, Tucson.*

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The chemical and botanical composition of the grazing animal's diet are difficult to determine. Hand-clipped samples, taken as the observer watches the animal graze, do not reliably match the composition of the animal's forage intake (Hardison et al., 1954; Anon., 1962; Lesperance et al., 1960). Now, with rumen and esophageal fistula techniques, the animal itself does the collecting (Torell, 1954; Cook et al., 1958). This paper deals mainly with comparisons between crude protein values for rumen fistula samples and for hand-clipped samples of Arizona cottontop *(Trichachne californica* [Benth.] Chase) and Lehmann lovegrass *(Eragrostis lehmanniana* Nees). Some protein values for certain common non-grasses are also included. Initial results of this study were reported by Shumway et al. (1963) and Shumway and Hubbert (1963).

Materials and Methods

The study area.—The study was conducted in a 150-acre pasture at an elevation of about 4,000 feet on the Santa Rita Experimental Range, south of Tucson, Arizona. Annual precipitation averages nearly 16 inches in two distinct rainy seasons: about 60% falls from late June through September, with most of the remainder during the winter-spring period of December through April.

The vegetation cover consisted of a shrubby overstory of velvet mesquite *(Prosopis juliflora* var. *velutina* [Woot.] Sarg.) and catclaw acacia *(Acacia greggii* A. Gray), with an understory of perennial grasses and low-growing shrubs. The dominant perennial grasses were Lehmann lovegrass, a reseeded introduction, and Arizona cottontop. The most common low shrubs were false-mesquite *(Calliandra eriophylla* Benth.) and velvet pod mimosa *(Mimosa dysocarpa* Benth.). In addition, several species of annual grasses and forbs were common during the winter-spring and summer growing seasons, when moisture conditions were favorable.

The perennial grasses are primarily summer growers, although all of them produce some herbage during the spring. All except one of the shrubs mentioned are deciduous and produce most of their leaf and stem growth in the March to May period. In general, growth begins in the

spring when soil and air temperatures meet species requirements, and growth in the summer begins with the beginning of effective summer rains.

Procedure. — Three rumen-fistulated yearling Hereford steers were used in this study the first year, May 1961 till April 1962, and a second set of three steers from November 1962 till September 1963. Rumen samples were taken at approximately monthly intervals, with more frequent collections during some periods of rapid vegetation growth. The night before a collection was to be made, the steers were penned off feed and water. The next morning the rumen contents were removed and stored in clean garbage cans, while the steers were returned to the study pasture to graze for about 45 minutes. The freshly grazed material was then removed from the rumen for later analysis and possible identification, and the original rumen contents were replaced. While the steers were grazing, they were observed with binoculars to see what they were taking. Perennial grass forage was abundant at all seasons of the year.

Samples of the two dominant perennial grasses, Arizona cottontop and Lehmann lovegrass, were clipped on each day that rumen samples were collected, and also midway between monthly rumen collections. No attempt was made to simulate the steers' grazing in the clippings. Depending on availability, samples of common forbs and shrubs were also collected. Observations of the stage of growth of the important vegetation species were recorded for each clipping date.

Crude protein content of the rumen samples and of the clipped vegetation samples were determined in the laboratory by standard A.O.A.C. (1955) methods. Subsequent references to protein will mean crude protein. Data were also obtained for green-material-only, in addition to that for the whole-plant clippings, for three clipping dates in March and April 1961.

Results

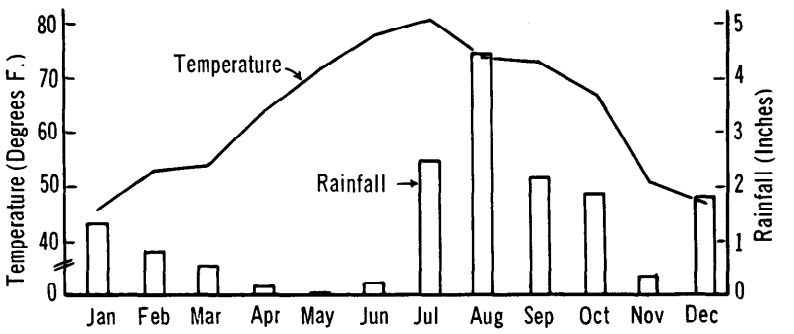
Growth patterns of grasses and shrubs. — Lehmann lovegrass completed two growth cycles each year in response to the two rainy seasons; a minor one in the spring, and a major one in the summer. New leaf growth began in January, heads began emerging from the boot in March, and the foliage was dried up by June (Fig. 1). For the main growing season, new leaf growth started in late June, seed stalks developed rapidly, and flowers were in bloom in August. Foliage was dried up by December.

Arizona cottontop started growing a little later in the winter-spring period, but also completed two growth cycles, although total leaf growth was much shorter and flower stalks much less numerous in the spring than during the main summer growing season.

The three shrubs on which records were kept remained dormant until March, when leaf buds began bursting. The main stem elongation period for mesquite and catclaw acacia was from March until June, with a second shorter period in August. False-mesquite had a comparatively short period of stem elongation in the spring (April), followed by a longer period in July and August.

Protein content of clipped

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lovegrass	A	B	B–D	B–F	E–G	H–A	B–C	C–E	E–F	E–F	G	H
Cottontop	H	A	A–B	B–H	B–H	H–A	B–C	C–E	E–F	F–G	H	H
Mesquite	E	E	E–A	A–C	C	C–D	D	C	D	D	D	D
Catclaw acacia	E	E	E–A	A–C	C	C–D	D	C–D	D	D	D	E
False mesquite	E	E	E–A	A–C	D–E	D–E	A–B	B–C	D	D	E	E



Grass Stages

A Green growth appears
B Leaves or stems 4" long
C Flower stalks evident
D Heads emerging from boot
E Flowers in bloom
F Seed ripe
G Seeds disseminating
H Foliage dried up

Shrub Stages

A Leaf buds bursting
B Stems elongating
C New stem growth 6" long
D Stem elongation stops
E Leaves dried up

FIGURE 1. Growth and development of grasses and shrubs in relation to monthly rainfall and temperatures, March 1961 to October 1964 (rainfall and temperature data interpolated from nearby stations).

grasses.—The protein content of whole-plant grass clippings was highest in young, succulent growth and decreased rapidly as plants matured. Thus, a significant increase in crude protein was recorded for lovegrass, but not for cottontop, in the spring, but the major high was in August during the main growing season. The low points were recorded when plants were dormant in winter, November to January, and during the late spring drought in May and June (Fig. 2).

The two grasses exhibited about the same pattern of change in protein content during the year; monthly averages seldom differed by more than one percentage point. Lowest protein content was 3.6% for cottontop in January, and the highest was 12.8% for cottontop in August, with an overall average of 6.3% (Table 1).

Percent protein in lovegrass green-material-only in mid-March 1961 was over 2½ times as high as that of the whole-plant clippings, but declined to about 1⅔ times as high by mid-April, as shown in the following tabulation:

Date	Whole plant	Green only
3-15-61	3.56	9.52
4- 3-61	4.25	9.31
4-12-61	4.50	7.52

This overall change in the relationship between whole plant and green-material-only, between March 15 and April 12, was the net effect of two contrasting trends: average protein content of the green-material-only was declining as it matured, especially during the latter part of the period, and average protein content of the whole plant was increasing as green material made up an increasing percentage of the whole plant, especially during the first part of the period.

Protein content of forbs and shrubs.—Protein content of these plants, too, was highest when growth was young and succulent, but periods of growth differed somewhat among species, and protein did not reach a peak in all species at the same time (Table 1). Mesquite leaves were very high in protein in April when first developing (25.6%), and decreased steadily until August (15.6). Mesquite beans were high when green (25.5% in June), but dropped to 12 to 13% when dry.

Other shrubs, catclaw acacia, false-mesquite, and desert zinnia (*Zinnia pumila* Gray) increased from a low of 11% in January to an average of 18.2% in May (catclaw acacia was 23.9% in April).

Protein content of cacti (jumping cholla [*Opuntia fulgida* Engel.] and pricklypear [*O. engelmannii* Salm-Dyck]) generally followed the clipped-grass pattern; they varied from a low of 5.7% in February to a high of 15.0% in August.

Annual forbs were present in useful amounts only in the spring and summer growing periods. Important genera included

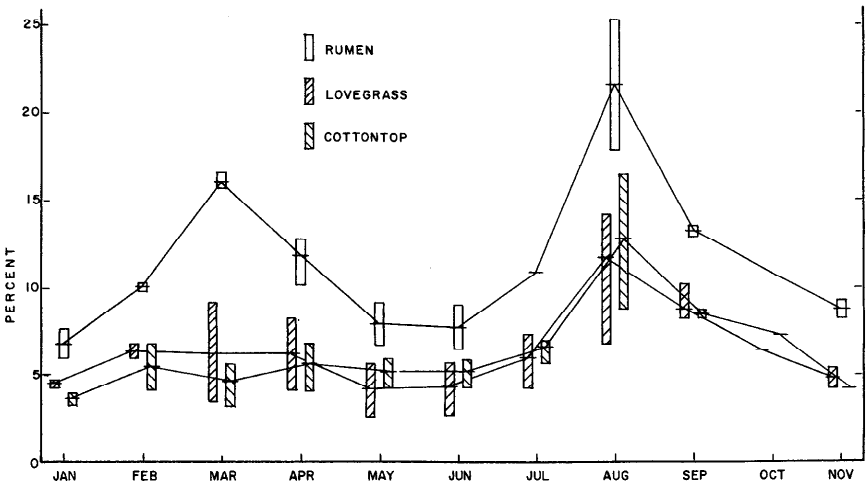


FIGURE 2. Changes in crude protein of clipped grasses and of rumen contents; range and averages of monthly determinations.

Table 1. Crude protein percent in dry matter; monthly averages, May 1961 to September 1963.

Month	Rumen	Lovegrass	Cottontop	Annual Forbs	Cacti	Mesquite Foliage	Other Shrubs
Jan.	6.80	4.54	3.58		7.18		10.98
Feb.	10.10	6.42	5.54		5.69		13.88
Mar.	16.06	6.38	4.64	20.45	9.50		15.31
Apr.	11.88	6.28	5.68	17.34	6.99	25.58	16.13
May	7.94	4.24	5.22		6.01	20.62	18.16
June	7.78	4.34	5.12		7.28	18.12	
July	10.90	6.00	6.68			15.56	
Aug.	21.60	11.64	12.76	21.91	15.04		
Sept.	13.24	8.76	8.50		9.99		
Oct.		6.44	7.28				
Nov.	8.76	4.84	4.19		6.69	15.81	11.36

Sisymbrium, Eschscholtzia, Amaranthus, and *Tribulis*. When available, these plants were always high in protein (13.5 to 26.5%).

Crude protein content of rumen samples.—Rumen protein content followed about the same pattern of change as the clipped grasses: a peak in March (16.1%), a higher peak in August (21.6%), and lows in May and June (7.8%), and from November till January (6.8%) (Fig. 2). For all months, rumen protein content averaged 11.5%.

Although three animals constitutes a rather small sample, variability among animals was not considered excessive. Coefficients of variation for 18 dates, with 3 animals each, varied from 0.11% to 18.82%, with an overall average of 7.81%. On only two dates did CV exceed 15%, and it was less than 5% on seven dates.

Discussion

Protein content of the rumen samples consistently exceeded that of the grass clippings but, in general, followed the same pattern of change (Fig. 2). Two possible sources of the higher rumen protein content were: 1) contamination of the grazed material between the time it was grazed and the time it was removed from the rumen, or 2) selective grazing of other higher protein plants in addition to the two grasses, or of certain parts of the grass plants which were higher in protein than the whole plant.

The possibilities of protein content increasing appreciably by saliva contamination or bacterial action in the rumen are remote. Separate tests with alfalfa and cottonseed hulls indicated non-significant or only slight average increases in nitrogen due to saliva contamination (Shumway et al., 1963). And, since essentially all the rumen bacteria were removed with the rumen contents prior to each test grazing, contamination from this source was not likely. Also, the rumen samples showed no evidence of fermentation. Thus, the higher rumen protein content appears to be due to selective grazing.

Direct observation of the animals as they grazed, and preliminary examination of the rumen samples, showed that plants other than grasses were eaten. Unfortunately, loss of the frozen rumen samples due to refrigeration failure prevented us from determining botanical composition. At times the steers grazed almost exclusively on annual forbs or on mesquite leaves, even though perennial grasses were available. They even occasionally ate such apparently unpalatable plants as cholla and barrelcactus. The influence of other-than-grass plants was especially marked in March, when annual forbs comprised a high percentage of the rumen content.

Protein content of the rumen averaged 1.82 times that of the whole-plant clippings of the two grasses for the 10 calendar months in which rumen samples were collected, but varied considerably between months because of differences in the availability of high-protein forbs and shrubs. In September, a month with few high-protein forbs, rumen protein was only 1.53 times the grass protein; but in March, a month with many high-protein forbs, rumen protein was 2.91 times that of the grasses. For the other months, rumen protein varied from 1.67 to 1.99 times that of the grasses. The results for the summer months are similar to those of Van Dyne and Heady (1965) in California, who found 1.5 to 2 times as much crude protein in esophageal fistula samples of sheep and cattle as in clipped herbage collected in July, August, and September; but these results are somewhat higher than reported for esophageal-fistulated sheep on native range in California by Weir and Torell (1959). And, Edlefson et al. (1960) found no significant differences in protein between hand plucked and esophageal fistula samples from winter grazing by sheep on Utah desert range.

These ratios between grass and rumen protein are a measure of the relative opportunity for the steers to improve their diet by selective grazing. This relative opportunity for diet improvement was highest in March and August, when the grass protein was at its peak and other forages were also at their peaks. The excess of rumen protein over grass protein at this time was about 10 percentage points. By contrast, in winter when grasses were dormant, annual forbs absent, and deciduous browse was defoliated due to low temperature and sometimes low moisture, the relative opportunity for diet improvement was low. High temperatures and lack of rainfall bring about similar vegetation conditions in May and June. During these periods the excess of rumen over grass protein averaged only 3 to 4 percentage points (Fig. 2 and Table 1).

As suggested above, protein content in the rumen was strongly correlated with that in the grass clippings. However, this relation is believed to have little value for extrapolation to other areas and other times because the presence and abundance of high-protein forbs and shrubs, on which the relation depends, vary markedly from year-to-year and place-to-place.

Based on National Research Council recommendations of 7.5% crude protein for wintering 600-lb steers, as quoted by Savage and Heller (1947), the two grasses were deficient in all months except August and September (Table 1), although protein content of lovegrass green-material-only was adequate in March and April. The rumen samples contained more than

7.5% in every month except January, however, which was about 10% low. Apparently the deficiencies in protein in the grasses were made up by higher content in the forbs and shrubs grazed by the steers.

Summary and Conclusions

A comparison of the crude protein contents of rumen samples from fistulated steers with those of hand-clipped vegetation samples shows that the steers invariably selected a diet higher in protein than whole-plant clipped samples of the major available perennial grasses. Data obtained over a period of 2½ years show that rumen protein varied from 1.53 to 2.91 times that of the clipped grass samples, and suggest that the higher protein content in the rumen was due to selective grazing by the steers of green parts of grasses rather than the whole plant, and of high-protein shrubs and annual forbs when they were available.

Although protein content of the rumen was highly correlated with that of the clipped grasses, clipped grass samples will not give reliable estimates of rumen protein in other years or other places because of large variability from year-to-year and place-to-place in the abundance of the high-protein forb and shrub forage which supplements the perennial grasses.

The data presented and reviewed indicate that non-grass plants contribute significantly to the protein intake of grazing animals, even when perennial grasses are abundant. This becomes of immediate practical importance when considering the need for feeding protein supplements. If the perennial grasses have some green shoots around the base, or if palatable annual forbs or browse are available, protein supplements probably are not needed even though the average protein level in grasses is below the recommended level.

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