Intake and Diet Selection by Protein Supplemented Grazing Steers

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Abstract

Nine esophageal-fistulated and 12 rumen-cannulated steers were randomly allotted to 3 equal supplement groups: cottonseed cake (CSC), ground, pelleted alfalfa hay (ALF), or no supplement (CON). Supplements were individually fed at isonitrogenous levels ($1.7 \text{ kg} \cdot \text{hd}^{-1}$ CSC vs $3.5 \text{ kg} \cdot \text{hd}^{-1}$ ALF) every other day. Animals were maintained on treatment from January through April 1983 while grazing blue grama (*Bouteloua gracilis*) rangeland in south-central New Mexico. Esophageal samples were collected at 2 times during this period: early February and late March; intake was estimated from total fecal collections in late February and early April. Esophageal samples were analyzed in the laboratory for nitrogen (N) components, in vitro digestibility, fiber, and botanical composition. Animal selection for total grass content of the diet was not influenced ($P > .10$) by supplementation but declined from February to March (31.8% vs. 21.2%, respectively). Blue grama and mat muhly (*Muhlenbergia richardsonii*) comprised over 66% of the grass component. Total forbs selected was not influenced by supplementation but increased ($P < .05$) from February (68.2%) to late March (78.8%), which may be the result of declining quantities of grass and emergence of forbs because of spring moisture. Dietary N components were not affected by supplementation. Soluble N, insoluble unavailable N, and crude protein were higher ($P < .05$) in February than March as a result of increasing forb consumption and possible N leaching from grass. Fiber components, acid detergent fiber and acid detergent lignin, as well as organic matter digestibility of the diet, were not influenced by supplementation, and increased from February to March but only organic matter digestibility was higher ($P < .05$) in late March than in early February. Forage organic matter intake was not influenced by supplementation ($P > .49$), type of supplement consumed, or sampling period ($P > .90$). Total organic matter intake however, differed ($P < .05$) between treatment groups because of addition of supplements. Results of this study indicate protein supplementation of wintering steers does not influence botanical or chemical composition of their diets or amount of forage consumed.

Improved weight gains and reproductive performance of protein supplemented cattle grazing dormant rangelands are well documented (Parker et al. 1974, Langlands and Bowles 1974, Falvey 1977, Adams and Kartchner 1983). Satisfying dietary requirements for nitrogen is a major mechanism involved in improved livestock performance; however, responses primarily limited to intake and digestibility have been noted (Campling 1970, Conrad 1966). Rit-

tenhouse et al. (1970) reported forage intake increased upon addition of protein supplements to low-quality forage diets (<6% crude protein). However, results of other studies on the effect of supplements on forage intake have been varied (Weston and Hogan 1968, Rittenhouse et al. 1970). Effects of nitrogen supplementation on diet selectivity have not been investigated, although nutritional status has been proposed to influence preference (Heady 1964).

The objective of this study was to evaluate effects of 2 protein supplements, cottonseed cake and ground alfalfa pellets, on diet selectivity from the standpoint of botanical and chemical composition and forage intake.

Study Area

Field data for this study were collected at New Mexico State University's Fort Stanton Experimental Ranch in the foothill-mountain region of southcentral New Mexico. Elevation of the area is variable, but averages 1,950 m above sea level. Climate is mild, but cold weather can occur during the winter. January is the coldest month with a mean minimum of -6.7°C and average date of last frost is 2 May. Winter precipitation (January to April) averages 55.9 mm with most occurring as snowfall (U.S. Department of Commerce 1973). Climate during the study period (January to May 1983) was characterized by an above-average precipitation of 84.1 mm.

The study area was a 117-ha pasture fenced into 2 nearly topographically and vegetatively equal paddocks. Animals were allowed to graze the larger, 61-ha paddock 4 weeks before and during esophageal collections. The 56-ha paddock was used to maintain animals during nonsampling interval.

Both paddocks are similar in vegetative composition (Wallace et al. 1983). Major grasses are blue grama (*Bouteloua gracilis*), side-oats grama (*B. curtipendula*), sand dropseed (*Sporobolus cryptandrus*), mat muhly (*Muhlenbergia richardsonii*), ring muhly (*M. torreyi*), wolftail (*Lycurus phleoides*), western wheatgrass (*Agropyron smithii*), and Halls panicum (*Panicum hallii*). Important forbs and shrubs are Carruth sagewort (*Artemisia carruthi*), tall globemallow (*Sphaeralcea angustifolia*), Dakota verbena (*Verbena bipinnatifida*), nuttall milkvetch (*Astragalus nuttallianus*), buckwheat (*Eriogonum* spp.), fendler bladderpod (*Lesquerella fendleri*), broom snakeweed (*Xanthocephalum sarothrae*), and yucca (*Yucca elata*).

Methods

Nine esophageal-fistulated steers and 12 rumen-cannulated steers (average weight of 230 kg) were randomly allotted to 1 of 3 treatments: control (no supplemental feed [CON]), mechanically extracted cottonseed cake ($1.7 \text{ kg} \cdot \text{hd}^{-1}$ [CSC]), and ground pelleted alfalfa hay ($3.5 \text{ kg} \cdot \text{hd}^{-1}$ [ALF]). Supplements were individ-

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Review of the manuscript by Dr. J.L. Holechek was helpful and we appreciate his efforts.

Journal Article 1096, N.Mex. Agr. Exp. Sta., Las Cruces, N. Mex. 88003.

Manuscript accepted September 13, 1984.

ually fed at the specified amounts (isonitrogenous) every other day from January to May. Individual feeding involved tethering animals to assigned feeding stations within a large pen. Chemical composition of supplements is shown in Table 1. The supplementation level was chosen to represent winter supplementation levels recommended for ranchers in this region (Parker et al. 1974). Esophageal-fisulated and rumen-cannulated steers were driven into a central location on supplementation days at 0800 h. Control steers were withheld from grazing while supplemented steers were fed. A salt-mineral mix (50% dicalcium phosphate, 45% salt and 5% cottonseed meal) was provided free choice in the pasture.

Esophageal collections were obtained over 2 periods (mid-February, and late March) from 3 steers per treatment group. Collections were made by penning all 9 steers before supplementation (0700 h). Animals were fed appropriate supplements and water was made available in the holding pen. Steers were fitted with collection bags and harnesses at 1600 h and released. Because the holding pen was centrally located, collection animals were allowed to walk to the remaining herd and graze for 15 to 30 minutes. No hazing or restriction was imposed on grazing behavior during collections.

Esophageal samples were composited across days so each steer had 1 sample per period representing a 3-day collection. Samples were frozen before laboratory analyses. In the laboratory, samples were dried at 50 ° C for 48 h and ground to pass a 2-mm screen. Dry matter and ash were determined by AOAC (1980) procedures. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) analyses were conducted according to procedures of Goering and Van Soest (1970).

Kjeldahl procedures were used for all nitrogen (N) analyses (AOAC 1980). Nitrogen content of esophageal samples was fractionated into soluble (SN), insoluble (IN), insoluble available (IAN), and insoluble unavailable N (acid detergent insoluble, ADIN). Soluble and insoluble N fractions were determined by the

Table 1. Organic matter, crude protein and fiber components of protein supplements¹ fed to steers grazing blue grama rangeland in southcentral New Mexico.

Component %	Supplement	
	CSC ²	ALF ²
Organic matter	91.5	89.0
Crude protein	47.7	23.0
Soluble nitrogen	0.85	1.40
Insoluble unavailable nitrogen	0.31	0.15
Neutral detergent fiber	21.9	42.1
Acid detergent fiber	16.2	30.1
Acid detergent lignin	6.5	6.7

¹All components expressed as a percentage of organic matter.

²CSC = cottonseed cake; ALF = ground, pelleted alfalfa hay.

procedure of Waldo and Goering (1979). Insoluble available N is the portion remaining after SN and ADIN are subtracted from total N.

The Tilley and Terry (1963) two-stage technique (48-hour rumen fluid, 48-hour pepsin digests) was used to determine extent of in vitro organic matter digestion (inoculum donor animals were fed alfalfa hay). Calcium (Ca) was determined by atomic absorption and phosphorus (P) by the molybdovanadate colorimetric procedure (AOAC 1980). All analyses except Ca and P were expressed on an organic matter basis.

Botanical composition of diets was determined using procedures outlined by Sparks and Malechek (1968). Five slides were made from each steer's sample and were examined until 50 fields of view were tallied with identifiable plant fragments. Dietary similarities between groups were calculated using Kulczynski's similarity index (Oosting 1956).

Table 2. Botanical composition (%) of steer diets supplemented with ground, pelleted alfalfa (ALF) or cottonseed cake (CSC) on blue grama rangeland in south-central New Mexico.

Forage	Sampling Date			Treatment			
	February	March	SE ¹	Control	ALF	CSC	SE ¹
Grasses:							
Blue grama	12.9 ^a	8.7 ^b	.19	11.4	10.2	10.7	.15
Mat muhly	8.4	6.2	.18	7.3	6.9	7.2	.19
Halls panicum	2.5	1.7	.12	3.0	2.0	0.8	.11
Western wheatgrass	1.7	2.1	.08	3.2	1.8	1.8	.06
Wolftail	3.5 ^a	1.3 ^b	.09	2.4	1.5	3.8	.08
Sand dropseed	2.0 ^a	0.0 ^b	.08	1.1	1.2	0.8	.08
Other grasses ¹	0.8	1.2	.08	T ⁴	1.0	0.6	.03
Total Grasses	31.8 ^a	21.2 ^b	.25	28.1	24.7	26.4	.22
Forbs and Shrubs:							
Carruth sagewort	56.6	53.0	.24	54.2	54.4	54.8	.25
Scarlet globemallow	3.9	2.5	.13	3.2	3.7	2.6	.14
Locoweed	3.5	4.1	.16	2.3	4.2	4.9	.12
Dakota verbena	1.7	3.2	.11	2.6	1.8	2.7	.11
Buckwheat	0.0 ^a	5.5 ^b	.13	3.3	2.1	2.9	.13
Bladderpods	0.0 ^a	2.1 ^b	.10	0.9	2.2	T	.11
Snakeweed	1.3	3.6	.18	1.9	1.8	1.7	.18
Yucca	T	1.5	.07	0.8	0.8	1.9	.05
Other forbs ²	T ^a	1.7 ^b	.03	T	1.4	1.2	.06
Other shrubs ³	T	T	.03	T	0.7	T	.05
Total Forbs	68.2 ^a	78.8 ^b	.24	71.9	75.3	73.6	.21

¹Includes: bottlebrush squirreltail (*Sitanion hystrix*), threeawns (*Aristida* spp), and ring muhly.

²Includes: plains zinnia (*Zinnia grandiflora*), plantain (*Plantago patagonica*), babywhite aster (*Leucelene eriocoides*), whitestem mentzelia (*Mentzelia albicalis*) and Belvedere summer-cypress (*Kochia scoparia*).

³Includes: fourwing saltbush (*Atriplex canescens*) and one-seeded juniper (*Juniperus monosperma*).

⁴Traces (<.5%).

⁵Standard error of the mean for sampling date or treatments.

^{a,b}Period means with different letters differ ($P < .05$).

Table 3. Chemical composition¹ of steer diets supplemented with ground pelleted alfalfa (ALF), cottonseed cake (CSC) or no supplement (CON) on blue grama rangeland in south-central New Mexico.

Component %	Sampling Date			Treatment			
	February	March	SE ²	CON	ALF	CSC	SE ²
Organic matter	82.6 ^a	79.3 ^b	.55	81.2	81.2	80.5	1.0
Neutral detergent fiber	80.7	78.0	.68	80.3	79.7	78.1	2.3
Acid detergent fiber	62.3	65.4	.90	63.4	63.4	64.8	1.2
Acid detergent lignin	9.3	10.7	.40	9.6	9.3	11.1	.60
Organic matter disappearance	42 ^a	48 ^b	.15	45	45	46	.15
Calcium	.70	.84	.03	.76	.78	.77	.04
Phosphorus	.22	.23	.01	.22	.23	.24	.01

¹Diet composition as a percentage of organic matter except for calcium and phosphorus which are expressed as percentage of dry matter.

²SE = Standard error of the mean.

^{a,b}Sampling date means followed by different letters differ ($P < .05$).

Total fecal collections were conducted in late February and early April (2 weeks following diet sampling) using the rumen-cannulated steers. It was assumed that changes in forage chemical and botanical composition would be minimal over the 2-week interval between esophageal and fecal collections. Collection bags were placed on the steers for 5 consecutive days and bags were changed every 12 hours. Fecal collections were emptied into plastic sacks and stored at 4° C. When each 24-hour collection had been obtained, bags were combined to represent a 24-hour collection for each steer. Feces were weighed, mixed, and a subsample of 500 g was obtained. Each steer's daily subsample was frozen until dry matter and organic matter were determined. Organic matter intake was estimated using fecal organic matter output and diet in vitro organic matter indigestibility.

Data were analyzed as a split-plot design with supplement as the main plot and sampling period as subplot treatment. The least significant difference procedure was used in comparing means following preliminary F tests by analysis of variance (Steele and Torrie 1980). No supplement by sampling period interactions were noted for any of the data analyzed.

Results and Discussion

Botanical composition of steer diets revealed no effect ($P > .10$) of supplementation on animal dietary selectivity; however, collection period differences ($P < .05$) were noted (Table 2). Total grass content of diets declined ($P < .05$) between February (31.8%) and late March (21.2%). This decline was typified by reduced selection ($P < .05$) of blue grama, wolf tail and sand dropseed. However, at both samplings, blue grama and mat muhly comprised over 66% of the grass component. Other investigators have reported grasses to be the most important component of cattle diets on Utah desert ranges (Cook et al. 1963) and California annual grasslands (Van Dyne and Heady 1965). However, Pfister et al. (1984) at Fort Stanton and Holechek et al. (1982) in the Blue Mountains of Oregon reported green forbs are preferred over dormant grasses. Total forb content increased ($P < .05$) between February and late

March. Increased diversity of forbs available because of favorable spring precipitation might have been responsible for increased dietary levels consumed.

Carruth sagewort was the major species consumed in both February (56.6%) and March (53.0%). High dietary content of total forbs, in particular sagewort, is in sharp contrast with results obtained by earlier researchers in this study area. Allison et al. (1977) and Havstad et al. (1979) indicated sagewort made up only 15 to 16% of the diet during January and March, respectively. However, both indicated abundance of sagewort in the diet was a function of the availability of sagewort and other palatable forage. Pfister et al. (1984) found cattle grazing on a similar vegetative type in a rest-rotation system consumed 25–39% carruth sagewort.

Total forb content of 68.2% (February) and 78.8% (March) is in sharp contrast to the 28.7% (January) and 23.4% (March) level reported by Havstad et al. (1979). These discrepancies can be accounted for, in part, by 2 confounding factors. First, below average winter precipitation during previous studies, compared with above average precipitation in the current study, may account for dietary composition differences. Although forage production data are not available to make comparisons, precipitation data indicates potential for forb growth. Increased diversity of diets from February to late March support this hypothesis. Second, Havstad et al. (1979) stocked the pasture for only 2 weeks at each sampling, while in the current study, grazing occurred for 6 weeks before each sampling. Thus, discrepancies in forb and grass content of our diets compared with other results, as well as the decline of grass (increase in forbs) with time in this study, is indicative of seasonal climatic differences and a decreasing forage base.

Dietary similarities between the 3 groups of animals was high during both February (91.5%) and March (88.0%) sampling periods. Control vs ALF had the highest similarities (91.6%) across sampling periods followed by CON vs CSC (89.3%) and CSC vs ALF (88.3%).

Organic matter content of diets did not differ ($P > .10$) between treatments but decreased ($P < .05$) between February and March

Table 4. Nitrogen fractions¹ of steer diets supplemented with ground pelleted alfalfa (ALF), cottonseed cake (CSC) or no supplement (CON) on blue grama rangeland in south-central New Mexico.

Component %	Sampling Date			Treatment			
	February	March	SE ²	CON	ALF	CSC	SE ²
Crude protein	10.43 ^a	12.63 ^b	.54	11.06	11.06	12.50	.82
Total nitrogen	1.67 ^a	2.02 ^b	.09	1.77	1.77	2.00	.13
Soluble nitrogen	.42 ^a	.50 ^b	.04	.47	.38	.54	.04
Insoluble available nitrogen	.86	.79	.08	.83	.82	.83	.11
Insoluble unavailable nitrogen	.40 ^a	.73 ^b	.05	.48	.58	.64	.09

¹Nitrogen fractions expressed as a percent of organic matter.

²SE = Standard error of the mean.

^{a,b}Period means followed by different letters differ ($P < .05$).

Table 5. Total and forage organic matter intake¹ of steers supplemented with ground pelleted alfalfa (ALF), cottonseed cake or no supplements (CON) while grazing blue grama rangeland in south-central New Mexico.

Intake level	Sample Date			Treatment			
	February	March	SE ²	CON	ALF	CSC	SE ²
Forage	9.8	8.9	.44	10.8	7.7	9.6	1.07
Total	13.1	12.1	.46	10.8 ^a	14.1 ^a	12.9 ^b	.59

¹Intake expressed in grams of intake per kg of liveweight.

²SE = Standard error of the mean.

^{a,b}Treatment means followed by a different letter differ significantly ($P < .05$).

(Table 3). These values are consistent with previous studies at Fort Stanton (Wallace et al. 1983, McCollum 1983). Neutral detergent fiber, ADF, ADL, and OMD, likewise were not affected ($P > .10$) by supplementation. Although ADF and ADL increased slightly ($P > .10$) and OMD increased ($P < .05$) between February and March, NDF (February = 80.7%, March = 78.0%) showed a general decline ($P > .10$). The slight increase in ADF (February = 62.3%, March = 65.4%) and OMD (February = 42%, March = 48%) with a concurrent decline in NDF is indicative of a higher forb content and increasing maturity of the grass component in March. Similar values were reported by McCollum (1983) and Havstad et al. (1979) from these same pastures.

Calcium and P contents of esophageal samples may not be representative of actual consumption because of salivary contamination (Van Dyne and Torell 1964). Calcium levels increased slightly ($P > .10$) from February (0.70%) to March (0.84%) and P levels remained constant (February = 0.22%, March = 0.23%) while forbs increased in the diet. Carruth sagewort, the major forb, contains fairly high levels of P (0.27%) based on clipped samples (Cordova and Wallace 1975). Major grasses at Fort Stanton (wolftail, blue grama, and sand dropseed) were reported by Pieper et al. (1978) to contain 0.094% P in March and 0.102% P in February. Calculation of dietary percentage P, based on 88.4% of the diet as wolftail, blue grama, sand dropseed, and carruth sagewort in February and 74.2% in March, indicates at least 0.18% P in February and 0.16% P in March. Because the remainder of the diet was forbs, these values can be expected to rise slightly or stay static since forbs are typically high in P (Cordova and Wallace 1975). Phosphorus contamination from saliva makes up about one-half of total bolus P (Little 1972). Results from this study, based on P levels extrapolated from clipped forage and from total bolus P (February = 0.22% and 0.18%, March = 0.23% and 0.16% P for bolus and clipped results, respectively) indicate the possibility of less than half the bolus P arising from saliva.

Total N and N fractions were not affected by treatment (Table 4; $P > .10$). However, total N (February = 1.67%, March = 2.02%), ADIN (February = .40%, March = .73%) and soluble N (February = .42%, March = .50%) increased ($P < .05$) between February and late March. Crude protein levels observed in this study are higher than those observed by other researchers at Fort Stanton in January or March. Havstad et al. (1979), Wallace et al. (1983) and Thetford et al. (1971) in January noted 6.4%, 8.4% and 10% crude protein and in March 6.0%, 10.4% and 7% crude protein, respectively in fistula samples.

McCollum (1983) stated SN and IAN fractions are of greatest importance to the grazing ruminant because SN is the primary N source for rumen microbes and tends to decline with forage maturity. Protein supplements will reverse a decline in total N intake. However, insoluble N supplements may not appreciably increase the SN consumption. In this study, level of supplemental soluble N (CSC = .78% SN; ALF = 1.21% SN) did not have an effect on chemical content of the diet selected.

Forage intake did not differ ($P > .49$) between treatment groups (Table 5) or sampling periods ($P > .90$). However, there appeared to be a slight reverse relationship between quantity of supplement consumed and forage intake. Increased intake, as a result of pro-

tein supplementation has been reported by several researchers (Cook and Harris 1968, Campling 1970, Lusby et al. 1976); however, Rittenhouse et al. (1970) indicated associative effects from protein supplementation are negligible when dietary crude protein is above 6–8%. Dietary crude protein levels in this study (February = 10.43%; March = 12.63%) were greatly above this level, supporting the findings of Rittenhouse et al. (1970).

Total intake (forage + supplement) did not differ between sampling periods ($P > .90$), but was lower ($P < .05$) for CON steers (10.8 g/kg of body weight) than for ALF (14.1 g/kg of body weight) and CSC steers (12.9 g/kg of body weight). Treatment differences reflect additional amounts consumed as supplements, and do not represent an associative effect of supplement on forage intake.

Esophageal masticate crude protein levels reflect adequate crude protein for moderate rates of gain for growing steers (10% crude protein for 250 kg steers or heifers gaining 0.7 kg/day; National Research Council 1976) and heifers or for lactating cows. However, due to low forage intake levels (approximately 275 g crude protein/day supplied by forage diet), quantities of protein consumed were insufficient for gain (620 g crude protein/day for 250 kg steers or heifers gaining 0.7 kg/day; National Research Council 1976). Cordova et al. (1978) showed intake estimates in grazing cattle vary from 10 to 28 g of organic matter per kilogram of body weight. Intake levels in this study would fall at the lower end of these estimates. Supplementation with either cottonseed cake or ground, pelleted alfalfa hay would, therefore, appear to be an effective means of providing additional dietary protein.

Overall, protein supplementation in this study did not alter animal plant selectivity based on chemical and botanical composition. Increased intakes with supplementation reported in the literature did not occur in this study. Management of cattle grazing dormant rangeland from a forage habit and consumption basis, may not differ with protein supplementation or type of supplement with dietary crude protein levels observed in this study.

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