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ESCAPE PROTEIN SUPPLEMENTATION OF YEARLING STEERS GRAZING SMOOTH BROME PASTURES[1]

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ABSTRACT

Two grazing trials utilizing individually supplemented yearling steers were conducted to study the effect of supplemental escape protein on steer performance during the active growth periods, spring and fall, of smooth brome (Bromus inermis). Graded levels (0, .11, .23 and .34 kg·head^{-1}·d^{-1}) of an equal-protein-basis mixture of bloodmeal and corn gluten meal were offered daily, replacing corn starch, which was used as the negative control. All steers received 582 g supplemental dry matter per day. Supplementation with escape protein improved daily performance in both spring ($P<.01$) and fall ($P<.02$). Analysis of pooled data from both trials indicated a linear ($P<.01$) and quadratic ($P<.05$) increase in steer performance with increasing level of escape protein in the diet. Analysis of grass samples collected throughout and composited over each trial demonstrated that grass protein was highly degraded in the rumen. Using a modified dacron bag technique, 12-h degradability was found to be 80 to 90% of the potentially digestible protein fraction. Rates of protein degradability were 14 and 11.7%/h. Assuming 5%/h rate of passage, escape protein was calculated to be 9.2 and 13.1% of total protein. As a result of the significant growth response observed above that of the energy-supplemented controls and the high ruminal protein degradabilities of the grass observed in the laboratory, it was concluded that growing ruminants grazing actively growing smooth brome pastures were deficient in metabolizable protein.
(Key Words: Beef Cattle, Protected Protein, Supplementary Feeding, Bromus inermis, Pastures, Protein Degradation.)

Introduction

Protein is generally overlooked as the first nutrient limiting performance in beef cattle grazing lush green pastures. However, in a recent review, Beever and Siddons (1986) estimated an apparent loss of N between mouth and duodenum, which may account for up to 30% of ingested N. Cammell et al. (1983) estimated microbial N flows at over 75% of nonammonia-N flow for ryegrass and clover diets, of which 60 (MacRae and Ulyatt, 1974) to 80% (Salter and Smith, 1977; Storm et al., 1983) would be available. From the estimates of N loss, energetic limits to microbial protein synthesis and limited true digestibility of microbial N, it is plausible that only a fraction of the ingested forage N is actually used by the animal.

Various researchers have observed responses to proteins supplied postruminally (Black et al., 1979; Barry, 1980; Barry et al., 1982) in sheep maintained on fresh forages. Slowly degraded and protected proteins have also promoted improved performance when used to supplement fresh forage diets (Stobbs et al., 1977; Orr et al., 1982; Penning and Treacher, 1982; Craig, 1983). These responses indicate that the fresh forage, though high in crude protein, was not meeting the metabolizable protein requirements of the animals studied.

One objective of these trials was to attempt to offset this potential protein deficiency by determining if yearling steers, grazing spring vegetative or fall regrowth smooth brome, would respond to supplemental escape protein (EP). Another objective was to characterize the degradability of smooth brome protein.

Experimental Procedure

Trial 1. Fifty-nine crossbred steers (277 kg) were used in a randomized block design (April 24 to July 8, 1985). Treatments (table 1) included control (no EP); .11 kg·head^{-1}·d^{-1} of protein from high EP; .23 kg·head^{-1}·d^{-1} EP; or .34 kg·head^{-1}·d^{-1} EP.

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TABLE 1. SUPPLEMENT COMPOSITION, TRIALS 1 AND 2

Ingredient	Trial 1		Trial 2	
	Control	.34 kg EP[a,b]	Control	.34 kg EP[a,c]
	Percentage of dry matter			
Corn starch	64.4		43.9	
Bloodmeal		33.2		18.8
Corn gluten meal		44.8		25.1
Soyhulls			22.1	22.1
Salt	7.0	7.0	4.0	4.0
Molasses	28.6	15.0	30.0	30.0

[a]Protein from escape protein sources.

[b]582 g dry matter/d.

[c]1020 g dry matter/d.

Control supplement was corn starch with 30% molasses. Escape protein supplements were an equal-protein-basis mixture of corn gluten meal and bloodmeal (Klopfenstein et al., 1985) with 15% molasses. Both supplements contained salt equivalent to .04 kg·head^{-1}·d^{-1}. All steers received 582 g supplemental dry matter (DM) per day. The .11 and .23 levels of EP were achieved with 2:1 and 1:2 mixtures of control and .34 EP supplements, respectively.

Each morning (0630 to 0700) calves were gathered and brought to a barn equipped with electronically controlled Calan[4] gate feeders that allowed individual feeding. After consuming the daily allotment of supplement, calves were returned to pastures to graze (stocking density 4.1 steers/ha). Groups (29 or 30 steers) were rotated among pastures on a weekly basis to reduce any possible effect due to pasture.

Trial 2. Sixty crossbred steers (244 kg) were used (August 30 to November 19, 1985) and were offered the same treatments as in Trial 1. Due to palatability problems in Trial 1, .23 kg·head^{-1}·d^{-1} of soyhulls were added across all treatment, and molasses level of EP supplements was increased to 30% (table 1). As in Trial 1, control and .34 EP supplements were mixed at feeding to create intermediate levels. Calves were handled daily as outlined in Trial 1.

Initial and final weights for both trials were averages of weights taken on three consecutive days before feeding. Three days before each weighing, all steers were confined to the barn. Corn silage was fed at 2% of body weight in Trial 1 and alfalfa hay (2% of body weight) in Trial 2 to equalize digestive tract fill. Both trials were analyzed with steer as experimental unit using least-squares analysis (SAS, 1982). Ten steers in Trial 1 refused to consume their supplement and were deleted from statistical analysis. Single-degree-of-freedom contrasts were used to determine significance of supplementation (control vs supplement). Linear and quadratic responses to level of EP supplement were tested with orthogonal contrasts (Steel and Torrie, 1980; SAS, 1982).

Forage Analysis. Grass samples, clipped at approximately 2.5 cm above ground level, were collected at 2-wk intervals throughout the duration of each trial. In Trial 1, five 1.39-m^2 plots were collected per sampling date in each pasture. In Trial 2, forage was sampled using eight .18-m^2 plots per sampling date per pasture. Duplicate subsamples were oven-dried (60 C for 48 h) for determination of DM yield. Additional subsamples were composited for each clip date, frozen and later freeze-dried. Trial 2 samples were sorted to remove dead stems. Each composite was then ground to pass through a 1-mm screen.

The dacron bag technique has provided estimates of ruminal protein degradation with higher correlations to values observed in vivo than have solubility procedures (DeBoever et al., 1984; Stern and Satter, 1984). However, with samples of relatively low total N contents but high solubilities and fiber contents, contamination due to microbial attachment may significantly alter the degradability estimate (DeBoever et al., 1984).

[4]American Calan, Northwood, NH.

TABLE 2. GAIN RESPONSE TO ESCAPE PROTEIN FOR STEERS IN TRIAL 1 GRAZING SMOOTH BROME PASTURES

Item	Escape protein supplement, kg/d				
	Control	.11	.23	.34	None[a]
Number	14	14	13	8	10
Initial wt, kg[b]	279 ± 2.9[c]	278 ±2.8	280 ± 2.9	270 ± 3.6	278 ± 3.5
Daily gain, kg	.91 ± .03	.94 ± .03	1.06 ± .03	1.01 ± .04	.89 ± .04

[a]Animals that refused to consume supplement.

[b]Control vs supplemented ($P<.01$); supplement level linear ($P<.01$); supplement level quadratic ($P=.23$).

[c]Standard error.

A technique was developed whereby the protein degradability of forage samples could be determined. It is a modified dacron bag technique, and it accounts for microbial attachment by incorporating bags containing control fiber.

Polyester (35 to 80 μm pore size) bags measuring 7.6 × 12.7 cm were filled with either 1.5 g of ground forage or an amount of acid detergent fiber (ADF) such that cellulose in the ADF was equivalent to cellulose plus hemicellulose of the forage sample. Acid detergent fiber was selected due to the lower amount of N it contained compared with the neutral detergent fiber (NDF) fraction of the same forage material, which contains some potentially degradable N. Acid detergent fiber N was assumed to be indigestible (Yu and Thomas, 1976). The objective was to provide microbial binding sites in the control fiber equivalent to sites in the test forage. Therefore, assuming microbes attach equally to both forage and control fiber, residual, nondegraded forage N may be determined by simple subtraction.

To arrive at a manageable number of bags, a single composite of forage material (DM basis) for each trial was developed. Neutral detergent fiber, ADF (Goering and Van Soest, 1970) and lignin (Van Soest and Wine, 1968) procedures were conducted on each forage sample to determine quantities of control fiber necessary.

Triplicate bags of clipped forage and corresponding ADF fraction were made for each sampling hour. All bags were presoaked for 5 min in warm tap water. Each bag then was placed in the bottom of the rumen of a fistulated steer maintained on an ammoniated corn-cob diet with no natural protein other than that present in the cobs for a period of 6, 12, 18 or 24 h. Two runs were conducted using forage from both trial composites.

At the end of each trial, chains were removed from the rumen and immediately placed in warm water. Each chain was rinsed with a continuous flow of fresh warm water for 45 min. Nitrogen content of each bag was determined by macro-Kjeldhal technique.

Net residual N at each sampling time was determined by subtracting the mean N content of ADF bags, corrected for actual fiber content, moisture and acid detergent insoluble N (ADIN), from the mean of respective forage samples. Rate of protein degradation was calculated by determining the slope of the line generated from the log transformation of the average net residual N for 6, 12 and 18 h across runs as a percentage of that at zero hour (Waldo et al., 1972). Nitrogen solubility of the forage was determined in bicarbonate-phosphate buffer (Poos-Floyd et al., 1985).

Results and Discussion

Trial 1. A response to EP supplementation was observed above ($P<.01$) the performance of the energy control (table 2; figure 1). A linear ($P<.01$) increase in gain with increasing level of EP was observed with a trend for a quadratic increase ($P=.23$). Maximum gain was observed at the .23 kg·head^{-1}·d^{-1} level of EP addition.

The initial weights and gains of 10 steers that did not consume the supplement are shown in table 2; these animals were predominantly from the .34-kg EP treatment. Their initial weights were similar to those of steers in the other treatments, and their gains were similar to gains of the controls. Therefore, we think that their removal from the statistical analysis does not bias the remaining data.

Corn starch and molasses were used as the control to prevent confounding of results be-

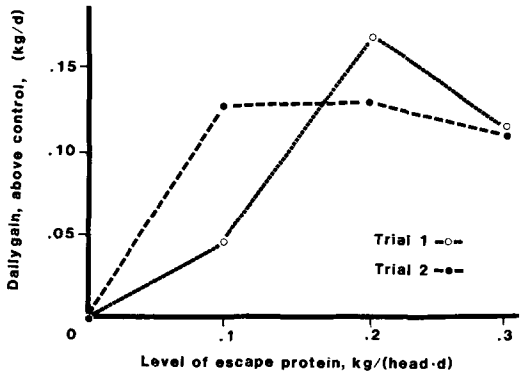

Figure 1. Gain response to escape protein.

tween protein and energy. The additional ruminal digestible energy would be expected to increase microbial protein synthesis in, and consequently the metabolizable protein supply to, the steers (Burroughs et al., 1974). Goedeken et al. (1987) obtained .33 kg/d increased gain from .23 kg/d of the same EP supplement used in this trial compared with nonsupplemented controls. The cattle grazed the same brome pastures used in this study. This is a 65% greater response than obtained in the present study, suggesting that supplementing starch and molasses might stimulate microbial growth and animal gain compared with no energy supplement.

Conversely, the starch and molasses might reduce fiber digestion and, consequently, steer gains. The 582 g/d is certainly less than 10% of total feed intake. Although intakes above 20% have reduced fiber digestion (Amos and Evans, 1980; McDonnell, 1982; Hoover, 1986), intakes of 5 to 10% have either had no effect or have stimulated fiber digestion (Burroughs et al., 1950; Chappell and Fontenot, 1968). It seems unlikely, then, that the levels of readily fermentable carbohydrate fed in these trials reduced fiber digestion.

Trial 2. A gain response to EP supplementation was observed above ($P<.05$) the corn starch control (figure 1). Performance increased both linearly ($P=.09$) and quadratically ($P=.09$) as EP increased. In this trial, the first addition of EP, .11 kg, promoted performance essentially equal to that of higher levels.

When data were pooled across trials, gain increased linearly ($P<.001$) and quadratically ($P<.05$) with increasing EP (figure 1). Both trials support the theory that, in spite of high crude protein contents in actively growing cool-season grasses, ruminants may still be deficient in metabolizable protein.

Forage Analysis. Analyses of fiber components yielded expected values (table 3). Crude protein of the spring trial composite was lower (10.4%) than that of the fall trial composite (13.4%; table 4). At 60% digestibility (or total digestible N [TDN]), approximately 6 percentage units of ruminally degraded protein would be needed to meet the NH_3 needs of the microorganisms (Burroughs et al., 1974). In addition, cattle usually select diets higher in protein and energy than the average of the standing forage. Esophageally collected samples the previous year from the same pastures used in these trials averaged 15.6% protein; the lowest value measured was 12.4%. Both composites contained about 50% soluble protein (table 4). Composites were also very degradable; 90.4 and 81.6% of the potentially digestible fraction degraded in 12 h for Trials 1 and 2, respectively. It is unlikely, then, that ruminal NH_3 limited performance of any of the cattle.

Rate of degradation was determined using the in situ points at 6, 12 and 18 h; rapid rates of degradation with high R^2 were obtained

TABLE 3. SMOOTH BROME FIBER ANALYSIS

Sample	NDF[a], %	ADF[b], %	Lignin, %	IVDMD[c], %
Trial 1[d]	66.9	41.5	6.7	60.1
Trial 2[e]	65.3	40.9	7.5	56.4

[a]Neutral detergent fiber.

[b]Acid detergent fiber.

[c]In vitro dry-matter disappearance.

[d]Spring trial composite.

[e]Fall trial composite.

TABLE 4. SMOOTH BROME PROTEIN COMPONENTS

Sample	Crude protein, %	Soluble protein[a], %	Degrad. 12 h[b], %	K_d[c] %/h	K_d[c] R^2
Trial 1[d]	10.4	56.5	90.4	14.0	.920
Trial 2[e]	13.4	45.2	81.6	11.7	.995

[a]Percentage of total N soluble in bicarbonate-phosphate buffer.

[b]Percentage of potentially degradable protein degraded in situ in 12 h.

[c]Rate of protein degradation, 6, 12 and 18 h in situ.

[d]Spring trial composite.

[e]Fall trial composite.

(table 4). The rates for spring and fall composites (14 and 11.3%/h) were not different ($P>.05$). Beever and Siddons (1986) reported N degradation rates in the range of 9 to 14%/h for ryegrass.

Rate of passage must be taken into account before a reliable estimate of the amount of plant protein escaping degradation can be made. Passage rates of forages with similar digestibilities to those in these studies range from 5 to 7%/h (Pond et al., 1981; Ellis and DeLaney, 1982), which equates to mean retention times of 15 to 20 h. This, coupled with the fact that about half the protein was soluble in buffer and that the remaining portion digested very rapidly, suggests that protein degradability is high in the animal.

TABLE 5. PREDICTION OF ESCAPE PROTEIN IN SMOOTH BROME

Item	Trial 1	Trial 2
Total N, % dry matter	1.63	2.14
Soluble[a], % dry matter	− .91	− .96
Acid detergent insoluble N, % dry matter	− .14	− .26
Insol. poten. degr.[b]	.57	.92
% Escape[c]	× .263	× .299
Amount of escape N	÷ .15	÷ .28
Estimated % of escape N	= 9.2%	= 13.1%

[a]Protein soluble in buffer solution.

[b]Insoluble potentially degradable plant protein (N).

[c]Estimate of the amount of a dietary component that may exit the rumen before being digested. K_p (rate of passage) = 5%/h: % Escape = $K_p/(K_p + K_d)$ = 5/(5 + 14) = 26.3% or 5/(5 + 11.7) = 29.9%.

Ellis (1978) proposed a model to estimate the proportion of a feedstuff that passes from the rumen before it is digested. This model is based on the assumption that, as the feed is consumed, some of the particles are small enough to exit the rumen immediately. Using the K_d (rate of digestion) for each composite sample (14%/h for spring and 11.7%/h for fall) and 5%/h for K_p (rate of passage) resulted in estimates of escape of 26.3 and 29.9%, respectively (table 5), of the insoluble, but potentially digestible, protein. Assuming the soluble portion is rapidly removed from the forage upon entering the rumen and degraded, this results in estimates of EP of 9.2 and 13.1% of total N intake of the composites of Trials 1 and 2, respectively (table 5).

Merrill (1984) concluded that the minimal gain response observed in a fall smooth brome grazing trial supplemented with two energy sources, corn or soyhulls, over an unsupplemented control was due to some other nutrient-limiting growth. These studies and the prediction models agree with this conclusion and suggest that the limiting nutrient was metabolizable protein.

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