Supplementation and monensin effects on digesta kinetics I. Cattle grazing summer range

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Abstract

Sixteen ruminally cannulated beef steers grazing native summer range in the Northern Great Plains were assigned to 4 treatments in a 2 × 2 factorial arrangement. Main effects were barley grain and monensin. Rolled barley (RB) containing 7.5% molasses was fed at 0 and 1.36 kg • head^{-1}• day^{-1}. Steers received no monensin (M) or M released at 101 mg/d via a ruminal delivery device. Forage intake and digestibility, ruminal fermentation, and ruminal passage rate were measured during trials in: (1) June, (2) July, and (3) August. Diet samples were collected from esophogeally fistulated steers during each trial. Dietary crude protein was greater ($P<0.05$) during trials 1 (15.2%) and 3 (14.3%) than in trial 2 (10.2%). In vivo organic matter (OM) digestibility, ruminal fluid passage rate, and fermentation variables varied by trial ($P<0.01$). Forage OM intake was reduced ($P<0.10$) by RB, but was not influenced ($P>0.10$) by M or the M and RB combination. In vivo OM digestibility was increased ($P<0.05$) by M, while RB had no effect. Particulate passage was not affected by M or RB but gastrointestinal tract fill was reduced by monensin ($P<0.05$). Ruminal fluid passage rate was affected by the RB × M × Trial interaction ($P<0.05$). Within June and July, fluid passage rate was similar among treatments and ranged from 14.0 to 11.3 %/h, respectively. During trial 3, a RB × M interaction ($P<0.05$) increased fluid passage rate. Ruminal ammonia-N concentration was similar among treatments. Barley lowered ($P<0.05$) ruminal pH and increased ($P<0.10$) total volatile fatty acids. A RB × M × Trial interaction ($P<0.05$) was noted for molar proportions of acetate, propionate, and butyrate. Within trials, RB, M, and their combination affected ($P<0.01$ to $P<0.10$) acetate, propionate, and butyrate. We conclude that barley, monensin, and forage quality influence ruminal fermentation, passage rate, and intake traits of steers grazing summer range.

Key Words: particulate passage, fluid passage, digestibility, rumen fermentation, intake, forage, barley grain

Advancing maturity of range plants during the spring-summer is associated with lower nutrient density in the forage (Adams and Short 1987) and changes in ruminal function (i.e., digesta kinetics and ruminal fermentation) in the animal (Adams et al. 1987). The economic impact of forage maturity is low rate of live weight gain or live weight loss in steers (Currie et al. 1989) and lactating cows (Adams et al. 1989). Supplemental grain and(or) monensin could potentially improve live weight gain on immature range forages and alleviate or lessen effects of advancing forage maturity on live weight gain (Goodrich et al. 1984, Wagner et al. 1984, Adams 1985), by modifying energy balance (Adams 1985) and ruminal function in the animal (Schelling 1984). Although much is known about the effect of monensin on ruminal fermentation (Schelling 1984), effects of monensin on cattle consuming range forages are not well defined. Moreover, grain supplementation studies on rangeland have generally involved cattle grazing dormant or winter forage rather than summer rangeland.

Our study evaluated the effects of supplemental grain, monensin, and their interaction on ruminal function and forage intake in steers grazing native range in the early, mid, and late summer. Supplemental grain and monensin were hypothesized to favorably influence forage intake and ruminal function, with an additional benefit from the combined use of energy and monensin.

Materials and Methods

Sixteen Angus × Hereford ruminally cannulated steers, with an average initial live weight of 292 kg, grazed native range from 16 May 1987 to 5 September 1987. The rangeland was moderately level, with deep, well-drained soils formed from alluvial sediments located on the USDA-ARS Fort Keogh Livestock and Range Research Laboratory, Miles City, Montana. Soils were primarily Borollic Camborthids of the Kobar series. Major forage species were western wheatgrass (*Pascopyrum smithii* [Rydb.] Löve), blue grama (*Bouteloua gracilis* [H.B.K.] Lag. ex Griffiths), Sandberg bluegrass (*Poa sandbergii* vasey), cheatgrass (*Bromus tectorum* L.), needle-and-thread grass (*Stipa comata* Trin. and Rupr.), green needlegrass (*Stipa viridula* Trin.), and silver sagebrush (*Artemisia cana* Pursh). Perennial forbs were rare. The majority of grass growth generally occurs by early June and ceases in early July (Reed and Peterson 1961). A more detailed description of this range and its production characteristics is given by Holscher and Woolfolk (1953) and Reed and Peterson (1961). The January through August precipitation was 312 mm compared with the 30-year average of 308 mm.

Steers were assigned randomly to 4 treatments (4 steers/treatment) in a 2 × 2 factorial arrangement. Main effects were barley and monensin. Steam-rolled barley containing 7.5% molasses (RB) was fed at either 0 or 1.36 kg • head^{-1} • day^{-1}. Barley contained 15.1% crude protein on a dry matter (DM) basis. Monensin (M) was released via a ruminal delivery device[1] (MRDD) as described by Parrott et al. (1986). Barley was fed to individual steers at 1300 daily to minimize disruption of grazing behavior (Adams 1985). The MRDD were weighed at the beginning and end of the study, and were determined by bolus weight change to have released an average of 101 mg of monensin/day. Steers received monensin and barley continuously from 15 May to 5 September.

Ruminal fermentation variables, fluid passage rates, particulate digesta kinetics, organic matter (OM) intake, and in vivo OM digestibility were measured during 3 trials while steers grazed a single 21.4-ha pasture. Trials were conducted from: (1) 1 to 6 June, (2) 13 to 18 July, and (3) 31 August to 5 September. To maintain a common forage supply for all trials, steers were moved to an

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[1]Monsensin ruminal delivery devices were supplied by Lilly Research Laboratories, Greenfield, Indiana 46104.

adjacent 40.5-ha pasture of similar botanical composition at the end of each trial. Stocking rate was considered light for this range (Reed and Peterson 1961), and forage was abundant during the early fall study period. Steers grazed in the study pasture 15 d before each trial began.

Seven days before the start of each trial, 16 mature crossbred esophageally fistulated steers were turned into the study pasture. When not grazing the study pasture, esophageally fistulated steers grazed the adjacent pasture occupied by ruminally cannulated steers between trials. At 0700, after a 1-d pasture adaptation, a mass esophageal extrusa sample was collected. Extrusa samples were composited across steers and labeled with Yb (Teeter et al. 1984) for use as a particulate phase marker. At 0700 (0 h) on day 1 of each trial, particulate passage rate and gastrointestinal DM fill were estimated by giving each ruminally cannulated steer an intraruminal pulse dose of 250 g DM of Yb-labeled forage containing an average of 4.1 g Yb (Cochran et al. 1986a). Ruminal fluid dilution rate and volume were estimated by a subsequent intraruminal dose of 1,045 mg of cobalt in a Cobaltethylene-diaminetetraacetate solution (EDTA; Uden et al. 1980).

Before dosing (0 h) with Yb-labeled forage and Co EDTA, and again at 4, 8, 12, 16, 20, 24, and 36 h after dosing, 100-ml samples of whole ruminal contents were withdrawn from the ventral sac of the rumen of each steer. The pH was determined immediately with a combination electrode, samples were then strained through four layers of cheesecloth, acidified with 2 ml of .25N H_2SO_4 and frozen for later analysis. Fecal grab samples were taken from each steer at 0, 4, 8, 12, 16, 20, 24, 28, 32, 36, 42, 48, 54, 60, 72, 84, 96, 108, and 120 h after dosing, dried at 45° C, and ground to pass a 1-mm screen.

Ruminal fluid samples were thawed at room temperature and centrifuged at 10,000 × g for 15 min. Supernatant fluid was analyzed for ammonia-N (Broderick and Kang 1980) and for Co by atomic absorption spectrophotometry with an air-acetylene flame. After addition of 2-ethylbutyric acid as an internal standard, fluid was recentrifuged at 10,000 × g for 10 min and volatile fatty acid (VFA) concentrations were determined by gas chromatography (Supelco 1975). Ruminal fluid passage rates and fluid volume were calculated by regressing the natural logarithm of Co concentration on time after dosing. Fluid dilution rate is the slope of the regression line and volume is calculated by dividing the estimated concentration of Co at 0 h into the original dose.

Ytterbium was extracted from fecal samples with .05 M EDTA (Hart and Polan 1984), and Yb concentration determined by atomic absorption spectrophotometry with a nitrous oxide/acetylene flame. Fecal Yb concentrations were fitted to a one-compartment model (Pond et al. 1982) to estimate particulate passage rate and gastrointestinal DM fill. Fecal OM output was calculated by dividing the original dose amount of Yb by the K_o parameter of the one-compartment model (Krysl et al. 1988). Intake was determined by dividing fecal OM output by forage in vivo OM indigestibility. In vivo OM digestibility was determined using the indigestible neutral detergent fiber technique described by Cochran et al. (1986b). Intake and digestibility estimates of steers receiving RB were adjusted for contribution of the supplement as described by Kartchner (1980).

Diet samples were collected by 5 mature crossbred esophageally fistulated steers from the study pasture during the third d of each 6-d trial. Esophageally fistulated steers had grazed the study pasture 2 d before each sample collection. Collections began about 0700 and lasted for 30 to 45 min. Fistula diet samples were oven dried at 45° C and ground to pass a 1-mm screen. Fistula samples were analyzed for crude protein. DM, and ash by standard methods (AOAC 1980). Neutral detergent fiber, acid detergent fiber, and acid detergent lignin were determined by the non-sequential procedures of Goering and Van Soest (1970). Indigestible neutral detergent fiber of fecal and fistula forage samples were determined as described by Cochran et al. (1986b).

Ruminal fermentation measurements, ruminal fluid volume, and fluid flow rates, along with intake, particulate passage and in vivo digestibility were analyzed by split-plot analysis of variance with the 4 treatments arranged in a 2 × 2 factorial as the main-plot and trial as the sub-plot (Gill and Hafs 1971) using the General Linear Models procedure of SAS (1985). Steer within treatment was the error term to test the main-plot and the residual was the error term to test the sub-plot. Ruminal fermentation variables were averaged across samples taken at 0, 4, 8, 12, 16, and 20 h and a mean was analyzed. Main effects were evaluated on a within-trial basis when RB × M × Trial interactions occurred. chemical composition of fistula diet samples was analyzed as a split plot with no main plot and trial as the subplot (repeated measurements). When significant ($P<0.10$), means were separated using the Least Significant Difference technique and, except where noted, significant differences are reported at the $P<0.10$ level.

Results and Discussion

Nutrient Composition

Chemical composition of esophageal masticate samples during the 3 trial periods are presented in Table 1. Plants were green and growing actively during trial 1. Between trials 1 and 2, plants completed normal spring growth and cured. Approximately 76 mm of precipitation was received between trials 2 and 3, resulting in an abundant amount of new growth during trial 3. Crude protein content of esophageal masticate was greater ($P<0.05$) during trials 1 and 3 than in trial 2. Neutral detergent fiber, acid detergent fiber, and acid detergent lignin were greatest ($P<0.05$) during trial 3.

Table 1. Chemical composition of range forage consumed by esophageal-fistulated steers.

Chemical component	Trial 1	Trial 2	Trial 3	EMS[a]
	----- % of dry matter -----			
Organic matter	87.3[b]	88.8[b]	79.4[c]	16.4
	---- % of organic matter ----			
Crude protein	15.2[b]	10.2[c]	14.3[b]	3.7
Neutral detergent fiber	81.9[b]	84.9[b,c]	89.3[c]	10.9
Acid detergent fiber	52.6[b]	50.3[b]	61.1[c]	23.4
Acid detergent lignin	7.3[b,c]	6.4[b]	10.1[c]	4.3

[a] EMS = Error mean squares.
[b,c] Row means without a common letter in their superscript differ ($P<0.05$).

Intake and Passage Rate

Forage OM intake (kg/100 kg body weight; Table 2) was not influenced by M or any significant interactions; hence, values were analyzed over trials. Overall intake values in this study were similar to those reported by Adams et al. (1987) for this study area. Forage OM intake was decreased by RB, but total OM intake (forage + barley) was similar among treatments. In contrast, Horn and McCollum (1987) reported that concentrates could be fed in amounts up to 30 g/kg metabolic body weight without affecting forage intake. Monensin did not increase forage OM intake as suggested by Ellis et al. (1983), even though forage OM digestibility was less than 65%; however, M increased ($P<0.05$) forage OM digestibility (Table 2). Organic matter digestibility was not affected by RB, although ruminal pH values (Table 4) were below those suggested for optimal fiber digestion (Mertens 1979). With regard to OM digestibility our results agree with those of Horn and McCollum (1987), who suggested that barley could be fed at levels up to 30 g/kg metabolic weight without affecting OM digestibility.

Table 2. Intake, digesta passage, fill, and digestibility as influenced by supplemental energy and monensin in steers grazing native range.

Item	Treatment[a] NR	NR+RB	NR+M	NR+RB+M	EMS[b]
Forage organic matter intake, kg • day^{-1} • 100 kg body wt^{-1}	2.0[c]	1.7	2.2	1.8	.147
Total organic matter intake, kg • day^{-1} • 100 kg body wt^{-1}	2.0	2.1	2.2	2.2	.163
Gastrointestinal tract fill, kg dry matter	3.8[d]	3.6	3.1	3.2	.675
Particulate passage rate, %/h	3.7	3.9	3.8	4.2	.338
Gastrointestinal mean retention time, h	50.3[e]	42.8	48.6	42.7	72.0
Forage organic matter digestibility, %	60.4[d]	58.6	62.2	61.7	12.7

[a] NR = native range, RB = rolled barley, M = monensin.
[b] EMS = Error mean squares.
[c] Barley effect significant ($P<0.01$).
[d] Monensin effect significant ($P< 0.05$).
[e] Barley effect significant ($P<0.05$).

Gastrointestinal tract DM fill (Table 2) was decreased ($P<0.05$) by M. Particulate passage rate tended to increase ($P = 0.13$) and gastrointestinal mean retention time decreased ($P<0.05$) when RB was fed but neither were affected by M. Forage and total OM intake, gastrointestinal tract fill, particulate passage rate and gastrointestinal mean retention time, and OM digestibility all varied ($P<0.01$) by trial; but treatment × trial interactions were non-significant.

Ruminal fluid dilution rate and turnover time (Table 3) were analyzed with trial because of a RB × M × Trial interaction ($P<0.05$). During trials 1 and 2, no treatment differences were detected for fluid passage rate or turnover time. During trial 3, a RB × M interaction ($P<0.05$) was detected for fluid passage rate and turnover time, with barley producing an added effect when combined with M. Fluid passage rate and turnover time were greater and less, respectively, for steers receiving RB + M than for steers fed RB alone. Fluid passage rate and turnover time values are comparable to values reported by Adams et al. (1987) on a similar range. Fluid passage rate and turnover time values reported in a New Mexico study (Branine 1987) were less and slower, respectively, than values reported here. Ruminal fluid volume and flow rate were similar for all treatments but varied ($P<0.05$) by trial. Adams et al. (1987) reported greater ruminal fluid volumes and flow rates on a similar range. Reported decreases (Lemenager et al. 1978) in fluid passage rate and volume as a result of feeding monensin with a low quality forage were not observed in the present study.

Table 3. Ruminal fluid flow and volume as influenced by supplemental energy and monensin in steers grazing native range.

Trial	Treatment[a] NR	NR+RB	NR+M	NR+RB+M	Mean	EMS[b]
	Fluid Passage rate, %/h					
1	14.0	14.0	14.3	14.5	14.2	1.42
2	11.3	11.6	12.0	13.0	12.0	2.10
3[c]	12.5	10.4	11.2	12.8	11.7	1.62
Mean[d]	12.7	12.0	12.5	13.4		
	Turnover time, h					
1	7.2	7.2	7.0	6.9	7.1	.361
2	8.9	8.6	8.5	7.8	8.4	1.15
3[c]	8.0	9.6	9.1	7.9	8.7	.954
Mean[d]	8.0	8.5	8.2	7.5		
	Flow rate, liter/h[e]					
1	3.8	3.3	2.8	3.8	3.4	
2	4.3	5.0	5.6	4.6	4.8	
3	2.8	3.2	4.0	4.3	3.6	
Mean	3.6	3.8	4.2	4.2		5.02
	Volume, liters[e]					
1	27.9	23.5	19.3	26.7	24.4	
2	36.2	43.9	47.4	36.0	40.9	
3	22.9	30.7	36.9	34.9	31.3	
Mean	29.0	32.7	34.6	32.5		411.7

[a] NR = native range, RB = rolled barley, M = monensin.
[b] EMS= Error mean squares.
[c] Barley × monensin interaction ($P<0.05$).
[d] Barley × monensin × trial interaction ($P<0.05$), therefore analyzed within trial.
[e] Trial differences ($P<0.05$).

Ruminal Fermentation

Ruminal pH was decreased ($P<0.05$) by RB and varied ($P<0.01$) by trial (Table 4). This finding contrasts work reported by Branine (1987) in which grain supplementation of steers grazing summer blue grama rangeland had no effect on ruminal pH. Steers in our study consumed 36% more grain/day than those in Bramine's study which may explain the difference in pH response to grain. Further, Branine (1987) fed corn rather than barley grain, which further complicates comparison of results. Barley starch typically has a greater extent of digestion in the rumen than corn (Theurer 1986). Adams et al. (1987) reported slightly greater pH values than those observed in the present study for steers grazing a comparable range.

Table 4. Ruminal pH and ammonia-N concentration as influenced by supplemental energy and monensin in steers grazing native range.

Trial	Treatment[a] NR	NR+RB	NR+M	NR+RB+M	Mean[b]
	pH				
1	6.3	6.0	6.1	6.1	6.1
2	6.2	6.1	6.4	6.3	6.3
3	5.9	5.8	6.0	5.9	5.9
Mean[c]	6.1	6.0	6.2	6.1	(0.98)[d]
	Ammonia-N mg/100 ml				
1	12.2	14.1	12.6	11.5	12.6
2	3.1	3.8	2.5	3.7	3.3
3	21.0	20.6	19.3	18.6	19.9
Mean	12.1	12.8	11.5	11.3	(16.2)[d]

[a] NR = native range, RB = rolled barley, M = monensin.
[b] Trial difference for pH and ammonia-N ($P<0.01$).
[c] Barley effect significant ($P<0.05$).
[d] Error mean squares for treatment.

Ruminal ammonia-N was similar for all treatments, but varied ($P<0.01$) by trial (Table 4). Dinius et al. (1976) also found no significant effect of M on ruminal ammonia-N concentration. If monensin altered ruminal degradation of dietary protein as reported in other studies (Chalupa 1980) it was not reflected in ruminal ammonia concentration. Greater concentrations of ammonia-N in trials 1 and 3 reflect the greater concentration of protein in the diet (Roffler and Satter 1975). Low concentrations of ammonia-N in trial 2 also may have been influenced by increased ruminal fluid volume. Concentrations of ammonia-N observed during trial 2 approached what may be the lower limit for optimum microbial protein synthesis (Slyter et al. 1979).

Total ruminal VFA concentration (Table 5) was greatest for steers receiving RB and varied ($P<0.01$) by trial. This result contrasts work by Branine (1987) in which supplemental grain had no

Table 5. Ruminal concentration of total volatile fatty acids (VFA) and molar proportions of individual VFA as influenced by supplemental energy and monensin in steers grazing native range.

Trial	Treatment[a] NR	NR+RB	NR+M	NR+RB+M	Mean	EMS[b]
			Total VFA, mM[c]			
1	65.6	71.4	64.1	83.1	71.3	
2	76.5	79.0	63.6	74.1	73.5	
3	83.6	84.5	72.4	84.7	81.5	
Mean[d]	75.3	78.8	66.9	80.9		59.6
			Acetate, mol/100 mol			
1[e]	48.4	47.0	42.0	62.1	49.8	60.7
2[f,g]	74.1	71.3	73.3	69.1	72.0	1.47
3	72.2	71.1	72.4	70.6	71.5	3.04
Mean[h]	64.8	62.9	62.8	67.2		
			Propionate, mol/100 mol			
1[e]	29.8	30.0	35.5	22.9	29.6	33.1
2[d,g]	15.7	16.5	16.8	19.3	17.1	1.91
3[i]	16.7	16.9	17.5	18.2	17.3	1.33
Mean[h]	20.8	21.3	23.1	20.1		
			Butyrate, mol/100 mol			
1[e]	16.0	17.4	16.5	11.1	15.2	3.65
2[f]	8.0	9.8	7.5	9.1	8.6	.883
3[f,i]	8.0	8.9	7.3	8.4	8.1	.394
Mean[h]	10.7	12.1	10.3	9.5		
			Valerate, mol/100 mol			
1[e]	1.65	1.80	1.77	1.22	1.61	.075
2[f]	.67	.82	.60	.93	.75	.013
3	.83	.98	.76	.92	.87	.025
Mean[j]	1.05	1.21	1.03	1.02		
			Isovalerate, mol/100 mol			
1	2.27	1.99	2.34	1.43	2.00	
2	.71	.84	.72	.79	.76	
3	1.33	1.23	1.20	1.12	1.22	
Mean	1.44	1.37	1.39	1.11		.16
			Isobutyrate, mol/100 mol[c]			
1	1.97	1.81	1.98	1.33	1.77	
2	.79	.78	.97	.84	.84	
3	.97	.84	.89	.84	.88	
Mean	1.25	1.15	1.26	1.00		.040

[a] NR = native range, RB = rolled barley, M = monensin.
[b] EMS = Error mean squares.
[c] Trial difference ($P<0.01$).
[d] Barley effect significant ($P<0.10$).
[e] Barley × monensin interaction ($P<0.05$).
[f] Barley effect significant ($P<0.01$).
[g] Monensin effect significant ($P<0.05$).
[h] Barley × monensin × trial interaction ($P<0.05$), therefore analyzed within trial.
[i] Monensin effect significant ($P<0.10$).
[j] Barley × monensin × trial interaction ($P<0.01$), therefore analyzed within trial.

effect on total ruminal VFA concentration. As noted earlier, Branine (1987) fed lesser amounts, and a different type of grain, than was fed in the present study. Total ruminal VFA concentration may have increased for steers receiving RB because of the readily fermentable carbohydrate from the grain (Van Soest 1982). Monensin had no effect on total VFA with concentrations being similar to those reported by Dinius et al. (1976).

Ruminal acetate, propionate, butyrate, and valerate were analyzed within trial because of a RB × M × Trial interaction ($P<0.05$). During trial 1, a RB × M interaction ($P<0.05$) occurred for the molar proportion of ruminal acetate, and residual errors appeared to be unevenly distributed. Ruminal acetate was greater when RB was combined with M than when RB was fed alone. During trial 2, both RB and M decreased ($P<0.05$) ruminal acetate. No treatment differences were observed for ruminal acetate during trial 3. Higher acetate levels observed in trials 2 and 3 may have been associated with declining forage quality because acetate is often reflective of cell wall fermentation (Van Soest 1982); therefore, an increase in acetate level as the forage matured between trials 1 and 2 and 3 was expected. However, the low levels of acetate in trial 1 were much less than expected. It is doubtful that a smaller amount of cell wall fermentation would explain the large difference in acetate levels between trial 1 and trials 2 and 3, but a further explanation is not apparent. Except trial 1, ruminal acetate levels are comparable to those reported by Adams et al. (1987).

A RB × M interaction ($P<0.05$) occurred for the molar proportion of ruminal propionate during trial 1 and residual errors appeared to be unevenly distributed. In trial 1, ruminal propionate was less when RB was combined with M than when RB was alone. During trial 2, both RB and M increased ruminal propionate. Branine (1987) reported no difference in ruminal propionate resulting from the addition of a lower amount of corn grain than fed in the present study. Ruminal propionate proportions would be expected to increase with addition of supplemental grain because of the direct association propionate has with readily fermentable carbohydrate fermentation (Van Soest 1982). Ruminal propionate was increased by M during trial 3. In general, propionate levels, especially in trial 1, were greater than previously reported in research from this range type (Adams et al. 1987).

A RB × M interaction ($P<0.05$) occurred for the molar proportion of ruminal butyrate during trial 1. In trial 1, ruminal butyrate was less when RB was combined with M than when RB was alone. During trials 2 and 3, RB increased ($P<0.01$) ruminal butyrate. Branine (1987) observed no effect on ruminal butyrate from smaller amounts of supplemental corn grain. Monensin also decreased ruminal butyrate during trial 3. High butyrate proportions observed in trial 1 are typically associated with steers grazing actively growing forage (McCollum et al. 1985, Krysl et al. 1987).

Minor VFA are presented in Table 5. A RB × M interaction ($P<0.05$) occurred for the molar proportion of ruminal valerate during trial 1. Ruminal valerate was less when RB was combined with M than when RB was fed alone. During trial 2, RB increased ($P<0.01$) ruminal valerate. Molar proportions of ruminal isovalerate and isobutyrate showed no differences as a result of treatment, but varied ($P<0.01$) by trial. Increased proportions of branched-chained fatty acids observed during trials 1 and 3 probably resulted from greater forage protein content because branched-chain acids are derived primarily from degradation of dietary protein (Orskov 1982).

Conclusions

Supplemental energy and monensin, either separately or in combination, had varying effects on intake, particulate digesta, and ruminal fluid flow kinetics, and ruminal fermentation variables. Forage maturity affected intake, digestibility, passage of particulate, and fluid passage and ruminal fermentation. Forage maturity also interacted with barley and(or) monensin for some of these same variables. We conclude that monensin and grain supplementation may be viable methods to improve and sustain performance of cattle grazing summer range. A primary benefit from supplemental grain and M would be increased molar proportions of propionate and reduced proportions of acetate that would have favorable effects on protein and energy metabolism by the grazing animal. Monensin may provide an additional energetic benefit from enhanced forage digestibility.

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