METHANE PRODUCTION BY STEERS ON PASTURE

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ABSTRACT
Grazing system, stocking rate and monensin controlled release capsule (CRC) administration were investigated to determine impacts on methane (CH_4) production by steers grazing alfalfa (*Medicago sativa* L.)/meadow bromegrass (*Bromus biebersteinii* Roem & Schult.)/Russian wildrye (*Psathyrostachys juncea* (Fisch.) Nevski) pastures. Pasture treatments consisted of 2 replications each of two grazing systems (continuous stocking or 10-paddock rotational stocking) at each of two stocking rates (low, 1.1 steer ha^{-1} or high, 2.2 steers ha^{-1}). Half of the animals in each pasture were administered a monensin CRC while untreated animals served as controls. During the grazing season, 1 steer per treatment combination (n = 16) was sampled on four occasions for a 24 h period. Chemical composition of diets was affected by grazing management and sampling date, however, voluntary intake (x = 13.8 kg d^{-1}) and methane production (x = 0.69 ± 0.1L•kg BW^{-1}•d^{-1}) were unaffected by grazing treatment or sampling period. The energy lost through eructation of methane averaged 8.9% of gross energy intake.

KEYWORDS
Methane, cattle, environment, digestion efficiency, pasture, forage

INTRODUCTION
The production of methane (CH4) by cattle and other ruminant livestock has recently become a subject of scientific debate. It has been estimated that ruminant livestock may be responsible for as much as 15% of the world's output of CH4 (Crutzen et al. 1986) and therefore may be contributors to global warming. Most studies have measured methane gas production using respiration chambers in which animals were fed conserved feedstuffs (Blaxter and Clapperton, 1965). However, this may not accurately reflect normal rumen fermentation patterns in pastured animals. Ionophores such as monensin may modify rumen fermentation so that less methane gas is produced during digestion (Schelling 1984). The recent development of an intraruminal controlled release capsule delivering monensin (CRC; Provel/Elanco, Guelph, ON) makes it theoretically possible to reduce methane production by free ranging cattle without the need for supplemental feeding. Currently, no published information exists documenting methane production by cattle under range or pasture conditions. Thus, the purpose of this study was to determine the effects of grazing management (grazing system and stocking rate), diet quality, voluntary intake and ionophore use on methane production by steers grazing alfalfa/grass pastures.

METHODS
In the 1994 grazing season, forty-eight steers and eight-3.7 ha pastures were used to determine the effect of grazing system, stocking rate and monensin bolus administration on CH4 production by steers. All pastures were of similar composition (approximately 70% alfalfa (*Medicago sativa* L.), 20% meadow bromegrass (*Bromus biebersteinii* Roem And Schult.) and 10% Russian wildryegrass (*Psathyrostachys juncea* (Fisch.) Nevski)). Treatments consisted of various combinations of grazing system (continuous stocking or 10-paddock rotational stocking) and stocking rate (low, 1.1 steers ha^{-1} or high, 2.2 steers ha^{-1}), with 2 replications of each pasture treatment. Half of the animals on each grazing treatment received a monensin controlled release capsule (CRC) and the remainder were untreated. One steer on each treatment combination was selected at random from each pasture to monitor CH_4 production on four occasions during the 1994 grazing season.

Diet quality was monitored using esophageally fistulated steers fitted with sample collection bags. Samples were analysed for CP (AOAC 1984, method 7.025), ADF and NDF (Goering and Van Soest 1970), ash (AOAC 1984, method no. 7.009) and IVOMD (Tilley and Terry 1963). Gross energy was determined using a Parr adiabatic bomb calorimeter (model 1241). Fecal output was determined using chromium sesquioxide (Cr_2O_3) controlled release capsules (Captechrome, Nufarm Ltd., New Zealand) and IVOMD of pasture samples was used to estimate voluntary intake of digestible organic matter. Methane gas production was determined by the SF_6 tracer gas method (Johnson et al. 1994). A gas chromatograph (Star 3000, Varian, Mississauga, ON) fitted with both electron capture (EC) and flame ionization (FID) detectors was used for determination of SF_6 and CH_4, respectively. The experiment was analysed by analysis of variance (SAS 1985) as a split-split-plot experiment where main plots were combinations of grazing system and stocking rate, monensin treatment was the sub-plot and sampling date was the sub-sub-plot.

RESULTS AND DISCUSSION
Diet quality. Diet quality of steers grazing alfalfa/grass pastures changed over the course a grazing season in the case of continuously grazed pastures and changes from paddock entry to paddock exit in the case of rotationally grazed pastures. Overall, CP content of diets ranged from 8.3 to 25.0%, IVOMD ranged from 47.7 to 69.8 %, ADF ranged from 23.7 to 52.1 % and NDF ranged from 31.0 to 72.2 % depending on grazing management treatment and sampling period. Ash and gross energy content of diets were not affected by treatment and averaged 12.23 % and 4.21 Mcal kg^{-1}, respectively. In general, diet quality was greater in June when esophageal extrusa often had greater ($P < 0.05$) levels of CP and IVOMD; and lower ($P < 0.05$) levels of ADF and NDF than they did during the August sampling period.

Performance, intake and methane production. Steer weights differed between treatments and ranged from 380.1 kg for steers continuously grazed at high stocking rates to 417.1 kg for steers rotationally grazed at high stocking rates (Table 1). Steers on low stocking rate treatments were heavier ($P < 0.05$) than steers on high stocking rate treatments for both grazing systems tested. Average daily gain was greatest (1.48 kg d^{-1}) for steers on lightly stocked, continuously grazed pastures and lowest (1.07 kg d^{-1}) for steers on heavily stocked, continuously grazed pasture, while steers on rotationally stocked pastures at both high and low stocking rates (1.26 and 1.29 kg d^{-1}, respectively) were intermediate. Neither grazing management nor sampling period affected steer dry matter intake (x=13.8 kg), organic matter intake (x=12.5 kg) or gross energy intake (x = 58.8 Mcal d^{-1}).

Methane production was greatest for steers which were continuously grazed at low stocking rates and least for steers continuously grazed at high stocking rates ($P < 0.05$; 306.7 vs. 242.2 L d^{-1}). Methane production rates by rotationally grazed steers at both high and low stocking rates were intermediate between these two values (263.8 and 280.1 L d^{-1}, respectively). However, when methane production measurements were compared on a per kg of body weight basis, no differences were found between grazing management treatments (x = 0.69 L kg BW^{-1} d^{-1}). The energy lost through eructation of methane averaged 8.9% of gross energy intake which is similar to estimates reported in the literature for forage fed cattle (Blaxter and Clapperton 1965; Johnson and Huyler 1994).

Despite the wide range in diet quality, no differences in voluntary intake or methane production were observed and reliable equations predicting methane production by steers could not be developed. No benefits were observed from administering monensin controlled release capsules in terms of animal performance, voluntary intake or methane production (Table 2). It does not appear that daily methane production of steers grazing alfalfa/grass pastures can be easily altered by changes in grazing management. Methane production and voluntary intake remained relatively constant regardless of variations in diet quality.

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Table 1
Effect of grazing system and stocking rate on animal performance, intake and methane production by yearling steers grazing alfalfa/grass pastures

	Rotational stocking		Continuous stocking			
Parameter	High	Low	High	Low	SEM	P-value
Weight (kg)	391.5bc	417.1a	380.1c	402.6b	3.9	0.0001
ADG (kg d-1)	1.26b	1.29b	1.07c	1.48a	0.1	0.0001
DM Intake (kg d-1)	14.94	13.61	13.51	13.20	0.88	NS
OM Intake (kg d-1)	13.29	12.40	12.17	12.09	0.91	NS
GE Intake (Mcal d-1)	62.57	58.25	57.36	56.16	4.23	NS
Methane (L d-1)	263.8ab	280.1ab	242.2b	306.7a	24.2	0.0325
Methane (L kg-1d-1)	0.67	0.67	0.64	0.77	0.06	NS
Methane (% of GEI)	8.1	8.5	8.6	10.3	2.7	NS

a,b,c Different postscripts denote significant differences (P<0.05) between grazing treatments using SNK test.

Table 2
Effect of monensin CRC administration on animal performance, intake and methane production by yearling steers grazing alfalfa/grass pastures

	monensin treatment			
Parameter	- monensin	+ monensin	SEM	P-value
Weight (kg)	399.5	396.1	5.6	NS
ADG (kg d-1)	1.30	1.24	0.06	NS
DM Intake (kg d-1)	13.2	14.5	0.95	NS
OM Intake (kg d-1)	11.9	13.1	0.83	NS
GE Intake (Mcal d-1)	55.8	61.5	4.1	NS
Methane (L d-1)	278.3	268.1	21.0	NS
Methane (L kg-1d-1)	0.70	0.68	0.05	NS
Methane (% of GEI)	9.96	7.86	0.73	NS