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Repeatability of methane production in cattle fed concentrate and forage diets*

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ABSTRACT

Eight Angus steers whose methane emissions had had been found to be higher or lower than predicted when fed a commercial feedlot diet were re-tested on a medium quality forage diet. Methane emissions were within published ranges (136.4 g d^{-1}), but differences in actual vs predicted production between high and low ranked animals were diminished and several animals changed in rankings. This suggests that methane emission characteristics may not persist over time, and that any selection of animals for low methane emission may need to be diet specific.

KEY WORDS: methane, ruminant, sulphur hexafluoride, forage

INTRODUCTION

Anthropogenic methane production is a significant contributor to the greenhouse effect, and approximately 12% of this is generated by ruminants (Crutzen et al., 1986). Opportunities for amelioration of methane production by ruminants may include: a. selection for animals which produce relatively less methane, and/or b. dietary manipulation or management of animals' internal environment which predispose them to the production of lower levels of methane.

Blaxter and Clapperton (1965) observed that animals produce relatively more methane per unit energy intake on forage rather than concentrate but an important question that has remained unresolved is whether animals that are assessed as high or low CH_4 emitters on one type of diet retain the characteristic or rank on other feed types.

Direct measurement of methane production in respiratory chambers is constrained by the relatively small number of animals that can be screened for

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methane production. The development of indirect techniques using tracer gases (Johnson et al., 1994) has facilitated the screening of relatively large numbers of animals in the field. This has led to identification of animals that exhibit higher or lower methane production than would be expected based on body size and intake (Pinares-Patiño et al., 2003; Hegarty et al., 2004).

The purpose of this trial was to determine if cattle producing more or less methane than expected demonstrate this characteristic when changed from a concentrate to an exclusively forage diet.

MATERIAL AND METHODS

Animal management and feeding

In a preceding study, methane production had been individually measured on 91 Angus steers fed a commercial feedlot diet (12.1MJ ME/kg DM, 16.0% CP, 100ppm Rumensin®). CH_4 production was expressed as a percentage of that predicted by the general equation of Blaxter and Clapperton (1965) and a subset of steers producing more (HIGH emitters; n=6) or less (LOW emitters; n=6) CH_4 than predicted was identified. Emissions from these were measured again on the same feedlot diet (Period 1). The cattle were then depastured for several months.

Eight animals (627±49.2 kg) were selected for further study (Period 2) and CH_4 production re-measured, during which the animals were housed individually in adjacent feedlot pens (15 m × 25 m) with unrestricted access to water and chaffed forage sorghum hay (*Sorghum bicolour c.v.* Superdan; 8.1 MJ ME/kg DM, 11.2% CP). Animals were adapted to the diet for 15 d before measurements were made, with *ad libitum* feed provided once daily, and refusals collected and weighed. During the measurement period, feed and refusals were sub-sampled daily and analysed (DM, CP, ADF, NDF and ME) at the trial's end.

Methane measurement

Enteric CH_4 production was measured using the sulphur hexafluoride (SF_6) tracer technique (Johnson et al., 1994) as modified by Hegarty et al. (2003). The SF_6 tracer gas was released at a known rate from permeation tubes placed per os in each steer's rumen prior to commencement of gas collection. Expired air was drawn continuously into an evacuated canister fitted to each animal's back *via* a capillary tube from tubes placed immediately above each animal's nose (attached to a headstall). Collection took place over 5 sequential, 2 day periods with background samples of CH_4 and SF_6 collected from 2 locations adjacent to the animals' pens.

Methane concentrations were measured using an Innova 1312 multi-gas analyser (Air Tech Instruments), and SF_6 concentrations measured using gas chromatography (Goldsack et al., 1979). Samples having less than 1ppb SF_6 or 30 ppm CH_4 were eliminated from the study. CH_4 emission was calculated by

proportion (Johnson et al., 1994) and additionally expressed as a percentage of that predicted by the general equation of Blaxter and Clapperton (1965).

RESULTS

Overall mean CH_4 production in Period 2 was 136.4 gd^{-1} and did not differ between those steers that were identified as HIGH emitters or LOW emitters in the preliminary screening and in Period 1 (Table 1). HIGH and LOW emitters showed less divergence in CH_4 production than in the earlier two studies and several animals changed from being more than, to less than predicted.

Table 1. Actual and predicted methane emissions on concentrate[2] and forage based diets

Animal, ID		Initial screening concentrate diet		Period 1 concentrate diet		Period 2 forage diet	
		CH_4, g produced	CH_4 (%) of predicted[1]	CH_4, g produced	CH_4, % of predicted[1]	CH_4, g produced	CH_4, % of predicted[1]
HIGH emitters	145	376	169	173	74	127	95
	102	328	148	243	101	212	119
	134	308	133	204	77	115	69
LOW emitters	338	140	75	151	69	110	69
	93	134	59	92	46	162	97
	360	134	58	155	62	116	67
	322	109	50	103	47	113	83
P value			0.0003		0.038		0.328

[1] methane predicted to be produced from the equation of Blaxter and Clapperton (1965)
[2] results of earlier studies (Hegarty et al., 2004) are re-produced for comparison purposes

Methane production per unit of feed intake was also higher on the forage diet, increasing from a mean of 1.34 g to 2.26 g CH_4/MJ ME intake.

DISCUSSION

Between animal variation in CH_4 production has been quantified (Blaxter and Clapperton, 1965; Uylatt et al., 1999) and potential physiological mechanisms underlying genetic differences in ruminant digestion and CH_4 production have recently been reviewed (Hegarty, 2004). The findings in this study that the characteristic of steers identified as HIGH or LOW CH_4 emitters was not maintained across diet types challenges the robustness of genetic selection of low CH_4 emitting cattle. Similar results were observed in sheep (Pinares-Patino et al., 2003) where ranking of animals on the basis of emissions changed with alterations in the composition of diets. Genotype x nutrition interactions are recognized

for many livestock production traits, and the results of this study indicate that selection for low methane production in cattle will need to be diet-specific. Failure of the general equation used to adequately reflect methane emissions also suggests that work needs to be done to develop more robust predictors of CH_4 emission in ruminants.

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