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Effects of grazing willow fodder blocks upon methane production and blood composition in young sheep

C.A. Ramírez-Restrepo[a,*], T.N. Barry[b], A. Marriner[c], N. López-Villalobos[b], E.L. McWilliam[b], K.R. Lassey[c], H. Clark[a]

[a] *Ruminant Nutrition, Climate, Land & Environment, AgResearch Limited, Grasslands Research Centre, Tennent Drive, Private Bag 11 008, Palmerston North, Manawatu 4442, New Zealand*
[b] *Institute of Veterinary, Animal and Biomedical Science, Massey University, Private Bag 11 222, Palmerston North, New Zealand*
[c] *National Institute of Water and Atmospheric Research, Private Bag 14 901, Wellington, New Zealand*

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ABSTRACT

A 79-day rotational grazing experiment was conducted over the summer and autumn of 2007 to compare effects of grazing willow (*Salix* spp.) fodder blocks, a combination of small trees (*i.e.*, 1.0 m) and herbage, or perennial ryegrass (*Lolium perenne*)/white clover (*Trifolium repens*) control pasture on breath methane (CH_4) emissions, concentrations and solubility of CH_4 and sulphur hexafluoride (SF_6) tracer gas in blood, and haematology variables in young growing female sheep (*i.e.*, hoggets). Measurements of gases in blood followed a double equilibration technique with two ($n = 20$) replicate per treatment. Ten ewe hoggets in each replicate were dosed on day 22 with intraruminal slow release SF_6 capsules, an inorganic tracer gas used to calculate CH_4 emissions. Breath samples were collected over 5-day periods in weeks 5 (period 1) and 11 (period 2). Total condensed tannin (CT) concentrations calculated in the diet selected by the willow fodder block sheep was 12 g CT kg/dry matter intake, with negligible amounts in control pasture hoggets. Compared to control pasture, grazing willow fodder blocks reduced CH_4 emission/kg metabolic body weight ($BW^{0.75}$) by 20% in period 1 ($P<0.01$), but not in period 2. Blood CH_4 concentrations (ng/mL blood) were similar for both groups on day 36, but higher ($P<0.001$) on day 76 for hoggets grazing willow fodder blocks, while a different trend was observed for SF_6 blood concentration being higher ($P<0.01$) on day 36 in hoggets grazing willow fodder blocks, but similar in both groups on day 76. Repeatability of blood CH_4 concentration was 75% in period *versus* 84% in period 2. Methane and SF_6 Ostwald solubility coefficients in blood were similar in both periods for sheep grazing willow fodder blocks and the control pasture. Hoggets grazing willow fodder blocks had lower BW gain (65 g/day), carcass weight (16.1 kg) and carcass fatness (9.2 mm) than hoggets grazing control pasture (102 g; 18.3 kg; 11 mm). Hoggets dosed with SF_6 capsules had lower ($P<0.05$) red blood cells, haemoglobin and haematocrit concentrations when grazing either willow fodder blocks or control pasture, while neutrophil ($P=0.063$), platelet ($P=0.073$) and monocyte ($P=0.072$), white blood cell and total lymphocyte counts ($P<0.05$) were higher for willow

Abbreviations: $BW^{0.75}$, metabolic body weight; CT, condensed tannins; CW, carcass weight; DM, dry matter; GC, gas chromatography; GHG, greenhouse gas; GR, carcass fatness; HB, haemoglobin; HCT, haematocrit; L, Ostwald solubility coefficient; MCH, mean cell haemoglobin; MCHC, mean cell haemoglobin concentration; NIWA, National Institute of Water and Atmospheric Research, New Zealand; PVC, polyvinyl chloride; RBC, red blood cells; SF_6, sulphur hexafluoride; WBC, white blood cells.

* Corresponding author. Tel.: +64 6 351 8111; fax: +64 6 351 8032.
E-mail address: carlosramirez720@yahoo.com (C.A. Ramírez-Restrepo).

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fodder block-fed hoggets than those fed the control pasture. Differences in the reduction in CH_4 emission between periods from grazing willow fodder blocks may be due to more willow leaf being eaten during the CH_4 measurement period in period 1 than in period 2.

1. Introduction

Greenhouse gas (GHG) emissions from livestock in traditional farming systems are of increased worldwide concern. This is because those emissions, predominantly of methane (CH_4) and nitrous oxide (N_2O), are major contributors to their respective anthropogenic inventories, and with livestock populations growing to meet an increasing global demand for food, emissions will increase concomitantly.

A recent assessment (Steinfeld et al., 2006) suggests that pastoral farming is responsible for 0.09, 0.37, 0.64 and 0.65 of the anthropogenic carbon dioxide (CO_2), CH_4, ammonia (NH_3) and N_2O net emissions, respectively. In New Zealand and Australia in 2005, GHG from enteric fermentation in grazing ruminants comprised 0.97 and 0.87 of the agricultural CH_4 emissions and 0.31 and 0.11 of the national GHG inventories (Lassey, 2008). Consequently, in relation to common objectives under the Kyoto Protocol, CH_4 mitigation from pastoral livestock is an important task for New Zealand if sustainable development and environmental integrity in grazing systems are to be achieved (Ramírez-Restrepo and Barry, 2005; Waghorn and Woodward, 2006).

Use of forages containing condensed tannins (CT) and other secondary compounds has demonstrated positive outcomes for CH_4 mitigation, increased animal productivity and improved parasite management in some instances (Ramírez-Restrepo and Barry, 2005). These outcomes appear to depend on CT concentration and their astringency (Waghorn, 2008), but there is no information on effects of feeding forage trees containing CT on CH_4 emissions of ruminants.

The first objective of this study was to examine the association between grazing willow (*Salix* spp.) fodder blocks, which also contain herbage, or perennial ryegrass (*Lolium perenne*)/white clover (*Trifolium repens*) pasture on CH_4 emissions and growth of young sheep. The second objective was to measure effects of the grazing treatments on blood composition, including concentrations and solubility coefficients of CH_4 and sulphur hexafluoride (SF_6) introduced to hoggets as an intraruminal tracer gas in the blood at eight months of age.

2. Materials and methods

2.1. Experimental design

A grazing experiment involving 80 Suffolk × Romney ewe hoggets was carried out from 14 February 2007 to 4 May 2007 (79 days) at Massey University's Riverside dryland farm, near Masterton in the Wairarapa on the the East Coast of Southern North Island of NZ (40°50′40″S, 175°73′00″E). The experimental procedure was approved by the Massey University Animal Ethics Committee, AEC 06/119, Palmerston North, NZ.

Hoggets were balanced for body weight (BW) and randomly allocated to pasture ($n = 40$) or willow fodder block ($n = 40$) treatments. There were two ($n = 20$) replicates of each treatment. All hoggets were drenched at the start of the experiment (day 0) with a combination of albendazole, ivermectin and levamisole anthelmintics (Erase MPC plus Scanda Coopers, Schering-Plough, Upper Hutt, NZ) and again at the end of the fourth week (day 28). Half of each replicate group was dosed with slow release SF_6 capsules (brass tubes) prepared by NIWA (National Institute of Water and Atmospheric Research, NZ; Lassey et al., 1997, 2001) on 8 March 2007 (day 22), to be used as a tracer gas for estimating daily emissions of CH_4 in the breath of the hoggets.

Solubility coefficients for both CH_4 and SF_6 gases in jugular blood were determined on heparinised samples collected from all SF_6 dosed hoggets on days 36 and 76. Haematology analysis was performed on jugular blood samples collected into vacutainers (BD, Franklin Lakes, NJ, USA) containing EDTA (ethylenediamine tetraacetic acid) on day 76 from all SF_6 dosed hoggets and from 10 non-dosed hoggets grazing both willow fodder blocks and perennial ryegrass/white clover pasture treatments.

2.2. Forages

The hoggtes grazed either willow (*Salix* spp.) fodder blocks or perennial ryegrass/white clover (*L. perenne*/*T. repens*) as the control pasture. Establishment and management of the willow fodder blocks were described by Pitta et al. (2005). Briefly, in winter 2001 branches of the willow specie (*Salix matsudana* Koidz × *alba* L.; cultivars Moutere NZ1184 and Tangoio NZ 1040) were harvested and cut into 700 mm lengths at the Greater Wellington Regional Council's Akura nursery near Masterton, NZ. Before planting, areas of low-lying wet hill slope soil (Pollok et al., 1994), inappropriate for grazing livestock were mechanically mowed and sprayed with Roundup® (glyphosate, Monsanto, St. Louis, MO, USA) 30 days later. Soil compaction was alleviated by mechanically digging rows in the soil (*i.e.*, ripping) to improve root development and penetration. Cuttings were planted half into the soil and spaced at 1200 mm with a density of 6000 trees/ha. Unimproved herbage grown between