Methane emissions from farmed red deer

A thesis in partial fulfillment of the requirements for the
degree of Master of Science in Animal Science
at Massey University, Palmerston North.

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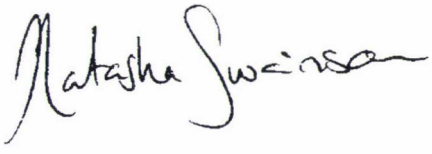
DECLARATION

The studies presented in this thesis were completed by the author while a post-graduate student in the Institute of Food Nutrition and Human Health, College of Sciences, Massey University, Palmerston North, New Zealand. This is all my own work and the views presented are mine alone. Any assistance received is acknowledged in the thesis.

I officially state that the contents of the thesis have not been submitted for any other degree and are not currently being submitted for any other degree. I certify that to the best of my knowledge, any help received in preparing this thesis, and all sources used, have been acknowledged in the thesis.



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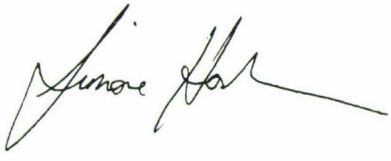

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ABSTRACT

Methane (CH_4) is one of the end products of fermentation of ingested feed by the microbial population residing in the foregut of ruminants. It represents a potential loss of 2-12% of gross energy consumed, and is a potent greenhouse gas. The objective of this study was to firstly measure methane emissions for the first time using the sulfur hexafluoride tracer technique in red deer (*Cervus elahus*) grazing ryegrass-based pasture *(Lolium perenne*) and secondly, to compare methane emissions of deer grazing chicory (*Cichorium intybus*) and plantain (*Plantago lanceolata*) with those grazing ryegrass-based pasture.

Methane production per day and per kg of dry matter intake (DMI) was measured using the sulfur hexafluoride tracer technique coupled the with η-alkane technique for feed intake estimation in 25 red deer grazing ryegrass-based pasture, chicory or plantain in March and May of 2003. Methane production per unit DMI obtained in this study (37.8 g / kg DMI) was approximately 75-80% greater than values used in the New Zealand National Greenhouse Gas Inventory for dairy cows and sheep, and estimated for deer grazing ryegrass-based pastures. Deer grazing chicory and plantain in March exhibited lower methane emissions per kg DMI compared with ryegrass-based pasture. However, in May methane emissions per kg of DMI from plantain was similar to pasture, which were both higher compared with chicory. The variability and accuracy of results obtained for estimated DMI using the alkane technique was questioned, and a lack of published information regarding methane production by red deer provided few possible explanations for the apparently high methane emissions. This prompted the initiation of an indoor study where DMI could be accurately measured concurrently with methane production using 12 animals from the grazing study.

Mean methane production per kg DMI of 12 mature hinds housed individually indoors in metabolism cages and fed fresh ryegrass-based pasture in August 2003 was 22.5 g CH_4/kg DMI. This figure was similar to published results obtained from sheep and cattle on similar diets and was 42% lower than the grazing study in autumn. This latter result emphasises the importance of

obtaining accurate individual DMI measurements with which to express methane emissions per unit feed intake.

Estimated dry matter intakes using the double n-alkane technique have not previously been validated against actual intakes for red deer, or for deer fed fresh forages. Therefore, the third experiment attempted to validate the use of this technique with rumen-fistulated, castrated red deer stags housed indoors and fed either fresh ryegrass-based pasture or plantain, while concurrently measuring methane production. Indirect estimation of DMI using the double n-alkane technique underestimated actual DMI of pasture by 23.5% and overestimated actual DMI of plantain by 13.9%. These results indicate that the estimation of DMI by the double n-alkane technique was possibly not valid for comparisons between treatments, and across experiments or animal species. The impact on methane emissions of the inaccurate estimation of DMI by the double n-technique resulted in methane production from deer fed pasture being overestimated by 11.0 g CH_4/kg DMI and an underestimation of methane production of 4.8 g CH_4/kg DMI for deer fed plantain.

Findings of this thesis suggest that the measurement of methane from grazing and/or forage-fed animals should be conducted under conditions where DMI can be measured accurately, otherwise comparisons of methane production across treatments, experiments or species may be invalid. The latter two studies indicate that methane production of forage-fed red deer is similar to published values for sheep and cattle. However, this should be confirmed by direct comparisons where all species are fed the same diet, methane measurements are conducted over the same time period using identical methods, and feed intake can be accurately determined.

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LIST OF ABBREVIATIONS

%	percentage
°C	degrees Celsius
/ (/kg)	per (per kilogram)
¼	one-quarter
⅔	two-thirds
ADF	acid detergent fibre
ANOVA	analysis of variance
ADP	adenosine diphosphate
ATP	adenosine triphosphate
BW	body weight
CH_4	methane
CO_2	carbon dioxide
CP	crude protein
CRC	controlled release capsule
CT	condensed tannin
D	digestible
d	day
DM	dry matter
DMI	dry matter intake
et al.,	and others
etc.	et cetera
Expt.	experiment
Fd	ferredoxin
FOR	fractional outflow rate
g	gram
GE	gross energy
GEI	gross energy intake
Gg	gigagram (10^9 g)
GHG	greenhouse gas (es)
H_2	hydrogen
hr (s)	hour (s)
ha	hectare

hd	head
HWSC	hot water soluble carbohydrates
kg	kilogram
kJ	kilojoules
kPa	kilopascal
l	litre
LW	liveweight
LWG	liveweight gain
m	metre
m^2	metres squared
MAF	Ministry of Agriculture and Forestry
ME	metabolizable energy
mg	milligram
min	minute
MJ	mega joule
ml	millilitre
mm	millimetre
N	nitrogen
n	number of observations
η	η-alkane
N_2O	nitrous oxide
n/a	not available
NAD	nicotinamide adenine dinucleotide
NDF	neutral detergent fibre
NDFI	neutral detergent fibre intake
NIR	near-infrared reflectance
O_2	oxygen
OM	organic matter
OMI	organic matter intake
R.	*Ruminococcus*
RFC:SC	ratio readily fermentable carbohydrate: structural charbohydrate
SF_6	sulphur hexafluoride

vs.	versus
$W^{0.75}$	metabolic liveweight