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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.

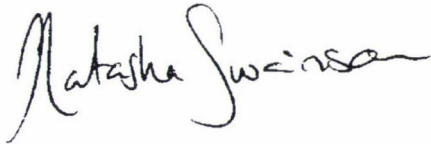
Natasha Madeleine Swainson

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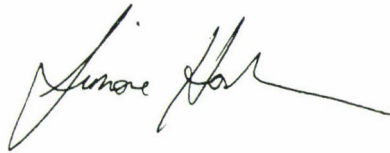
DECLARATION

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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ABSTRACT

Methane (CH₄) 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 CH₄/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 CH₄/kg DMI and an underestimation of methane production of 4.8 g CH₄/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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TABLE OF CONTENTS

DECLARATION	I
ABSTRACT	II
ACKNOWLEDGEMENTS.....	IV
TABLE OF CONTENTS.....	VI
LIST OF FIGURES.....	X
LIST OF TABLES.....	XII
LIST OF PLATES	XIV
LIST OF ABBREVIATIONS.....	XV
CHAPTER 1. REVIEW OF LITERATURE.....	1
1.1 INTRODUCTION.....	1
1.2. GLOBAL WARMING AND METHANE	1
1.2.1. <i>Global methane emissions</i>	2
1.2.2. <i>Methane emissions from New Zealand and New Zealand agriculture</i>	4
1.2.3. <i>Current research into enteric methane emissions</i>	5
1.2.4. <i>Livestock methane emissions and inventory</i>	8
1.2.5. <i>Methane emissions and deer</i>	8
1. 3. METHANOGENESIS.....	10
1. 3. 1. <i>Digestion in the rumen</i>	10
1.3.2. <i>Methanogens</i>	11
1.3.3. <i>Methanogenesis</i>	12
1.3.3.1. <i>Hydrogen transfer in the rumen</i>	12
1.4. MITIGATION	14
1.4.1. <i>Production systems</i>	15
1.4.2. <i>Feed intake</i>	16
1.4.3 <i>Apparent digestibility</i>	18
1.4.4. <i>Dietary manipulation</i>	19
1.5.1 <i>The New Zealand deer industry</i>	22
1.5.2. <i>Deer, energy requirements and forages</i>	23
1.6. CONCLUSION AND REQUIREMENTS FOR FURTHER RESEARCH.....	27

CHAPTER 2. METHANE PRODUCTION FROM FARMED RED DEER GRAZING PERENNIAL RYEGRASS PASTURE, CHICORY, OR PLANTAIN.	30
2.1. INTRODUCTION.....	30
2.2. MATERIALS AND METHODS.....	32
2.2.1. <i>Experimental design</i>	32
2.2.2. <i>Animals</i>	32
2.2.3. <i>Forages and Grazing Management</i>	34
2.2.4. <i>Forage Sampling and Measurements</i>	34
2.2.5. <i>Methane measurement</i>	35
2.2.6. <i>Voluntary feed intake</i>	38
2.2.7. <i>Laboratory Analyses</i>	39
2.2.8. <i>Statistical analysis</i>	40
2.3. RESULTS.....	41
2.3.1. <i>Botanical composition and dry matter</i>	41
2.3.2. <i>Chemical composition of forages</i>	43
2.3.2.1. <i>Feed offered</i>	43
2.3.2.2. <i>Feed Selected</i>	44
2.3.2.3. <i>Feed offered versus feed selected</i>	45
2.3.3. <i>Body weight and live weight change</i>	48
2.3.4. <i>Dry matter intake</i>	50
2.3.5. <i>Methane production</i>	56
2.4 DISCUSSION.....	59
2.5. APPENDIX.....	65
CHAPTER 3: METHANE PRODUCTION OF RED DEER HOUSED INDOORS AND FED FRESH PERENNIAL RYEGRASS-BASED PASTURE.....	68
3.1. INTRODUCTION.....	68
3.2. MATERIALS AND METHODS.....	69
3.2.1. <i>Experimental design</i>	69
3.2.2. <i>Animals</i>	69
3.2.3. <i>Diet and intake</i>	71
3.2.4. <i>Forage sampling</i>	71
3.2.5. <i>Laboratory Analyses</i>	72

3.2.6. Methane measurement	72
3.2.7. Statistical analysis	73
3.3. RESULTS	75
3.3.1. Forages	75
3.3.2. Dry matter intake.....	76
3.3.3. Animals	77
3.3.4 Methane production.....	79
3.3.5 Deer grazing pasture versus deer housed indoors.....	79
3.4. DISCUSSION	81
3.5. APPENDIX	88
CHAPTER 4: VALIDATION OF THE DOUBLE η-ALKANE PROCEDURE TO ESTIMATE THE DRY MATTER INTAKE OF RED DEER FED FRESH PASTURE OR PLANTAIN.....	91
4.1 INTRODUCTION.....	91
4.2 MATERIALS AND METHODS.....	93
4.2.1 Experimental design	93
4.2.2 Animals	93
4.2.3 Diets and actual intakes.....	94
4.2.4 Forage Sampling	95
4.2.5 Laboratory Analyses.....	95
4.2.6 Methane measurements	96
4.2.7 Voluntary Feed Intake – double n-alkane technique.....	96
4.2.8 Statistical analysis	97
4.3 RESULTS	99
4.3.1 Botanical composition.....	99
4.3.2 Chemical composition of forages.....	100
4.3.3 Dry matter intake - calculated and measured intake	102
4.3.4 Herbage concentrations, dose rates and faecal recovery rates of natural and synthetic alkanes	105
4.3.4 Methane production.....	112
4.4 DISCUSSION	114
4.5. APPENDIX	119
CHAPTER 5: GENERAL DISCUSSION	123

5.1 INTRODUCTION.....	123
5.2 METHANE PRODUCTION BY RED DEER	123
5.2 EFFECT OF FORAGE SPECIES ON METHANE PRODUCTION.....	127
5.3 DRY MATTER INTAKE	127
5.4 CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH.....	130
LIST OF REFERENCES	132

LIST OF FIGURES

Figure 1.1. Sources and sinks of methane on the earth and in the atmosphere.	3
Figure 1.2. Hexose fermentation by <i>Ruminococcus albus</i> in the absence and presence of methanogens.	13
Figure 1.3. Possible sites of microbial-intervention for lowering ruminant methane.	15
Figure 1.4. Change in efficiency of liveweight gain (LWG) in terms of methane emissions with increasing rate of liveweight gain (LWG) for <i>Bos indicus</i> eating a tropical forage diet (■), and <i>B. taurus</i> and <i>B. indicus</i> on a high grain diet (◆).	16
Figure 1.5. Methane emissions per unit of feed intake plotted against DM intake in sheep grazing the same pasture.	17
Figure 1.6. Estimated CH ₄ production by sheep and cattle receiving constant amounts of feed, at three different levels of feeding and apparent digestibility.	18
Figure 1.8. Classification of the Cervidae on the basis of morphophysiological feeding types.	24
Figure 1.9. Seasonal variation in pasture production and animal requirements in deer production systems in perennial ryegrass/white clover pastures.	25
Figure 3.1. Mean enteric methane emissions (g per day) from deer fed pasture from the grazing and indoor experiments.	89
Figure 4.1. Dry matter intakes (g/d) for deer fed ryegrass-based pasture and plantain, where DMI is measured (actual) or estimated using the double n-alkane technique.	103
Figure 4.2. Mean matrix disappearance rates of animals fed ryegrass-based pasture and plantain. Error bars represent the standard error of the mean.	108
Figure 4.3. Mean faecal recovery rates of dosed and naturally occurring n-alkanes, of deer fed pasture or plantain, error bars represent the standard error of the mean.	111
Figure 4.4. Methane emissions per kg of DMI for deer fed ryegrass-based pasture and plantain, where DMI is measured (actual) or estimated using the double n-alkane technique.	113
Figure 4.5. The disappearance rates of the alkane matrix of individual deer when fed ryegrass-based pasture (a) or plantain (b).	120
Figure 4.6. The disappearance rates of the alkane matrix in March (a) and May (b) from the fistulated red deer used to calculate dosage rates of n-alkanes for animals used in the grazing trial (chapter 2).	121

Figure 5.1. Methane production per day (a) and per kg of DMI (b) from red deer across three experiments, Grazing experiment (Chapter 2), Indoor experiment (Chapter 3), Alkane validation experiment (Chapter 4)..... 126

Figure 5.2. Dry matter intake from red deer across three experiments, Grazing experiment (Chapter 2), Indoor experiment (Chapter 3), Alkane validation experiment (Chapter 4)..... 129

LIST OF TABLES

Table 1.1. Atmospheric volume mixing ratios of main agricultural greenhouse gases during the last glacial, the pre-industrial Holocene and from 1900 to 1990.....	2
Table 1.2. Summary of New Zealand's Greenhouse Gas Emissions.....	4
Table 1.3. Methane measurements using the SF ₆ technique from different classes of ruminant livestock, under grazing conditions fed ryegrass-based pasture.....	7
Table 1.4. Methane emissions from sheep and dairy cows fed a range of diets indoors, determined with the SF ₆ tracer technique.....	21
Table 2.1. Number of animals in each treatment group, mean and standard deviation expressed for age and weight.	33
Table 2.2. The botanical composition of the three treatment forages grazed by hinds in March and May.....	42
Table 2.3. Mean dry matter percent and standard deviation of forages, feed offered and feed selected, as sampled during the methane measurement period.	43
Table 2.4. a & b. Chemical composition of the forages fed during the methane measurement period for feed offered (3a) and feed selected (3b) (% DM).....	46
Table 2.5 Average body weight of deer at start of experimental periods and body weight change.	49
Table 2.6. The alkane content of n-monotriacontane (C ₃₁ H ₆₄), n-dotriacontane (C ₃₂ H ₆₆) and n-tritriacontane (C ₃₃ H ₆₈) of the three forage treatments (ryegrass/clover, chicory and plantain) for March and May (n = 2).	51
Table 2.7 Gross analyses of η-alkanes (C ₃₁ to C ₃₃) for all forages for both feed selected and feed offered as analysed by both Lincoln University and Dexcel laboratories.	52
Table 2.8. Effect of the method of forage sampling, either feed selected or feed offered, on estimated dry matter intake and methane production per unit of intake of deer grazing ryegrass/clover, plantain or chicory.	54
Table 2.9. Intake and methane production for red deer grazing ryegrass-based pasture, chicory and plantain.	58
Table 2.10. Methane emissions (g) per day (a) and per kg of DMI (b) of individual red deer feed ryegrass-based pasture, chicory and plantain over the entire methane measurement period (March and May).	66
Table 3.1. Botanical composition of pasture offered and feed refused.	75

Table 3.2. Nutrient composition of pasture offered and refused during the methane measurement period.....	76
Table 3.3. Mean (\pm SEM) daily methane production and dry matter intake (DMI) of hinds fed ryegrass pasture indoors.....	78
Table 3.4. A comparison of dry matter intake, body weight, body weight change and methane production of deer firstly grazing, and then being fed perennial ryegrass-based pasture indoors.....	80
Table 3.5. Summary of experiments measuring methane using the SF ₆ technique in NZ from ewes, wethers and cows grazing or housed indoors fed a ryegrass-based pasture.	82
Table 3.6. A comparison of the DMI, methane production per day and per kg of DMI of deer feed pasture in the grazing and indoor experiments.....	90
Table 4.1. The botanical composition of feed offered and feed refused of ryegrass-based pasture (a) and plantain (b).....	99
Table 4.2. Chemical composition and apparent dry matter digestibility of forages fed to deer.....	101
Table 4.3. Dry matter intake of individual deer as measured (actual) or calculated using the double η -alkane technique (alkane).	104
Table 4.4. The η -alkane concentrations present in forage species offered to deer.....	105
Table 4.5. Calculated and recommended dose rates of synthetic alkanes, η -dotriacontane (C ₃₂ H ₆₆) and n-hexatriacontane (C ₃₆ H ₇₂).	106
Table 4.6. The faecal recovery rates of dosed and naturally occurring η -alkanes in pasture (a) and plantain (b).....	110
Table 4.7 Methane production and actual DMI from deer when fed either ryegrass-based pasture or plantain.	112
Table 4.8. Dry matter intakes and methane emissions per day and per kg DMI based upon actual intakes for deer when fed pasture and plantain.	122

LIST OF PLATES

Plate 2.1. Deer wearing methane collection equipment, grazing ryegrass-based pasture in March 2003.....	35
Plate 2.2. Deer wearing methane collection equipment while grazing plantain in May 2003.....	36
Plate 2.3. Deer wearing methane collection equipment, grazing chicory in March 2003.	36
Plate 3.1 Hind housed in a metabolism cage and wearing methane-collecting apparatus, with the yoke attached near the rear of the sliding door of cage.....	73

LIST OF ABBREVIATIONS

%	percentage
°C	degrees Celsius
/ (/kg)	per (per kilogram)
$\frac{1}{4}$	one-quarter
$\frac{2}{3}$	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
<i>n</i>	number of observations
η	η -alkane
N ₂ O	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
<i>R.</i>	<i>Ruminococcus</i>
RFC:SC	ratio readily fermentable carbohydrate: structural carbohydrate
SF ₆	sulphur hexafluoride

vs.
 $W^{0.75}$

versus
metabolic liveweight