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A COMPARATIVE STUDY OF VOLUNTARY INTAKE  
AND RUMEN DIGESTION  
BY DEER, GOATS AND SHEEP

A thesis presented in partial fulfilment  
of the requirements for the degree of  
Doctor of Philosophy in Animal Science  
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New Zealand

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## DEDICATION

To my mother and father, to whom I am thankful for everything.

## ABSTRACT

The following experiments were carried out to study the voluntary feed intake and rumen digestion of Red Deer and Angora-NZ feral goats, compared to Border-Leicester/Romney cross sheep, namely: (1) Intake and utilisation of a low quality threshed prairie grass straw (13.7 g N/Kg DM) by goats and sheep; (2) chewing behaviour per 24 h during eating and ruminating by goats and sheep fed on lucerne hay, and the efficiencies of chewing during eating and ruminating upon the breakdown of feed particles; (3) seasonality in nutrient supply by deer, goats and sheep fed on a medium quality lucerne hay diet (28.3 g N/Kg DM) in summer and in winter, and (4) the role of melatonin (Me) in the control of seasonal VFI in Red Deer.

1. Goats showed a superior utilisation of the low quality forage diet, with a greater voluntary intake ( $\text{g/Kg W}^{0.75}/\text{d}$ ) of DM (55.6 g vs 33.8 g) and DDMI (17.4 g vs 8.2 g), apparent digestibilities of DM (31.2% vs 24.3%) and total fibre (36.8% vs 32.6%), especially that of lignin (11.3% vs 5.3%), when compared to sheep. The greater VFI ( $\text{g/Kg W}^{0.75}/\text{d}$ ) by goats was associated with a larger rumen pool size ( $\text{g/Kg W}^{0.75}$  of (DM + liquid) by goats than sheep (334.7 g vs 213.5 g). The superior fibre digestibility by goats was associated with a greater rumen  $\text{NH}_3\text{-N}$  concentration ( $\text{mg N/L}$ : 115 mg vs 80 mg), greater production rates of  $\text{NH}_3\text{-N}$  in the rumen (IRL:  $\text{g N/Kg W}^{0.75}/\text{d}$  of 0.84 for goats and 0.49 for sheep). A mechanism for increasing rumen  $\text{NH}_3\text{-N}$  concentration in goats was apparent through slower rates of inflow and outflow of water from the rumen ( $\text{g/g DMI/d}$ ). Goats also showed greater rumen molar proportions of valerate and butyrate, and a tendency for a longer rumen MRT (h) of particulate DM (lignin and Ru-Phen), compared to sheep. Goats had smaller proportions (5.1% vs 9.6%) of large particles (>4.0 mm), and greater proportions (19.4% vs 16.1%) of small particles (<1.0 mm) in the rumen contents than sheep. The factors listed above would all favour the potential growth and attachment to feed particles of fibre-digesting bacteria in the rumen of goats, compared to sheep.

2. Goats spent more time chewing during eating (+3.1 h/24 h) and less time chewing during ruminating (-2.2 h/24 h) than sheep when fed on lucerne hay. Goats had a greater number of chews/min spent eating (154 vs 128) than sheep, and a smaller number of chews during ruminating (79 vs 100) than sheep. The efficiency of chewing during eating in breaking down feed particles to <1.0 mm (<C.EAT>) was greater by goats than by sheep (85% vs 48%) and <C.RUM> was smaller by goats than sheep (48% vs 59%). When corrected for the number of chews spent chewing during eating and ruminating, the differences in <C.EAT> and <C.RUM> between goats and sheep disappeared (for <C.EAT>, 2.1% vs 2.4%; for <C.RUM>, 0.6% vs 0.6%).

3. Sheep showed no evidence of seasonal cycles of VFI when fed on lucerne hay. In contrast to sheep, deer showed marked seasonal cycles of an increase in summer of voluntary DMI (+33.8%), DDMI (+29.9%), MEI (+25%), apparent fibre digestibility (+11.2%), MRT of lignin (+26%), rumen pool of DM + liquid (51.3%), internal recycling of water to the rumen (+74.1%), rumen  $\text{NH}_3\text{-N}$  concentration (+56.4%) and Ac/Pr ratio (+16%). All the cycles showed a trough in winter and a marked increase in summer. The expansion in the rumen pool size, a longer rumen MRT of digesta and a greater recycling of water into the rumen, allowed for an increase in VFI (without depressing apparent DMD), and for an increase in apparent fibre digestibility in summer.

Goats also showed an increase in voluntary DMI in summer (+19.7%), associated with increases in a number of rumen digestive functions, which were all not as marked as for deer. Unlike deer, the increased VFI in summer occurred at the expense of a reduced apparent DMD (-9.8%) and fibre digestibility (-5.8%).

Deer showed a faster rumen FOR of liquid (15.6%/h) than goats (10.0%/h) and sheep (10.4%/h) both in summer and in winter. Goats digested lignin, the least digestible component of fibre, more efficiently than sheep, both in summer (18.9% vs 14.6%) and in winter (21.9% vs 9.4%). The greater fibre digestibility by goats than sheep in winter was associated with a greater rate of  $\text{NH}_3\text{-N}$  production in the rumen (IRL of 1.13 g vs 0.98 g (g N/Kg  $W^{0.75}/d$ )). The threshold to passage of particles through the reticulo-omasal orifice was 1.0 mm

for deer, goats and sheep, with more than 98% of the particles in the faeces being <1.0 mm.

4. Exogenous subcutaneous implants of melatonin (Me) in spring in castrated male Red Deer caused reductions in VFI, water-filled rumen capacity, rumen digesta load, and heart rate (beats/min), to occur in both early and in late summer. Melatonin possibly entrains the seasonal cycles of VFI in Red Deer to photoperiod, and controls the seasonality of VFI. Methods are suggested for reducing the magnitude of the winter depression in VFI in Red Deer stags, using immunisation against Me.

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## TABLE OF CONTENTS

	Page
Abstract	ii
Acknowledgements	v
List of Tables	xvi
List of Figures	xxv
List of Plates	xxix
List of Abbreviations	xxx
INTRODUCTION	1
CHAPTER 1. A REVIEW OF THE LITERATURE	3
1.1 INTRODUCTION	3
1.2 VOLUNTARY FEED INTAKE AND DIGESTIBILITY IN DEER, GOATS AND SHEEP	4
1.2.1 Goats and sheep	4
1.2.1.1 Voluntary feed intake	4
1.2.1.2 Selection of feed by goats and sheep	2
1.2.1.3 Digestible organic matter intake	7
1.2.1.4 Apparent fibre digestibility	14
1.2.1.5 Nitrogen balance	18
1.2.1.6 Rumen ammonia concentration	20
1.2.1.7 Maintenance energy requirements	20
1.2.2 Deer and sheep	22
1.2.2.1 Voluntary feed intake	22
1.2.2.2 Selection of feed by deer and sheep	26
1.2.2.3 Digestibility	26
1.2.2.4 Fasting metabolism and maintenance energy requirements in deer	28
1.3 PHYSIOLOGICAL CONTROL OF SEASONAL FEED INTAKE IN DEER: A HORMONAL BASIS	29



## TABLE OF CONTENTS (continued)

	Page
1.4 HORMONAL MANIPULATION OF FEED INTAKE IN DEER	33
1.4.1 Active immunisation against melatonin	34
1.4.2 Manipulation of plasma prolactin concentration	34
1.4.3 Active immunisation against LHRH	35
1.5 SEASONAL VARIATIONS IN RUMEN FUNCTIONS	35
1.6 CLEARANCE OF DIGESTA FROM THE RUMEN, AND CONTROL OF INTAKE	37
1.6.1 Passage of particles through the reticulo-omasal orifice	37
1.6.2 Breakdown of particulate matter in the rumen	39
1.7 CONCLUSIONS AND AREAS REQUIRING FURTHER STUDY	42
1.7.1 Goats vs sheep	42
1.7.2 Deer vs sheep	43
1.7.3 Areas requiring further study	44
<b>CHAPTER 2. MATERIALS AND METHODS</b>	<b>45</b>
2.1 ANIMALS	45
2.2 DIET	46
2.3 HOUSING	46
2.4 EXPERIMENTAL DESIGN	47
2.5 MEASUREMENT OF VOLUNTARY FEED INTAKE	47
2.6 DETAILS OF DIGESTIBILITY TRIAL	50

## TABLE OF CONTENTS (continued)

	Page
2.7 INFUSION PROCEDURES	51
2.7.1 Infusion of the dual-phase marker, Cr-EDTA/Ru-Phen	51
2.7.1.1 Preparation of markers	51
2.7.2 Infusion of $^{15}\text{NH}_4\text{Cl}$	51
2.7.3 Infusion techniques	52
2.8 SAMPLING PROCEDURES AND SAMPLING PREPARATION	52
2.8.1 Rumen fluid sampling	52
2.8.2 Ammonia in rumen fluid	54
2.8.3 VFA in rumen fluid	54
2.8.4 pH of rumen fluid	54
2.8.5 Rumen emptying ("bailing")	54
2.8.6 Sampling for enrichment of N with $^{15}\text{N}$	55
2.8.6.1 Sampling protocol	55
2.8.6.2 Sample preparation	55
2.8.6.2.1 Rumen fluid sample	55
2.8.6.2.2 Rumen bacterial sample	55
2.8.6.2.3 Rumen digesta sample	55
2.9 CHEMICAL ANALYSIS	56
2.9.1 Organic matter	56
2.9.2 Total nitrogen	58
2.9.3 Heat of combustion	58
2.9.4 Carbohydrate analysis	58
2.9.5 Ammonia in rumen fluid samples	60
2.9.6 Volatile fatty acids in rumen fluid samples	60
2.9.6.1 Gas-liquid chromatography	60
2.9.6.2 Preparation of standard VFA solutions	61
2.9.6.3 Analysis of rumen fluid samples	62
2.9.7 Chromium and ruthenium determinations	62
2.9.7.1 Preparation of analytical standards	62
2.9.7.2 Preparation of samples for XRFs	62
2.9.8 Estimation of enrichment with $^{15}\text{N}$	63

## TABLE OF CONTENTS (continued)

	Page
2.9.8.1 Rumen fluid samples	63
2.9.8.2 Rumen bacterial and digesta samples	63
2.9.9 Particle size analysis	63
2.10 TERMINOLOGY AND CALCULATIONS	64
2.10.1 Marker kinetics	64
2.10.1.1 Fractional Outflow Rate (FOR, %/h)	65
2.10.1.2 Mean Retention Time (MRT, h)	66
2.10.1.3 Fraction Disappearance Rate (FDPR, %/h)	66
2.10.1.4 Fractional Outflow Rate of lignin (FOR, %/h)	66
2.10.1.5 Fractional Degradation Rate of lignin (FDR, %/h)	67
2.10.2 <sup>15</sup> N Tracer kinetics	67
2.10.2.1 Irreversible Loss Rate of NH <sub>3</sub> -N (IRL, g N/d)	67
2.10.2.2 Proportion of bacterial-N from NH <sub>3</sub> -N (%)	68
2.10.2.3 Proportion of bacterial-N from digesta-NAN (%)	68
<b>CHAPTER 3. VOLUNTARY INTAKE AND RUMEN DIGESTION OF A LOW QUALITY ROUGHAGE BY GOATS AND SHEEP</b>	<b>69</b>
3.1 INTRODUCTION	69
3.2 EXPERIMENTAL	70
3.2.1 Diet	70
3.2.2 Animals	70
3.2.3 Experimental design	70
3.2.3.1 Experiment 1a	70
3.2.3.2 Experiment 1b	72
3.2.4 Marker infusion procedures	72

## TABLE OF CONTENTS (continued)

	Page
3.2.5 Sampling	72
3.2.6 Chemical analysis	73
3.2.7 Calculations of data	74
3.2.8 Statistical design and analysis	75
3.3 RESULTS	75
3.3.1 Chemical composition of diet and selection of feed offered	75
3.3.2 Voluntary intake and N retention	78
3.3.3 Fibre digestion	78
3.3.4 Rumen pool size	82
3.3.5 MRT (h) and FOR (%/h) of Cr-EDTA, Ru-Phen and lignin from the rumen	89
3.3.6 "Apparent" MRT (h) and "apparent" FOR (%/h) of feed particles from the rumen	89
3.3.7 Rumen volatile fatty acids and pH	91
3.3.8 Water transactions in the rumen	91
3.3.9 Rumen ammonia kinetics	94
3.4 DISCUSSION	98
3.4.1 Voluntary intake and digestibility	98
3.4.2 Rumen fermentation	101
3.4.3 Particulate marker methodology	102
3.4.4 Fibre degradation	105
3.4.5 Validity of assumptions for <sup>15</sup> N marker methodology	107
3.4.6 Kinetics of rumen ammonia production	107
3.5 CONCLUSIONS	113
CHAPTER 4. VOLUNTARY INTAKE AND RUMEN DIGESTION OF A MEDIUM QUALITY FORAGE BY DEER, GOATS AND SHEEP. A SEASONAL STUDY	116
4.1 INTRODUCTION	116

## TABLE OF CONTENTS (continued)

	Page
4.2 EXPERIMENTAL	117
4.2.1 Diet	117
4.2.2 Animals	117
4.2.3 Experimental design	118
4.2.4 Marker infusion procedures	118
4.2.5 Sampling	120
4.2.6 Chemical analysis	122
4.2.7 Calculations of data	122
4.2.8 Statistical design and analysis	124
4.3 RESULTS	125
4.3.1 Chemical composition of diet and selection of feed offered	125
4.3.2 Voluntary feed intake and apparent digestibility of DM and OM	125
4.3.2.1 Seasonal effects	125
4.3.2.2 Species effects	130
4.3.3 MRT of digesta in the rumen	131
4.3.4 Particle size breakdown in the rumen in winter	131
4.3.5 "Apparent" FOR (%/h) of particles from the rumen in winter	135
4.3.6 Fibre digestion	135
4.3.6.1 Seasonal effects	135
4.3.6.2 Species effects	141
4.3.7 Rumen water transactions	142
4.3.7.1 Seasonal effects	142
4.3.7.2 Species effects	144
4.3.8 Rumen fermentation patterns	144
4.3.8.1 Seasonal effects	144
4.3.8.2 Species effects	146
4.3.9 Seasonality in N retention	146
4.3.10 Ammonia kinetics in the rumen	146
4.3.10.1 Rumen ammonia concentration, rumen ammonia pool and rumen ammonia outflow from the rumen	150

## TABLE OF CONTENTS (continued)

	Page
4.3.10.1.1 Seasonal effects	150
4.3.10.1.2 Species effects	150
4.3.10.2 Ammonia production rate in the rumen	150
4.4 DISCUSSION	151
4.4.1 Seasonal cycles in nutrient supply in deer, goats and sheep	151
4.4.2 Seasonal effects upon nutrient supply	153
4.4.2.1 Voluntary feed intake and nitrogen retention	153
4.4.2.2 Digestive efficiency	155
4.4.3 Species differences in nutrient supply	157
4.4.3.1 Voluntary feed intake and nitrogen retention	157
4.4.3.2 Digestive efficiency	157
4.4.4 Marker and tracer methodology	158
4.4.4.1 Marker methodology	158
4.4.4.2 Tracer methodology	160
4.4.5 Estimation of nitrogen outflow from the rumen	161
4.5 CONCLUSIONS	163
<b>CHAPTER 5. TIME SPENT EATING AND RUMINATING IN GOATS AND SHEEP DURING A 24-H PERIOD, AND THE EFFICIENCY OF CHEWING DURING EATING AND RUMINATING UPON THE BREAKDOWN OF FEED PARTICLES</b>	<b>166</b>
5.1 INTRODUCTION	166
5.2 EXPERIMENTAL	167
5.2.1 Diet	167
5.2.2 Animals	167
5.2.3 Experimental design	168
5.2.4 Methodology	168

## TABLE OF CONTENTS (continued)

	Page
5.2.4.1 Determination of time spent eating and ruminating per 24 h	168
5.2.4.1.1 Method	168
5.2.4.1.2 Calculations	170
5.2.4.2 Efficiency of chewing during eating	170
5.2.4.2.1 Method	170
5.2.4.2.2 Calculations	170
5.2.4.3 Efficiency of chewing during rumination	174
5.2.4.3.1 Method	174
5.2.4.3.2 Calculations	174
5.2.5 Chemical analysis	176
5.2.6 Statistical design and analysis	177
<b>5.3 RESULTS</b>	<b>177</b>
5.3.1 Time spent chewing during eating and ruminating by goats and sheep during 24 h	177
5.3.2 Efficiency of chewing during eating upon the breakdown of feed particles	177
5.3.3 Efficiency of chewing during ruminating upon the breakdown of feed particles	181
<b>5.4 DISCUSSION</b>	<b>183</b>
<b>5.5 CONCLUSIONS</b>	<b>185</b>
<b>CHAPTER 6. EFFECTS OF SUBCUTANEOUS MELATONIN IMPLANTS DURING LONG DAYLENGTH ON VOLUNTARY FEED INTAKE, RUMEN CAPACITY AND HEART RATE OF DEER FED A MEDIUM QUALITY FORAGE</b>	<b>187</b>
6.1 INTRODUCTION	187

## TABLE OF CONTENTS (continued)

	Page
6.2 EXPERIMENTAL	188
6.2.1 Experimental design	188
6.2.2 Animals and management	190
6.2.3 Melatonin treatment	190
6.2.4 Blood sampling	190
6.2.5 Liveweight recording	191
6.2.6 Diet	191
6.2.7 Determination of voluntary feed intake	191
6.2.8 Rumen capacity and rumen pool size	192
6.2.9 Heart rate	192
6.2.10 Radioimmunoassay (RIA) of melatonin	194
6.2.11 Chemical analysis	194
6.2.12 Calculations	194
6.2.13 Statistical analysis	196
6.3 RESULTS	196
6.3.1 Effects of melatonin treatment on liveweight	196
6.3.2 Effects of s.c. melatonin implants on day-time plasma melatonin concentrations	196
6.3.3 Effects of melatonin treatment on DMI, rumen capacity and rumen pool size	196
6.3.4 Effects of melatonin treatment on heart rate	200
6.4 DISCUSSION	200
6.5 CONCLUSIONS	203
<b>CHAPTER 7. GENERAL DISCUSSION AND CONCLUSIONS</b>	<b>205</b>
7.1 SEASONAL CYCLES OF NUTRIENT SUPPLY IN DEER, GOATS AND SHEEP	205



## TABLE OF CONTENTS (continued)

	Page
7.2 COMPARATIVE VOLUNTARY FEED INTAKE AND RUMEN DIGESTION BY GOATS AND SHEEP	208
7.3 COMPARATIVE VOLUNTARY FEED INTAKE AND RUMEN DIGESTIVE EFFICIENCY BY DEER AND SHEEP	212
7.4 POTENTIAL CONTROL OF WINTER VFI IN DEER	213
7.5 RUMEN OUTFLOW RATES AND MARKER METHODOLOGY	217
7.6 CONCLUSIONS	220
APPENDIX A	221
APPENDIX B	222
APPENDIX C	223
REFERENCES	224

## LIST OF TABLES

Table	Page
1.1 Voluntary feed intake (organic matter intake (OMI) or dry matter intake (DMI)) of forage and browse diets by goats and sheep (g/Kg $W^{0.75}/d$ )	5
1.2 Voluntary feed intake (dry matter (DMI)) of forage diets by the Desert (D) and Temperate (T) breeds of goat (g/Kg $W^{0.75}/d$ )	6
1.3 Chemical composition of feed offered and refusals (g/Kg DM) by goats and sheep, when fed "ad-lib" under stall-feeding conditions	8
1.4 Apparent digestibility (%) of organic matter (OMD) and dry matter (DMD), digestible organic matter intake (DOMI) and digestible dry matter intake (DDMI), by goats and sheep fed on forage and browse diets (g/Kg $W^{0.75}/d$ )	9
1.4.1 OMD and DMD (%) by goats and sheep	9
1.4.2 DDMI and DOMI by goats and sheep (g/Kg $W^{0.75}/d$ )	10
1.5 Mean Retention Time of particulate phase (Ru-Phen) and liquid phase (Cr-EDTA) of digesta in the rumen of goats and sheep fed on forages (MRT, h)	12
1.5.1 MRT (h) of Ru-Phen in the rumen	12
1.5.2 MRT (h) of Cr-EDTA in the rumen	12
1.6 Volume of rumen contents (litres, L) of goats and sheep fed on forage diets (as a proportion of $W^{0.75}$ )	13
1.7 Apparent digestibility of fibre (%) by goats and sheep fed on forage and browse diets	15

## LIST OF TABLES (continued)

Table	Page
1.8 Apparent digestibility of lignin (%) by goats and sheep	16
1.9 Apparent digestibility of fibre (%) by the Desert (D) and Temperate (T) breeds of goat	17
1.10 Nitrogen (N) retention by goats and sheep (mg/100 g DMI) fed on forage diets	19
1.11 Rumen ammonia concentration (NH <sub>3</sub> -N, mg N/L) in goats and sheep fed on forage and browse diets	21
1.12 Seasonal voluntary feed intake of forage and browse diets by castrated deer and sheep (g/Kg W <sup>0.75</sup> )	25
1.13 Digestibility of forage diets (%) and Mean Retention Time (MRT, h) of Ru-Phen in the rumen of deer and sheep, in summer and in winter	27
1.13.1 Apparent digestibility of organic matter (OMD, %), and rumen MRT (h) of Ru-Phen	27
1.13.2 Apparent digestibility of fibre (NDF, cellulose, hemicellulose)	27
1.14 Estimation of seasonal metabolisable energy requirements (ME) for maintenance (MJ/Kg W <sup>0.75</sup> /d), and fasting metabolism (MJ/Kg W <sup>0.75</sup> /d) for deer	30
1.15 Studies of seasonal hormonal status and associated seasonal physiology in deer	31
1.16 Seasonal variations in temperature and associated changes in rumen digestion	36
1.17 "Apparent" Fractional Outflow Rates (FOR, %/h) and "apparent" Mean Retention Time (MRT, h) of particles in the rumen of sheep fed a forage diet	38

## LIST OF TABLES (continued)

Table	Page
1.18 Comparison of eating behaviour by goats and sheep	40
1.19 Comparison of rumination behaviour by goats and sheep fed chopped ryegrass straw	41
2.1 Sampling protocol for $^{15}\text{N}$ samples	56
2.2 Concentrations (mmol/L) of VFA in the working standard solution	61
3.1a Chemical composition (g/Kg dry matter (DM)) of mature prairie grass straw ( <i>Bromus catharticus</i> ) fed to goats and sheep during Experiments 1a and 1b	76
3.1b Chemical composition (g/Kg organic matter (OM)) of mature prairie grass straw, and the feed refusals by goats and sheep when fed at "ad-lib" intake	77
3.2 Voluntary and digestible intakes of dry matter and organic matter (g/Kg $W^{0.75}$ /d), metabolisable energy intake (MJ/Kg $W^{0.75}$ /d), and apparent digestibilities of dry matter and organic matter (%) by goats and sheep fed on mature prairie grass straw in summer	79
3.3 Nitrogen (N) intake, faecal N and urinary N excretions, N balance, and apparent N digestibility by goats and sheep fed on mature prairie grass straw, at 90% of "ad-lib" intake	80
3.4 Voluntary and digestible intakes of total fibre, rumen pool, fractional disappearance rate (FDPR) and "apparent" fractional degradation rate (FDR) of total fibre in the rumen of goats and sheep, fed on mature prairie grass straw	81

## LIST OF TABLES (continued)

Table		Page
3.5	Voluntary and digestible intakes of cellulose, rumen pool, Fractional Disappearance Rate (FDPR) and "apparent" Fractional Degradation Rate (FDR) of cellulose in the rumen of goats and sheep fed on mature prairie grass straw	83
3.6	Voluntary and digestible intakes of hemicellulose, rumen pool, Fractional Disappearance Rate (FDPR) and "apparent" Fractional Degradation Rate (FDR) of hemicellulose in the rumen of goats and sheep fed on mature prairie grass straw	84
3.7	Voluntary and digestible intakes of lignin, rumen pool, Fractional Disappearance Rate (FDPR) and Fractional Degradation Rate (FDR) of lignin in the rumen of goats and sheep fed on mature prairie grass straw	85
3.8	Rumen total pool (DM + liquid), rumen dry matter (DM), and rumen liquid pool sizes ( $\text{g/Kg W}^{1.0}$ and $\text{g/Kg W}^{0.75}$ ), and percentage of DM in the rumen contents of goats and sheep fed on mature prairie grass straw, at 90% "ad-lib" intake	86
3.9	Particle size distribution (% particulate dry matter (DM) retained on sieve size) in the rumen and faeces of goats and sheep, fed on mature prairie grass straw, at 90% "ad-lib" intake	87
3.10	Mean Retention Time (MRT, h) and Fractional Outflow Rate (FOR, %/h) of Cr-EDTA, Ru-Phen and lignin, and the "apparent" MRT (h) and "apparent" FOR (%/h) of particulate DM (>2 mm, 2-1 mm, 1-0.5 mm, 0.5-0.25 mm, <0.25 mm, <1.0 mm, >1.0 mm) from the rumen of goats and sheep fed on mature prairie grass straw, at 90% "ad-lib" intake	90

## LIST OF TABLES (continued)

Table	Page
3.11 Total VFA (mmol/L), and concentrations of acetate, propionate, n-butyrate, iso-butyrate, n-valerate and iso-valerate in the rumen contents of goats and sheep fed on mature prairie grass, at 90% "ad-lib" intake (mmol/L and moles%), and pH of rumen	92
3.12 Water flows into and out of the rumen: drinking water and total water intakes, water outflow from rumen and net rumen water balance in goats and sheep fed on mature prairie grass straw, at 90% "ad-lib" intake	93
3.13 Kinetics of ammonia (NH <sub>3</sub> -N) production in the rumen of goats and sheep fed on mature prairie grass straw, at 90% "ad-lib" intake	96
3.14 Calculated microbial-NAN (g) and calculated non-microbial-NAN (g) in the rumen of goats and sheep, fed on mature prairie grass at 90% "ad-lib", with the abomasal flows	111
4.1 Infusion rates of Cr-EDTA/Ru-Phen (g/h), Cr and Ru (mg/h) in the rumen of deer, goats and sheep fed on lucerne hay, at 90% "ad-lib" intake in summer and in winter	121
4.2 Correlation coefficient values (r) of the calibration curves for Cr and Ru (summer and winter), made in the rumen digesta as matrix, for deer, goats and sheep	123
4.3.a Chemical composition (g/Kg dry matter (DM)) of lucerne hay ( <i>Medicago sativa</i> ) fed to deer, goats and sheep in summer and in winter	126

## LIST OF TABLES (continued)

Table	Page
4.3.b Chemical composition (g/Kg organic matter (OM)) of lucerne hay, and the feed refusals by deer, goats and sheep when fed "ad-lib" in summer and in winter	127
4.4 Voluntary and digestible intakes of dry matter and organic matter (g/Kg $W^{0.75}$ /d) together with their apparent digestibilities (%), and metabolisable energy intake (MJ/Kg $W^{0.75}$ /d) of deer, goats and sheep fed on lucerne hay in summer and in winter	128
4.5 Total rumen (DM + liquid) pool size, DM and liquid pool sizes (g/Kg $W^{0.75}$ ) of deer, goats and sheep fed on lucerne hay in summer and in winter, and the dry matter content (%) of the rumen digesta	129
4.6 Mean Retention Time (MRT, h) and Fractional Outflow Rate (FOR, %/h) of Cr-EDTA, Ru-Phen and lignin from the rumen of deer, goats and sheep fed on lucerne hay in summer and in winter, at 90% "ad-lib" intake	132
4.7 Particle size distribution (% particulate DM retained on sieve size) in the rumen digesta and faeces of deer, goats and sheep fed on lucerne hay in winter, at 90% "ad-lib" intake	134
4.8 "Apparent" Mean Retention Time (MRT, h) and "apparent" fractional outflow rate (FOR, %/h) of particulate DM (>2 mm, 2-1 mm, 1-0.5 mm, 0.5-0.25 mm and <0.25 mm) from the rumen of deer, goats and sheep fed on lucerne hay, at 90% "ad-lib" intake, in winter	136
4.9 Voluntary intake of total fibre, rumen pool (g/Kg $W^{0.75}$ ), fractional disappearance rate (FDPR, %/h) and "apparent" fractional degradation rate (FDR, %/h) of total fibre by deer, goats and sheep fed on lucerne hay, in summer and in winter	137

## LIST OF TABLES (continued)

Table	Page
4.10 Voluntary intake of cellulose, rumen pool (g/Kg $W^{0.75}$ ), fractional disappearance rate (FDPR, %/h) and "apparent" fractional degradation rate (FDR, %/h) of cellulose by deer, goats and sheep fed on lucerne hay, in summer and in winter	138
4.11 Voluntary intake of hemicellulose, rumen pool (g/Kg $W^{0.75}$ ), fractional disappearance rate (FDPR, %/h) and "apparent" fractional degradation rate (FDR, %/h) of hemicellulose by deer, goats and sheep fed on lucerne hay, in summer and in winter	139
4.12 Voluntary intake of lignin, rumen pool (g/Kg $W^{0.75}$ ), fractional disappearance rate (FDPR, %/h) and fractional degradation rate (FDR, %/h) of lignin by deer, goats and sheep fed on lucerne hay, in summer and in winter	140
4.13 Water flows into and out of the rumen: drinking water and total water intakes, water outflow from the rumen and net rumen water balance in deer, goats and sheep, fed on lucerne hay at 90% "ad-lib" intake, in summer and in winter	143
4.14 Total VFA (mmol/L), and molar concentrations of acetate, propionate, butyrate (n- and iso-) and valerate (n- and iso-) (moles %), in the rumen of deer, goats and sheep fed on lucerne hay at "ad-lib" intake in summer and in winter	145
4.15 Nitrogen (N) intake, faecal N and urinary N excretion, N balance and apparent N digestibility by deer, goats and sheep fed on lucerne hay at "ad-lib" intake, in summer and in winter	147



## LIST OF TABLES (continued)

Table	Page
4.16 Kinetics of ammonia (NH <sub>3</sub> -N) production in the rumen of deer, goats and sheep fed on lucerne hay at 90% "ad-lib" intake in winter, together with the rumen NH <sub>3</sub> -N concentration (mg N/L), rumen NH <sub>3</sub> -N pool (mg N/g N intake) and NH <sub>3</sub> -N outflow (mg N/g N intake/d) from rumen, in summer and in winter	148
4.17 Ratios of FOR (%/h) of lignin/FOR of particles <1.0 mm, FOR of Cr-EDTA/FOR of particles <1.0 mm and FOR of Cr-EDTA/FOR of lignin in deer, goats and sheep fed on lucerne hay, at 90% "ad-lib" intake	159
4.18 Calculated microbial-NAN (g) and nonmicrobial-NAN (g) rumen pool sizes, together with the calculated abomasal flows (g/d) of deer, goats and sheep fed on lucerne hay, at 90% "ad-lib" intake in winter	162
5.1 Time (h) spent chewing during eating and ruminating per 24 h by goats and sheep fed on lucerne hay, at 90% "ad-lib" intake	179
5.2 Efficiency of chewing during eating upon the breakdown of feed particles by goats and sheep, fed on lucerne hay	180
5.3 Efficiency of chewing during ruminating (RUM), by goats and sheep, upon the breakdown of feed particles >1.0 mm during a 5-h period (14.00-19.00 hours)	182

## LIST OF TABLES (continued)

Table		Page
6.1	Voluntary dry matter intake (DMI, g/Kg $W^{0.75}/d$ ), rumen capacity, rumen pool size of dry matter (DM) + liquid, rumen pool size of DM, rumen pool size of liquid (g/Kg $W^{0.75}$ ), and heart rate (beats/min) of Control (C) and melatonin-Treated (MeT) Red Deer castrates at d88-d106 (t1) and d 191-d210 (t2), after the first subcutaneous implants of melatonin	199
7.1	Seasonal cycles of dry matter intake (DMI) and associated cycles of rumen digestive function (as % increase or decrease from winter to summer) in deer, goats and sheep	206
7.2	Comparative study between goats and sheep of the Irreversible Loss Rate (IRL) of $NH_3$ -N and particle size breakdown of feed in the rumen	209
7.3	Rumen marker outflow rates (FOR, %/h) and marker methodology for deer, goats and sheep fed on a low and a medium quality forage diet	218

## LIST OF FIGURES

Figure	Page
1.1a Seasonal voluntary feed intake of a pelleted diet by intact and castrate stags (from Kay, 1979)	24
1.1b Seasonal voluntary feed intake of a pelleted diet by intact stags and hinds (from Suttie <u>et al.</u> , 1987)	24
1.2 Voluntary feed intake of a pelleted concentrate diet by intact Red Deer stags and intact domestic Suffolk cross rams, subjected to an artificial six-month photoperiod (from Kay, 1979)	24
1.3 Seasonal hormonal status of Red Deer: the seasonal hormonal profiles of Prolactin, Testosterone (Barrell <u>et al.</u> , 1985), Growth Hormone and IGF-I (Suttie <u>et al.</u> , 1989), together with the seasonal VFI	32
2.1 Rumen sampler (Agricultural Engineering Workshop; Massey University)	53
2.2 Preparation of rumen bacterial sample (modified from Nolan and Leng, 1972)	57
2.3 Sequential carbohydrate extraction (from Bailey, 1967)	59
3.1 Schematic representation of the experimental design (Experiment 1)	71
3.2 Cumulative dry matter distribution of faecal samples from goats and sheep	88
3.3 Water flows (g/g DMI/d) into and out of the rumen of goats and sheep fed on mature prairie grass straw, at 90% "ad-lib" intake	95

## LIST OF FIGURES (continued)

Figure	Page
3.4	97
Enrichment with $^{15}\text{N}$ (atoms % excess) of rumen fluid $\text{NH}_3\text{-N}$ , bacterial-N and rumen digesta-NAN samples for goats, fed on mature prairie grass straw	
3.5	97
Enrichment with $^{15}\text{N}$ (atoms % excess) of rumen fluid $\text{NH}_3\text{-N}$ , bacterial-N and rumen digesta-NAN samples for sheep, fed on mature prairie grass straw	
3.6	100
Relationship between the dry matter intake ( $\text{g/Kg W}^{0.75}/\text{d}$ ) and total rumen pool (DM + liquid) ( $\text{g/Kg W}^{0.75}$ ) by goats and sheep fed on mature prairie grass straw, at 90% "ad-lib" intake	
3.7	103
Relationship between the "apparent" Fractional Outflow Rate (FOR, %/h) of particles $<0.25$ mm and the FOR (%/h) of lignin by goats and sheep fed on mature prairie grass straw, at 90% "ad-lib" intake	
3.8	104
Relationship between the "apparent" Fractional Outflow Rate (FOR, %/h) of particles 1.0-0.5 mm and the FOR (%/h) of lignin by goats and sheep fed on mature prairie grass straw, at 90% "ad-lib" intake	
3.9	108
Ammonia concentration (mg N/L) in the rumen of goats and sheep during continuous intraruminal infusion of $^{15}\text{NH}_4\text{Cl}$	
4.1	119
Schematic representation of the experimental design (Experiment 2)	
4.2	133
Cumulative dry matter distribution of faecal samples from deer, goats and sheep	

## LIST OF FIGURES (continued)

Figure	Page	
4.3	Enrichment with $^{15}\text{N}$ (atoms % excess) of rumen fluid $\text{NH}_3\text{-N}$ , bacterial-N and rumen digesta-NAN samples for deer, goats and sheep	149
5.1	Schematic representation of the experimental design (Experiment 3)	169
5.2	Trace of rumination and eating cycles by goats	171
5.3	Trace of rumination and eating cycles by sheep	171
5.4	Trace showing number of chews during eating by goats	172
5.5	Trace showing number of chews during eating by sheep	172
5.6	Trace showing number of chews during rumination by goats	175
5.7	Trace showing number of chews during rumination by sheep	175
5.8	Time (h) spent chewing during eating and ruminating over a 24-h period, by goats and sheep, fed on lucerne hay at 90% "ad-lib" intake	178
6.1	Schematic representation of the experimental design (Experiment 4)	189
6.2	Measurement of rumen water-filled capacity in the deer	193
6.3	Trace showing number of heart beats by the control deer	195

## LIST OF FIGURES (continued)

Figure		Page
6.4	Trace showing number of heart beats by the melatonin-Treated deer	195
6.5	Profiles of mean liveweight for Control and melatonin-Treated Red Deer castrates	197
6.6	Profile of mean day-time plasma melatonin concentrations (pg/ml) of Control and melatonin-Treated Red Deer castrates in spring/summer	198
7.1	Control of voluntary feed intake in seasonal breeds of deer: a working hypothesis	215

## LIST OF PLATES

	Page
Plate 1. Front view of a deer metabolic crate used in the present study	48
Plate 2. Side view of deer metabolic crate	48
Plate 3. Deer metabolic crate showing the side door closed in, restraining the animal	49

## ABBREVIATIONS USED IN THIS THESIS

Cr-EDTA	Chromium complex of ethylenediamine tetraacetic acid
DDMI	Digestible dry matter intake
DM	Dry matter
DMD	Apparent dry matter digestibility
DMI	Dry matter intake
DOMI	Digestible organic matter intake
FDPR	Fractional disappearance rate
FDR	Fractional degradation rate
FOR	Fractional outflow rate
GH	Growth hormone
HCl	Hydrochloric acid
H <sub>2</sub> SO <sub>4</sub>	Sulphuric acid
ID	Internal diameter
IGF-I	Insulin-like growth factor I
IM	Intramuscular
IRL	Irreversible loss rate
IU	International units
K <sub>2</sub> SO <sub>4</sub>	Potassium sulphate
LH	Luteinising hormone
LHRH	Luteinising hormone releasing hormone
LWT	Liveweight
M	Metabolisable energy for maintenance
MCF	Malignant catarrhal fever
ME	Metabolisable energy
Me	Melatonin
MRT	Mean retention time
N	Nitrogen
<sup>15</sup> N	Stable isotope of nitrogen
NaOH	Sodium hydroxide
NH <sub>4</sub> Cl	Ammonium chloride
NH <sub>3</sub> -N	Ammonia
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Ammonium sulphate
OD	Outer diameter
OM	Organic matter
OMD	Apparent organic matter digestibility
OMI	Organic matter intake
P	Prolactin



## ABBREVIATIONS (continued)

RF	Rumen fluid
Ru-Phen	Ruthenium tris (1,10-phenanthroline)-ruthenium (II) chloride
s.c.	Subcutaneous
T	Testosterone
TH	Thyroid hormone
VFA	Volatile fatty acid
VFI	Voluntary feed intake
v/v	volume by volume
w <sup>0.75</sup>	Metabolic liveweight