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**Comparative Studies of Effects of Sward Structure  
on Ingestive Behaviour of Sheep and Goats  
Grazing Grasses and Legumes**

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## ABSTRACT

A review of the literature indicated that the ingestive behaviour and herbage intake of grazing animals are strongly influenced by characteristics of sward canopy structure. However, there is limited comparative information on the behavioural contrasts of animals grazing grasses and legumes, and little comparative information on the ingestive behaviour of sheep and goats. The projects which form the basis of this thesis concentrated on these two aspects of ingestive behaviour using an indoor crate grazing technique, in which animals were individually confined in metabolism crates, and offered prepared turves.

Three experiments were designed and were run over a period from 1989 to 1991 at the Ballantrae Research Station of the New Zealand Pastoral Agriculture Research Institute (AgResearch).

In the first experiment, five grasses and four legumes were each sampled at two stages of growth to produce a range of canopy structures. Two sub-sets of data were generated. One sub-set (restricted data set) embraced four forages (two grasses and two legumes) at two maturity stages across two experimental years (4 forages x 2 stages x 2 animal species x 2 years). This sub-set was intended to assess the effects of the variation in animal body size with increasing maturity (Chapter 4). Another sub-set (enlarged data set) involved nine forages at two maturity stages over the second experimental year. It involved an attempt to examine the effect of sward canopy structure induced by a range of forage conditions on ingestive behaviour of sheep and goats (Chapter 5).

The second experiment was designed to dissociate the effects of sward height from the confounding effects of plant growth habit and maturity stage by creating contrasting heights within a forage species, and by sampling vegetative swards only. This experiment involved four forages (two grasses and two clovers) grazed by four sheep and four goats (Chapter 6).

The third experiment tested the comparability and conformability of ingestive behaviour between indoor crate grazing and field grazing using sheep, and between oesophageal fistulated and intact sheep using a field cage grazing technique (Chapter 7).

Major conclusions may be drawn as follows:

Bite weight was strongly influenced by bite depth. There was a substantially greater response in bite depth than in bite area to variation in sward conditions. Bite depth was a major spatial component of bite volume, and hence bite weight. Bite rate declined as bite weight increased, and intake rate was determined as the combination of bite weight and bite rate.

Ingestive behaviour of the grazing animals was strongly influenced by the characteristics of the sward canopy structure. Sward height usually had a much more dominant impact than did other sward variables, and bite depth had a much greater response than did other behaviour variables. Very close positive relationships existed between sward height and bite depth, bite volume, and hence bite weight, but the relationship between sward height and bite rate was negative. There was no statistically significant relationship between bite area and either sward height or other attributes. However, there was a significant interaction between animal species (sheep vs goats) and sward categories (grasses vs legumes) in this process, as outlined below.

Chapter 5 (enlarged data set of Experiment 1) revealed that when the leguminous swards were grazed by sheep, sward bulk density had a substantially greater effect on ingestive behaviour than did sward height. In contrast, the ingestive behaviour of goats grazing legumes was influenced largely by sward height, though the effect of bulk density was substantially increased compared with that in grasses. Both animal species had a greater response in bite weight than in bite depth when grazing legumes.

Chapter 6 (Experiment 2) showed that sward height always had the most important effect in both grasses and legumes irrespective of animal species. Appreciation of the effect of bulk density on ingestive behaviour after the dominant effect of sward height was accounted for, depended very strongly upon the establishment of independent variation in sward height and bulk density over the range of test swards. Sward height had a dominant effect and bulk density had no significant effect where independent variation in height was achieved. Where the variation in sward height was confounded with bulk density, although sward height still had a dominant effect, the interactive effect of sward height and bulk density was significant in some cases, depending on the sward categories (grasses or legumes) and animal species.

Animals usually had smaller bite dimensions on legumes than on grasses. However, the reduced bite depth, hence bite volume of legumes compared to grasses could be compensated for by a greater bulk density within the grazed strata, a smaller effort required to harvest herbage and less plant components slipping out of the teeth, leading to a greater bite weight.

Other differences between sheep and goats were identified as follows:

Sheep were generally capable of penetrating into swards deeply, whereas goats grazed swards from the top downwards. Sheep usually had larger bite dimensions, and hence greater bite weights than goats when grazing legumes (irrespective of maturity stages), and vegetative grasses, leading to greater bite weights on average. However, goats were able to achieve greater bite weight in relation to live weight. On reproductive grasses goats showed a greater willingness to eat, whereas sheep were selective through pushing into the swards to graze leafy components and rejected the rigid components.

When swards matured, intake rate of sheep decreased because an increase in bite weight was counterbalanced by a large fall in biting rate. Intake rate of goats increased as a result of a substantial increase in bite weight and a relatively small fall in bite rate, compared with sheep.

The variation in bite weight and bite depth between sheep and goats for a given sward may be attributed, at least partially, to the discrepancy in incisor arcade breadth between the two species. Increases in bite weight and bite dimensions with increasing maturity of animals were ascribable to increases in incisor breadth of animals with increasing maturity over time.

Experiment 3 (Chapter 7) demonstrated that the results of indoor crate grazing can be reliably extrapolated to field grazing on a short-term basis, and grazing behaviour of animals is not significantly altered by oesophageal fistulation.

Recommendations and suggestions for application to grazing management and plant selection programmes were made in practical terms.

**Key words:** canopy structure, height, bulk density, grasses, legumes, stage of maturity, ingestive behaviour, bite dimensions, bite weight, bite rate, sheep, goats, indoor crate grazing, outdoor cage grazing, fistulated sheep, intact sheep.

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## Abbreviations

The following abbreviations and symbols of statistical conventions, technical terms and names of forages were used throughout this thesis.

### Statistical conventions

#### Abbreviations or symbols

ns	Not statistically significant
(*)	Significant at the $P < 0.1$ level of probability
*	Significant at the $P < 0.05$ level of probability
**	Significant at the $P < 0.01$ level of probability
***	Significant at the $P < 0.001$ level of probability
s.e	Standard errors of least squares means
LSD	Least significant difference ( $P < 0.05$ )
$R^2$	Coefficient of determination: proportion of variation accounted for by regression
Partial $R^2$	Proportion of variation accounted for by corresponding term included in the regression equation
F	Variance ratio
ANOVA	Univariate analysis of variance
MANOVA	Multivariate analysis of variance
MDF	Multivariate discriminant function analysis
MDF1	The first discriminant function
MDF2	The second discriminant function
CORR	Correlation coefficients between score and original variables in the discriminant function analysis
STAN	Standardized coefficients of variables in the discriminant function analysis

### Technical terms

DM	Dry matter
FM	Fresh matter
LW	Live weight
BW1	Bite weight 1 (mg FM/bite)

BW2	Bite weight 2 (mg DM/bite)
BW3	Bite weight 3 (mg DM/kgLW <sup>0.75</sup> )
BR	Bite rate (bites/min)
IR2	Intake rate 2 (mg DM/min)
IR3	Intake rate 3 (mg DM/kgLW <sup>0.75</sup> /min)
BD	Bite depth (cm)
BA	Bite area (cm <sup>2</sup> )
BV	Bite volume (cm <sup>3</sup> )

### **Forage identifiers**

The forage and sward identifiers which appear in the thesis frequently are listed below. Those which only appear on few occasions will be noted where appropriate.

ry	Ryegrass
br	Browntop
ck	Cocksfoot
pg	Prairegrass
ph	Phalaris
th	Tahora white clover
kp	Kopu white clover
rc	Red clover
Veg	Vegetative stage
Rep	Reproductive stage

### **Animal identifiers**

sh	Sheep
go	Goats
NOF	non-fistulated animals
OF	fistulated animals

## Contents

<b>Abstract</b> .....	I
<b>Acknowledgements</b> .....	IV
<b>Abbreviations</b> .....	VII
<b>Contents</b> .....	IX
<b>List of Tables</b> .....	XVII
<b>List of Figures</b> .....	XXIV
<b>List of Plates</b> .....	XXVII
<b>Chapter 1</b> <b>GENERAL INTRODUCTION</b> .....	1
<b>Chapter 2</b> <b>LITERATURE REVIEW</b> .....	3
2.1    Introduction .....	3
2.2    Significance of the research on ingestive behaviour and herbage intake .....	3
2.3    Control of herbage intake in grazing animals .....	5
2.4    Ingestive behaviour of grazing animals .....	6
2.4.1    Grazing activity .....	6
2.4.2    Variables of ingestive behaviour .....	6
2.4.2.1    Components of ingestive behaviour .....	6
2.4.2.1.1    Bite weight .....	7
2.4.2.1.2    Biting rate .....	9
2.4.2.1.3    Rate of intake .....	11
2.4.2.1.4    Grazing time .....	13
2.4.2.1.5    Total daily bites .....	16
2.4.2.1.6    Daily herbage intake .....	16
2.4.2.2    Components of bite dimensions .....	18
2.4.2.2.1    Bite depth .....	19
2.4.2.2.2    Bite area .....	22
2.4.2.2.3    Bite volume .....	25
2.4.2.3    Overall response patterns and compensatory changes in ingestive behaviour variables .....	26
2.4.3    Summary .....	27
2.5    Sward attributes affecting ingestive behaviour .....	28
2.5.1    Herbage mass .....	29
2.5.1.1    Concept .....	29
2.5.1.2    Effects of herbage mass and herbage allowance	

		X
	on ingestive behaviour .....	30
2.5.2	Sward canopy structure .....	32
	2.5.2.1 Concept .....	32
	2.5.2.2 Effects of sward canopy structure on ingestive behaviour .....	32
	2.5.2.2.1 Height .....	33
	2.5.2.2.2 Density .....	37
	2.5.2.2.3 Other sward attributes .....	39
2.5.3	Quality of sward .....	43
2.5.4	Summary .....	45
2.6	Animal attributes affecting ingestive behaviour .....	46
	2.6.1 Hunger .....	46
	2.6.2 Body sizes across animal species .....	48
	2.6.3 Degree of maturity within a species (age, body size and mouth dimensions) .....	50
	2.6.4 Summary .....	53
2.7	Comparison of ingestive behaviour and herbage intake between animal species .....	54
2.8	Grazing procedures involved in research on ingestive behaviour: field grazing vs indoor crated grazing .....	59
2.9	Conclusion .....	60
<b>Chapter 3</b>	<b>EXPERIMENT 1 .....</b>	<b>62</b>
	Experimental Details	
3.1	Introduction .....	62
3.2	Materials and Methods .....	62
	3.2.1 Experimental plots .....	62
	3.2.1.1 Natural and ecological conditions of experimental site .....	62
	3.2.1.2 Forages (plant species and cultivars) .....	63
	3.2.1.3 Establishment and general management of the plots .....	63
	3.2.2 Animals .....	64
	3.2.2.1 Training of the animals .....	65
	3.2.2.2 Animal measurements .....	65
	3.2.2.2.1 Body weight .....	65
	3.2.2.2.2 Incisor breadth and number .....	66
	3.2.2.2.3 Mouthpart dimensions .....	66
	3.2.3 Preparation and sampling of the swards (turves) .....	66
	3.2.4 Pre-grazing measurements of the sward .....	67
	3.2.4.1 Sward height .....	67

3.2.4.2	Point quadrat	68
3.2.5	Feeding procedures	69
3.2.5.1	Preparation of the animals	69
3.2.5.2	Feeding	70
3.2.6	Post-grazing measurements of the sward	72
3.2.6.1	Residual height	73
3.2.6.2	Bite area	73
3.2.6.3	Herbage mass remaining within grazed stratum	73
3.2.6.4	Calculation and calibration of DM% of the herbage of the grazed stratum	75
3.2.6.5	Herbage mass below grazed height	75
3.2.7	Calculation of the derived variables	76
3.2.7.1	Bite weight (BW)	76
3.2.7.2	Bite rate (BR)	77
3.2.7.3	Intake rate (IR)	77
3.2.7.4	Bite depth (BD)	77
3.2.7.5	Bite area (BA)	77
3.2.7.6	Bite volume (BV)	77
3.2.7.7	Mass bulk density	77
3.2.7.8	Leaf layer depth	78
3.2.7.9	Proportions and frequency bulk densities of plant components	78
3.3	Experimental Design and Organization of the Data	79
3.3.1	Experimental design and construction of data sets	79
3.3.2	Alignment and correspondence of the variables between sward, animal and ingestive behaviour	82
3.3.3	Statistical analysis	83
<b>Chapter 4</b>	<b>RESTRICTED DATA SET FROM EXPERIMENT 1</b>	<b>84</b>
	Effects of Permanent-incisor Breadth on Bite Weight and Bite Dimensions of Sheep and Goats	
4.1	Introduction	84
4.2	Statistical analysis	85
4.3	Results and data adjustment	86
4.3.1	Sward conditions	87
4.3.2	Animal variables	87
4.3.3	ANOVA of behaviour variables based on unadjusted data	87
4.3.4	Sward effects on ingestive behaviour across two years	90

- 4.3.5 Animal factors influencing ingestive behaviour across two years . . . . . 92
- 4.3.6 ANOVA of behaviour variables based on the first adjustment of the data . . . . . 96
- 4.3.7 ANOVA of behaviour variables based on the second adjustment of the  
data . . . . . 96
- 4.4 Discussion . . . . . 96
  - 4.4.1 Statistical approach employed in the data adjustment . . . . . 96
  - 4.4.2 Effect of incisor breadth on behaviour variables within animal species  
over time (the first adjustment) . . . . . 100
  - 4.4.3 Effect of incisor breadth on behaviour variables between animal species  
within time (the second adjustment) . . . . . 101
  - 4.4.4 Relative importance of incisor breadth to live weight in affecting  
ingestive behaviour . . . . . 102
- 4.5 Conclusions . . . . . 104
  
- Chapter 5 ENLARGED DATA SET FROM EXPERIMENT 1 . . . . . 105**
  - The Effects of Sward Canopy Structure on the Components of  
Ingestive Behaviour and Bite Dimensions of Sheep and Goats Grazing  
a Wide Range of Swards
- 5.1 Introduction . . . . . 105
- 5.2 Statistical analysis . . . . . 107
  - 5.2.1 Introduction . . . . . 107
  - 5.2.2 Analysis of variance . . . . . 108
    - 5.2.2.1 Univariate analysis of variance (ANOVA) . . . . . 109
    - 5.2.2.2 Multivariate analysis of variance (MANOVA)  
and multiple discriminant function (MDF) . . . . . 110
      - 5.2.2.2.1 Some concepts underlying principles of  
multivariate analysis . . . . . 110
      - 5.2.2.2.2 MANOVA and MDF . . . . . 110
      - 5.2.2.2.3 A scheme of interpretation of MANOVA and MDF . . . . . 115
  - 5.2.3 Cluster analysis . . . . . 116
  - 5.2.4 Analysis of correlation and regression . . . . . 118
    - 5.2.4.1 Canonical analysis . . . . . 118
    - 5.2.4.2 Multiple regression analysis . . . . . 121
  - 5.2.5 Transformation of data . . . . . 123
- 5.3 Results . . . . . 123
  - 5.3.1 Univariate analysis of variance . . . . . 123
    - 5.3.1.1 Descriptions of sward variables . . . . . 123

	5.3.1.1.1	Gross structural variables . . . . .	124
	5.3.1.1.2	Point-quadrat data . . . . .	127
5.3.1.2		Descriptions of animal variables . . . . .	130
5.3.1.3		Descriptions of ingestive behaviour variables . . . . .	130
	5.3.1.3.1	Main effects (animal species, forages and maturity stages) . . . . .	130
	5.3.1.3.2	The first order interactions . . . . .	132
	5.3.1.3.3	The second order interaction . . . . .	137
5.3.2		Univariate analysis of variance of behaviour variables by combining nine forages into the two herbage categories (grasses vs. legumes) . . . . .	137
5.3.3		Multivariate analysis of variance (MANOVA) and multiple discriminant function analysis (MDF) . . . . .	143
	5.3.3.1	Set of sward variables . . . . .	145
	5.3.3.1.1	The variables of the complete sward profile . . . . .	146
	5.3.3.1.2	The variables of the grazed strata . . . . .	149
5.3.3.2		Set of behaviour variables . . . . .	154
	5.3.3.2.1	Main effects . . . . .	156
	5.3.3.2.2	The first order interactions . . . . .	162
	5.3.3.2.3	The second order interaction . . . . .	171
5.3.4		Interrelationships between sward variables and behaviour variables . . . . .	174
	5.3.4.1	Canonical analysis between the set of sward variables and the set of behaviour variables . . . . .	174
	5.3.4.1.1	Overall relationship between sward variables and behaviour variables . . . . .	175
	5.3.4.1.2	Comparison between sheep and goats in responding to sward characteristics . . . . .	175
	5.3.4.1.3	Comparison between grasses and legumes in affecting ingestive behaviour of the animals . . . . .	177
	5.3.4.1.4	Comparison between sheep and goats grazing grasses and legumes . . . . .	178
	5.3.4.2	Multiple regression of individual behaviour variables against the set of sward variables . . . . .	180
5.4		Discussion . . . . .	188
	5.4.1	Over-time effect of incisor breadth covariate . . . . .	188
	5.4.2	Sward conditions . . . . .	188
	5.4.3	Ingestive behaviour . . . . .	189
	5.4.4	Influence of sward characteristics on ingestive behaviour . . . . .	196

5.4.5	Comparison of MANOVA and MDF between the set of sward variables (complete profiles) and the set of behaviour variables . . . . .	201
5.5	Conclusions . . . . .	201
<b>Chapter 6</b>	<b>EXPERIMENT 2 . . . . .</b>	<b>204</b>
	Effects of Contrasting Sward Heights on Components of Ingestive Behaviour of Sheep and Goats Grazing Grasses and Clovers	
6.1	Introduction . . . . .	204
6.2	Materials and Methods . . . . .	204
6.2.1	Experimental design . . . . .	204
6.2.2	Experimental procedures . . . . .	205
6.2.3	Statistical analysis . . . . .	206
6.3	Results . . . . .	207
6.3.1	Sward conditions . . . . .	207
6.3.2	Ingestive behaviour variables . . . . .	210
6.3.2.1	Bite weight . . . . .	211
6.3.2.2	Bite rate . . . . .	215
6.3.2.3	Bite depth . . . . .	215
6.3.2.4	Bite area . . . . .	215
6.3.2.5	Bite volume . . . . .	216
6.3.3	Correlation and regression relationships between sward and ingestive behaviour variables within forages . . . . .	216
6.3.4	Comparison of response patterns of ingestive behaviour to variation in sward height across forages (pooled analysis) . . . . .	224
6.4	Discussion . . . . .	228
6.4.1	Sward conditions . . . . .	228
6.4.2	Ingestive behaviour variables . . . . .	228
6.4.2.1	Bite depth . . . . .	230
6.4.2.2	Bite area . . . . .	231
6.4.2.3	Bite volume . . . . .	233
6.4.2.4	Bite weight . . . . .	233
6.4.2.5	Bite rate . . . . .	235
6.5	Conclusions . . . . .	235
<b>Chapter 7</b>	<b>EXPERIMENT 3 . . . . .</b>	<b>238</b>
	Comparison of Ingestive Behaviour between Indoor and Outdoor Grazing Using Fistulated Sheep, and between Fistulated and Intact	

## Sheep Using Indoor Grazing Procedures

7.1	Introduction . . . . .	238
7.2	Materials and Methods . . . . .	239
	7.2.1 Experimental design . . . . .	239
	7.2.2 Oesophageal fistulated animals . . . . .	239
	7.2.3 Experimental procedures . . . . .	240
	7.2.4 Statistical analysis . . . . .	244
7.3	Results . . . . .	244
	7.3.1 Sward conditions . . . . .	244
	7.3.2 Ingestive behaviour variables . . . . .	245
	7.3.2.1 Comparison between indoor intact sheep and indoor fistulated sheep . . . . .	245
	7.3.2.2 Comparison between indoor fistulated and outdoor fistulated sheep . . . . .	246
	7.3.2.3 Comparison of bite weight between turf-based and extrusa-based estimates . . . . .	251
	7.3.2.4 Recovery coefficients of fistulated sheep . . . . .	251
7.4	Discussion . . . . .	251
7.5	Conclusions . . . . .	256
 <b>Chapter 8 GENERAL DISCUSSION AND CONCLUSIONS . . . . .</b>		 <b>257</b>
8.1	Links between the three experiments conducted in this project . . . . .	257
8.2	Experimental procedures . . . . .	260
8.3	Appraisal of use of the multivariate approaches in this project . . . . .	263
8.4	Sward conditions . . . . .	265
8.5	Components of ingestive behaviour . . . . .	268
	8.5.1 Bite dimensions . . . . .	269
	8.5.1.1 Bite depth . . . . .	269
	8.5.1.2 Bite area . . . . .	272
	8.5.2 Bite weight and bite rate . . . . .	275
8.6	Effects of sward structure on grazing behaviour of animals . . . . .	278
8.7	Summary of comparisons of ingestive behaviour between sheep and goats . . . . .	281
8.8	Application and recommendation . . . . .	283
8.9	Conclusions . . . . .	286
 <b>References . . . . .</b>		 <b>288</b>

<b>Appendices</b> .....	303
<b>Appendix 3.1:</b> Description of agronomic characteristics of forages used in Experiment 1 .....	303
<b>Appendix 3.2:</b> Application of herbicide during the courses of plot establishment and experimental measurements .....	305
<b>Appendix 4.1:</b> Adjustment of data .....	306
<b>Appendix 5.1:</b> Graphs illustrating the canopy structures of swards for 9 forages x 2 stages using point-quadrat data .....	310
<b>Appendix 5.2:</b> Tables presenting scores of multiple discriminant functions at different levels of treatments for three data sets (entire profiles of sward set, grazed strata of sward set, and ingestive behaviour set) .....	313
<b>Appendix 5.3:</b> Dendrograms illustrating cluster hierarchy of discriminant scores for different sets of attributes at different levels of treatments .....	316
<b>Appendix 5.4:</b> Tables presenting truncation probabilities for clusters .....	319
<b>Appendix 5.5:</b> Tables presenting correlation matrices showing simple correlations between seven sward variables and five ingestive behaviour variables for animal species x herbage categories .....	324
<b>Appendix 7.1:</b> Correction of recovery for saliva contamination .....	329

## List of Tables

### Chapter 2

<b>Table 2.1</b>	Critical values of pre-grazing height on ryegrass dominant swards required to maintain levels of herbage intake and animal performance close to maximum (from Hodgson, 1990). . . . .	35
<b>Table 2.2</b>	Ranges of variation in components of ingestive behaviour and bite dimensions in sheep and cattle grazing temperate swards . . . . .	57
<b>Table 2.3</b>	Pregrazing herbage mass, height and grazing depth for adult cattle, sheep and goats (quoted by Hughes, 1988) . . . . .	59

### Chapter 3

<b>Table 3.1</b>	Plant species and cultivars utilised in experiment 1 . . . . .	63
<b>Table 3.2</b>	Experimental design and construction of data sets . . . . .	80
<b>Table 3.3</b>	Forages constructed in the two data subsets and distribution of the sampling dates . . . . .	81

### Chapter 4

<b>Table 4.1</b>	Structure of the restricted data set generated from Chapter 3 . . . . .	85
<b>Table 4.2</b>	Description of sward conditions for years x forages x stages . . . . .	88
<b>Table 4.3</b>	Changes in live weight and incisor breadth of six sheep and six goats over two experimental periods (two years) . . . . .	89
<b>Table 4.4</b>	Unadjusted values of bite weight and bite dimensions for sheep and goats grazing 4 forages x 2 maturity stages across two years . . . . .	91
<b>Table 4.5</b>	Significant levels of ANOVA for main effects and the first order interactions involved with year effect, based on unadjusted data . . . . .	92
<b>Table 4.6</b>	Correlation matrix of sward height, incisor breadth and liveweight, and bite weight and bite depth across forages and animal species . . . . .	92
<b>Table 4.7</b>	Regressions of bite weight and bite dimensions on incisor breadth, and on live weight by 3 models to define an appropriate covariate for adjustment of data . . . . .	93
<b>Table 4.8</b>	t tests of $\beta_0$ and $\beta_1$ values of the regression equations (bite weight 2 against incisor breadth) to assess heterogeneity of these equations in describing the effects of incisor breadth on bite weight among the forage x animal species combinations . . . . .	95

<b>4.8a:</b>	t tests of $\beta_0$ and $\beta_1$ values of the regressions equations (bite weight 2 against incisor breadth) for the contrasts between sheep and goats grazing the same forages . . . . .	95
<b>4.8b:</b>	t tests of $\beta_0$ and $\beta_1$ values of the regressions equations (bite weight 2 against incisor breadth) for the contrasts between forages grazed by the same animal species . . . . .	95
<b>Table 4.9</b>	Adjusted values of bite weight and bite dimensions of sheep and goats grazing 4 forages x 2 stages across two years based on the first adjustment (corresponding to Table 4.4 presenting the unadjusted values of these variables) . . . . .	97
<b>Table 4.10</b>	Comparison of year effect on bite weight and bite dimensions between the pre-adjustment and post-adjustment (the first adjustment) . . . . .	98
<b>Table 4.11</b>	Adjusted values of bite weight and bite dimensions based on the second adjustment for sheep and goats grazing 4 forages x 2 stages across two years (corresponding to Table 4.4 presenting unadjusted values of these variables) . . . . .	99
<b>Table 4.12</b>	Comparison of animal species effect on bite weight and bite dimensions between the pre-adjustment and post-adjustment . . . . .	100
<b>Chapter 5</b>		
<b>Table 5.1</b>	Experimental design and data structures generated from Chapter 3 . . . . .	107
<b>Table 5.2</b>	Gordon's scheme for interpreting multivariate analyses (Gordon pers. com., 1993) . . . . .	117
<b>Table 5.3</b>	Descriptions of sward variables for main effects (animal species, forages and stages) . . . . .	124
<b>Table 5.4</b>	Descriptions of sward variables for the first order interaction of forages by maturity stages of growth . . . . .	126
<b>Table 5.5</b>	Descriptions of the point-quadrat data of swards for main effects (animal species, forages and stages) . . . . .	128
<b>Table 5.6</b>	Descriptions of the point-quadrat data of swards for the first order interaction between forages and maturity stages . . . . .	129
<b>Table 5.7</b>	Descriptions of animal parameters . . . . .	130
<b>Table 5.8</b>	Ingestive behaviour variables for main effects (animal species, forages and stages) . . . . .	131

<b>Table 5.9</b>	Ingestive behaviour variables for the first order interaction of maturity stage by animal species . . . . .	133
<b>Table 5.10</b>	Ingestive behaviour variables for the first order interaction of forage by animal species . . . . .	135
<b>Table 5.11</b>	Ingestive behaviour variables for the first order interaction of forage by maturity stage . . . . .	136
<b>Table 5.12</b>	Ingestive behaviour variables for the second order interaction between forages, maturity stages and animal species . . . . .	138
<b>Table 5.13</b>	Comparison of ingestive behaviour variables of animals grazing the gramineous and leguminous swards . . . . .	139
<b>Table 5.14</b>	Ingestive behaviour variables for the interaction between herbage category and animal species . . . . .	141
<b>Table 5.15</b>	Ingestive behaviour variables for the interaction between herbage category and maturity stage . . . . .	142
<b>Table 5.16</b>	Ingestive behaviour variables for the second order interaction between herbage category, maturity stage and animal species . . . . .	144
<b>Table 5.17</b>	Structural coefficients (correlations), standardised coefficients and summary of important statistics of the multiple discriminant functions (MDF) at various levels of the treatments for sward variables of entire profile . . . . .	147
<b>Table 5.18</b>	Structural coefficients (correlations), standardised coefficients and summary of important statistics of the multiple discriminant functions (MDF) at various levels of the treatments for sward variables of grazed stratum . . . . .	152
<b>Table 5.19</b>	Structural coefficients (correlations), standardised coefficients and summary of important statistics of the discriminant functions at various levels of the treatments for behavioural variables . . . . .	157
<b>Table 5.20</b>	Summary of behaviour variables for each cluster and the associated information of four clusters for main effect, forages . . . . .	161
<b>Table 5.21</b>	Summary of behaviour variables for each cluster and the associated information of six clusters for the interaction between forage and stage . . . . .	165
<b>Table 5.22</b>	Summary of the behaviour variables for each cluster and the associated information of five clusters for the interaction between animal species and forages . . . . .	169

<b>Table 5.23</b>	Summary of the behaviour variables for each cluster and the associated information of seven clusters for the second order interaction .....	173
<b>Table 5.24</b>	Canonical correlation coefficients between the set of sward variables and the set of behaviour variables, standardised coefficients, structural coefficients and summary of important statistics of the first canonical score at various levels of the treatments .....	176
<b>Table 5.25</b>	Canonical correlation coefficients between sets of sward variables and behaviour variables, standardised coefficients and structural coefficients and summary of important statistics of the canonical scores at the level of interaction of herbage category (grass vs legume) with animal species .....	179
<b>Table 5.26</b>	Summary of multiple regression for the different treatments, determined by Stepwise procedure (bite weight 2) .....	182
<b>Table 5.27</b>	Summary of multiple regression for the different treatments, determined by Stepwise procedure (bite depth) .....	183
<b>Table 5.28</b>	Sequential F-test of improvement of regression precision after a quadratic term was included in the equation describing the relationship between bite depth and sward height on "grasses" .....	185
 <b>Chapter 6</b>		
<b>Table 6.1</b>	Experimental design .....	205
<b>Table 6.2</b>	Standardized coefficients of sward variables for the discriminant functions .....	210
<b>Table 6.3</b>	Descriptions of sward conditions for ryegrass, cocksfoot and clovers at different heights .....	211
<b>Table 6.4</b>	Summary of ingestive behaviour variables when grazing ryegrass for interaction between height and animal species .....	212
<b>Table 6.5</b>	Summary of ingestive behaviour variables when grazing cocksfoot for interaction between height and animal species .....	213
<b>Table 6.6</b>	Summary of ingestive behaviour variables when grazing clovers for interaction between height and animal species .....	214
<b>Table 6.7</b>	Overall correlation matrices for the relationships between three sward variables and five ingestive behaviour variables based on ryegrass, cocksfoot and clovers, separately .....	217
<b>Table 6.8</b>	Summary of regression equations for <b>ryegrass</b> .....	221

<b>Table 6.9</b>	Summary of regression equations for <b>cocksfoot</b> . . . . .	222
<b>Table 6.10</b>	Summary of regression equations for <b>clovers</b> . . . . .	223
<b>Table 6.11</b>	Significance levels of the pooled analysis for the main effects and their interactions in each bite variable . . . . .	224
 <b>Chapter 7</b>		
<b>Table 7.1</b>	Description of sward variables for 4 forages x 2 stages based on the averaged values of indoor turves and outdoor quadrats . . . . .	245
<b>Table 7.2</b>	Comparison of ingestive behaviour variables between indoor intact sheep (indoor-N.O.F) and indoor fistulated (indoor-O.F) sheep. Bite weight refers to turf-based estimate (Bite weight <sub>tb</sub> ) . . . . .	246
<b>Table 7.3</b>	Comparison of ingestive behaviour variables between indoor intact sheep (N.O.F) and indoor fistulated sheep (O.F) for the interaction of stock states x forages x stages. Bite weight refers to turf-based estimate (Bite weight <sub>tb</sub> ) . . . . .	247
<b>Table 7.4</b>	Significance levels of two main effects (forage and stage) and all the first-order interactions between the three main effects (stock state, forage and stage) on bite variables . . . . .	248
<b>Table 7.5</b>	Comparison of ingestive behaviour variables between indoor-O.F and outdoor-O.F in which bite weight was derived from extrusa-based estimate (Bite weight <sub>eb</sub> ) . . . . .	248
<b>Table 7.6</b>	Comparison of ingestive behaviour variables between indoor (IN) fistulated and outdoor (OUT) fistulated sheep for the interaction of grazing environments x forages x stages. Bite weight refers to extrusa-based estimate (Bite weight <sub>eb</sub> ) . . . . .	249
<b>Table 7.7</b>	Significance levels of two main effects (forage and stage) and all the first-order interactions between the three main effects (grazing environment, forage and stage) on bite variables . . . . .	250
<b>Table 7.8</b>	Recovery coefficients based on indoor fistulated sheep on 4 forages x 2 stages. They were calculated by the ratios of extrusa-based estimates (uncorrected estimates) to turf-based estimates . . . . .	252
<b>Table 7.9</b>	Comparison of recovery coefficients in the current trial with data withdrawn from literature . . . . .	255
<b>Table 7.10</b>	Recovery coefficients after saliva contamination was corrected . . . . .	255

**Chapter 8**

<b>Table 8.1</b>	Summary and comparison of experimental designs among the three Experiments . . . . .	258
<b>Table 8.2</b>	Comparisons of ratio of bite depth to sward height between the current research and the data drawn from previous work . . . . .	270

**Appendices****Appendix 4.1**

<b>Table 1:</b>	Regressions of bite weight and bite dimensions against incisor breadth for animal species x forages combinations to obtain coefficients to be used in the data adjustment . . . . .	308
<b>Table 2:</b>	Average incisor breadth of sheep and goats when grazing four forages. These values were used in the data adjustment . . . . .	309
<b>Table 3:</b>	Regressions of bite weight and bite dimensions against incisor breadth for maturity stages to obtain coefficients to be used in the second adjustment . . . . .	309

**Appendix 5.2**

<b>Table 1</b>	Scores of forages for three sets (entire profiles of sward, grazed strata of sward and behaviour set . . . . .	313
<b>Table 2</b>	Scores of forage x stage for three sets . . . . .	314
<b>Table 3</b>	Scores of forage x animal species, and forage x stage x animal species for behaviour set . . . . .	315

**Appendix 5.4**

<b>Table 1</b>	Truncation probabilities for sward attributes of complete profiles for forages (corresponding to Fig.1 of Appendix 5.3 and to Fig. 5.1B of Thesis text) . . . . .	319
<b>Table 2</b>	Sward attributes of complete profiles for forage x stages (corresponding to Fig. 2 of Appendix 5.3 and to Fig. 5.2B of Thesis text) . . . . .	320
<b>Table 3</b>	Sward attributes of grazed strata for forage (corresponding to Fig. 3 of Appendix 5.3 and to Fig. 5.3B of Thesis text) . . . . .	320
<b>Table 4</b>	Sward attributes of grazed strata for forage x stage (corresponding to Fig. 4 of Appendix 5.3 and to Fig. 5.4B of Thesis text) . . . . .	321

<b>Table 5</b>	Behaviour attributes for main effect, forages (corresponding to Fig. 5 of Appendix 5.3 and to Fig. 5.5C of Thesis text) . . . . .	321
<b>Table 6</b>	Behaviour attributes for interaction between forages and stages (corresponding to Fig. 6 of Appendix 5.3 and to Fig. 5.6C of Thesis text) . . . . .	322
<b>Table 7</b>	Behaviour attributes for interaction between forage and animal species (corresponding to Fig. 7 of Appendix 5.3 and to Fig. 5.7C of Thesis text) . . . . .	322
<b>Table 8</b>	Behaviour attributes for the second order interaction (corresponding to Fig. 8 of Appendix 5.3 and Fig. 5.9 of Thesis text) . . . . .	323
 <b>Appendix 5.5</b>		
<b>Table 1</b>	Correlation matrix at overall (unpartitioned) level . . . . .	324
<b>Table 2</b>	Correlation matrix for sheep x grasses . . . . .	325
<b>Table 3</b>	Correlation matrix for goats x grasses . . . . .	326
<b>Table 4</b>	Correlation matrix for sheep x legumes . . . . .	327
<b>Table 5</b>	Correlation matrix for goats x legumes . . . . .	328

## List of Figures

### Chapter 2

- Fig. 2.1** Factors influencing ingestive behaviour of grazing animals (after Burlison, 1987) . . . . . 4
- Fig. 2.2** The components of ingestive behaviour and bite dimensions (after Hodgson, 1990 and Burlison *et al.*, 1991) . . . . . 20

### Chapter 5

- Fig. 5.1** Scores of nine forages for sward attributes of entire profiles . . . . . 148
- A: Histogram of scores in MDF1
- B: Plot in 2 MDFs
- Fig. 5.2** Scores of forage x stage for sward attributes of entire profiles . . . . . 150
- A: Histogram of scores in MDF1
- B: Plot in 2 MDFs
- Fig. 5.3** Scores of nine forages for sward attributes of grazed strata . . . . . 153
- A: Histogram in MDF1
- B: Plot in MDFs
- Fig. 5.4** Scores of forage x stage for sward attributes of the grazed strata . . . . . 155
- A: Histogram in MDF1
- B: Plot in 2 MDFs
- Fig. 5.5** Scores of nine forages for behaviour attributes . . . . . 160
- A: Histogram in MDF1
- B: Histogram in MDF2
- C: Plot in 2 MDFs
- Fig. 5.6** Scores of forage x stage for behaviour attributes . . . . . 163
- A: Histogram in MDF1
- B: Histogram in MDF2
- C: Plot in 2 MDFs
- Fig. 5.7** Scores of animal species x forage for behaviour attributes . . . . . 167
- A: Histogram in MDF1
- B: Histogram in MDF2
- C: Plot in 2 MDFs
- Fig. 5.8** Histogram of scores of animal species x stage in MDF1 for behaviour attributes . . . . . 170
- Fig. 5.9** Plot of animal x forage x stage for behaviour attributes . . . . . 170

**Fig. 5.10** Linear relationships between bite depth and sward height based on grasses ..... 187

A: Linear relationship between bite depth and sward height for grasses, and grasses x animals.

B: Linear relationships between bite depth and sward height for animals x grasses x stages.

**Fig. 5.11** Variation in bite variables across animal x herbage category x stage ..... 191

A: Bite depth

B: Bite area

**Fig. 5.12** Variation in bite variables across animal x herbage category x stage ..... 192

A: Bite weight

B: Bite rate

**Chapter 6**

**Fig. 6.1** Diagrams (A<sub>1</sub> - G<sub>3</sub>) of bulk density of grazed stratum, bite weight, bite rate, bite depth, bite area and bite volume against sward height for three types of swards (ryegrass, cocksfoot and clovers) ..... 208

**Fig. 6.2** Response surfaces of bite variables to sward height (H) and bulk density (D) for goats grazing ryegrass ..... 219

A: Bite weight

B: Bite rate

C: Bite depth

D: Bite volume

**Fig. 6.3** Response surfaces of bite variables of bite variables to sward height (H) and bulk density (D) for sheep grazing clovers ..... 220

A: Bite depth

B: Bite volume

**Fig. 6.4** Diagrams showing the simple correlations between sward height and bulk density, and between bite variables and sward height, and bulk density for animal species x forage species ..... 225

A<sub>1</sub>: Sheep x ryegrass ..... 225

A<sub>2</sub>: Goats x ryegrass ..... 225

B<sub>1</sub>: Sheep x cocksfoot ..... 226

B<sub>2</sub>: Goats x cocksfoot ..... 226

C<sub>1</sub>: Sheep x clovers ..... 227

C <sub>2</sub> :	Goats x clovers .....	227
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## Chapter 8

<b>Fig. 8.1</b>	Comparisons of linear relationships between bite weight (BW) and sward height (H) among three experiments for the two species grazing grasses and legumes .....	276
A:	Grasses	
B:	Legumes	

## Appendices

<b>Appendix 5.1</b>	Graphs illustrating the canopy structures of swards for 9 forages x 2 stages using point-quadrat data .....	310
<b>Appendix 5.3</b>	Dendrograms showing cluster hierarchy of discriminant scores for different sets of attributes at different levels of treatments .....	316
<b>Fig. 1</b>	Sward attributes of complete profiles for forages (corresponding to Table 1 of Appendix 5.4 and Fig. 5.1B of Chapter 5) .....	316
<b>Fig. 2</b>	Sward attributes of complete profiles for forage x stage (corresponding to Table 2 of Appendix 5.4 and Fig. 5.2B of Chapter 5) .....	316
<b>Fig. 3</b>	Sward attributes of grazed strata for forages (corresponding to Table 3 of Appendix 5.3 and Fig. 5.3B of Chapter 5) .....	316
<b>Fig. 4</b>	Sward attributes of grazed strata for forage x stage (corresponding to Table 4 of Appendix 5.4 and Fig. 5.4B of Chapter 5) .....	317
<b>Fig. 5</b>	Behaviour attributes for forages (corresponding to Table 5 of Appendix 5.4 and Fig. 5.5C of Chapter 5) .....	317
<b>Fig. 6</b>	Behaviour attributes for forage x stage (corresponding to Table 6 of Appendix 5.4 and Fig. 5.6C of Chapter 5) .....	317
<b>Fig. 7</b>	Behaviour attributes for animal species x forage (corresponding to Table 7 of Appendix 5.4 and Fig. 5.7C of Chapter 5) .....	318
<b>Fig. 8</b>	Behaviour attributes for animal species x forage x stage (corresponding to Table 8 of Appendix 5.4 and Fig. 5.9 of Chapter 5) .....	318

## List of Plates

### Chapter 3

- Plate 3.1** Animals were individually confined in the metabolism crates . . . . . 71
- Plate 3.2** Animals were offered the prepared turves. The use of a metal sheet  
was intended to prevent grazing from the side . . . . . 71
- Plate 3.3A** Horizontal sampling device . . . . . 74
- Plate 3.3B** Horizontal sampling device . . . . . 74

### Chapter 5

- Plate 5.1** Sheep pushed into the sward canopy to graze deeply . . . . . 193
- Plate 5.2** Goats were shallow grazers and grazed from top downwards . . . . . 193

### Chapter 7

- Plate 7.1** A fistulated sheep was confined in the field grazing cage . . . . . 243
- Plate 7.2** Extrusa was collected from a fistulated sheep grazing in the field  
cage . . . . . 243