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STUDIES ON THE EFFECTS OF GRAZING REGIME

ON SWARD AND DAIRY COW PERFORMANCE

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TABLE OF CONTENTS

	page
TITLE PAGE	i
ABSTRACT	ii
ACKNOWLEDGEMENTS	iv
LIST OF TABLES	xiii
LIST OF FIGURES	xxi
LIST OF APPENDICES	xxiv
CHAPTER 1 REVIEW OF LITERATURE AND OBJECTIVES	
1.1 INTRODUCTION	1
1.2 SWARD RESPONSE TO DEFOLIATION REGIME	2
1.2.1 THE EFFECTS OF DEFOLIATION ON NET HERBAGE ACCUMULATION	5
1.2.1.1 HERBAGE GROWTH	7
1.2.1.2 HERBAGE DEATH	16
1.2.2 THE INFLUENCE OF DEFOLIATION REGIME ON SWARD STRUCTURE AND COMPOSITION	18
1.3 FACTORS AFFECTING THE INTAKE OF GRAZING ANIMALS	22
1.3.1 HERBAGE MASS	25
1.3.2 HERBAGE HEIGHT	28
1.3.3 BULK DENSITY	29
1.3.4 HERBAGE QUALITY	30
1.3.5 SPATIAL DISTRIBUTION OF SWARD COMPONENTS	32
1.3.6 THE INFLUENCE OF HERBAGE ALLOWANCE ON INTAKE	34

1.4	THE RELATIONSHIP BETWEEN INTAKE AND MILK YIELD IN THE LACTATING COW	37
1.4.1	THE EFFECTS OF LEVEL OF HERBAGE INTAKE ON MILK YIELD AND LIVEWEIGHT	37
1.4.1.1	IMMEDIATE RESPONSE	39
1.4.1.2	SUBSEQUENT EFFECTS	40
1.4.2	THE EFFECTS OF LEVEL OF HERBAGE INTAKE ON MILK COMPOSITION	42
1.4.2.1	IMMEDIATE RESPONSE	42
1.4.2.2	SUBSEQUENT EFFECTS	44
1.4.3	THE EFFECTS OF HERBAGE QUALITY ON MILK YIELD	45
1.4.4	CHANGES IN MILK FAT FATTY ACID COMPOSITION IN RESPONSE TO CHANGES IN ENERGY STATUS OF THE ANIMAL	46
1.5	SCOPE AND OBJECTIVES OF THE PRESENT STUDY	47
CHAPTER 2 GENERAL MATERIALS AND METHODS		
2.1	ENVIRONMENT	49
2.2	WEATHER	50
2.3	SWARD AND ANIMAL MANAGEMENT	50
2.4	SWARD AND ANIMAL MEASUREMENTS	51
2.5	STATISTICAL ANALYSES	51
2.6	DATA PRESENTATION	55
2.7	TERMINOLOGY AND DEFINITIONS	56
2.8	COMMON ABBREVIATIONS	57
2.9	BOTANICAL NAMES OF PASTURE PLANTS	58

CHAPTER 3 THE INFLUENCE OF SEASON AND GRAZING
REGIME ON THE SWARD CHARACTERISTICS
OF THREE SOWN MIXTURES

3.1	INTRODUCTION AND OBJECTIVES	59
3.2	MATERIALS AND METHODS	61
3.2.1	PREPARATION PERIOD	61
3.2.2	EXPERIMENTAL PERIOD	62
3.2.3	STATISTICAL ANALYSIS	65
3.2.4	PRESENTATION OF RESULTS	66
3.3	RESULTS	67
3.3.1	NON-SIGNIFICANT INDEPENDENT VARIABLES	68
3.3.2	HERBAGE COMPOSITION	68
3.3.3	NET HERBAGE ACCUMULATION	71
3.3.4	HERBAGE QUALITY	72
3.3.5	HERBAGE BULK DENSITY	73
3.3.6	HERBAGE MASS COMPONENTS	73
3.4	DISCUSSION	76
3.4.1	SEASON AND GRAZING REGIME	76
3.4.2	MIXTURE SOWN	79
3.4.3	METHODS AND DESIGN USED	81
3.5	CONCLUSIONS	84

CHAPTER 4	THE EFFECT OF DEFOLIATION INTENSITY IN SPRING ON SWARD CHARACTERISTICS IN SPRING AND EARLY SUMMER AND ON DAIRY COW PERFORMANCE WHEN GRAZING THOSE SWARDS IN EARLY SUMMER	
4.1	INTRODUCTION AND OBJECTIVES	115
4.2	GENERAL MATERIALS AND METHODS	117
4.2.1	MATERIALS	117
4.2.1.1	EXPERIMENTAL PADDOCKS	117
4.2.1.2	EXPERIMENTAL ANIMALS	118
4.2.2	METHODS	118
4.2.2.1	EXPERIMENTAL DESIGN	119
4.2.2.2	MANAGEMENT OF EXPERIMENTAL PADDOCKS	119
4.2.2.3	MANAGEMENT OF EXPERIMENTAL ANIMALS	120
4.2.2.4	MEASUREMENTS TAKEN	121
4.2.2.5	STATISTICAL ANALYSES	124
4.3	TRIAL 1 THE EFFECT OF GRAZING INTENSITY IN (1982/83) SPRING ON SWARD CHARACTERISTICS IN EARLY SUMMER AND ON COW PERFORMANCE WHEN GRAZING THOSE SWARDS AT BOTH A GENEROUS AND RESTRICTED DRY MATTER ALLOWANCE IN EARLY SUMMER	125
4.3.1	OBJECTIVES	125
4.3.2	METHODS	125
4.3.3	RESULTS	126
4.3.3.1	EXPERIMENTAL PERIOD	126
4.3.3.2	POST EXPERIMENTAL PERIOD	131

4.4	Trial 2	THE EFFECT OF DEFOLIATION INTENSITY	144
	(1983/84)	IN SPRING ON SWARD CHARACTERISTICS	
		IN EARLY SUMMER, AND ON THE PERFORMANCE	
		OF COWS GRAZING THOSE SWARDS AT A	
		GENEROUS DRY MATTER ALLOWANCE IN EARLY	
		SUMMER	
4.4.1		OBJECTIVES	144
4.4.2		METHODS	144
4.4.3		RESULTS	145
4.4.3.1		EXPERIMENTAL PERIOD	145
4.4.3.2		POST EXPERIMENTAL PERIOD	150
4.5	Trial 3	THE EFFECT OF GRAZING INTENSITY IN	168
	(1984/85)	SPRING ON SWARD CHARACTERISTICS	
		THROUGHOUT SPRING AND EARLY SUMMER,	
		AND ON THE PERFORMANCE OF COWS GRAZING	
		THOSE SWARDS WHEN OFFERED A COMMON NOMINAL	
		GREEN LEAF ALLOWANCE IN EARLY SUMMER	
4.5.1		OBJECTIVES	168
4.5.2		METHODS	169
4.5.3		RESULTS	170
4.5.3.1		SWARD PREPARATION AND EXPERIMENTAL PERIODS	170
4.5.3.2		POST EXPERIMENTAL PERIOD	185
4.6		DISCUSSION AND CONCLUSIONS OF TRIALS 1, 2 AND 3	211
4.6.1		SWARD RESPONSE TO GRAZING REGIME IN SPRING	213

4.6.2	SWARD TYPE, DRY MATTER INTAKE, AND COW BEHAVIOUR	218
4.6.3	HERBAGE ALLOWANCE, DRY MATTER INTAKE AND MILK YIELD	222
4.6.4	IMPLICATIONS OF RESULTS TO DAIRY FARMING	229
4.6.5	CONCLUSIONS	231
CHAPTER 5 THE INFLUENCE OF SWARD REGROWTH INTERVAL IN AUTUMN/WINTER ON SWARD CHARACTERISTICS AND DAIRY COW PERFORMANCE IN EARLY SPRING		
5.1	INTRODUCTION AND OBJECTIVES	238
5.2	MATERIALS AND METHODS	239
5.2.1	PREPARATION PERIOD	241
5.2.2	EXPERIMENTAL PERIOD	242
5.2.3	POST EXPERIMENTAL PERIOD	242
5.2.4	MEASUREMENTS TAKEN DURING THE EXPERIMENTAL PERIOD	242
5.2.5	STATISTICAL ANALYSES	245
5.3	RESULTS	245
5.3.1	SWARD PREPARATION PERIOD	245
5.3.2	EXPERIMENTAL PERIOD	246
5.3.2.1	PRE-GRAZING SWARD CHARACTERISTICS	246
5.3.2.2	HERBAGE ALLOWANCE AND INTAKE	249
5.3.2.3	COW MEASUREMENTS	252
5.3.3	POST EXPERIMENTAL PERIOD	254
5.4	DISCUSSION	254

5.4.1	NET HERBAGE ACCUMULATION OVER THE AUTUMN/WINTER PERIOD	255
5.4.2	SWARD STRUCTURE AND COMPOSITION	256
5.4.3	ALLOWANCE AND INTAKE	258
5.4.4	MILK PRODUCTION	260
5.5	CONCLUSIONS	264
CHAPTER 6 GENERAL DISCUSSION AND CONCLUSIONS		
6.1	RESUME OF RESULTS AND CONCLUSIONS	279
6.2	COMPARISON OF RESULTS WITH RELEVANT PUBLISHED WORK	282
6.3	SOME PROBLEMS ASSOCIATED WITH MEASUREMENT TECHNIQUES USED	284
6.4	FUTURE WORK	288
6.5	RELEVANCE OF RESULTS TO DAIRY FARMING	290
APPENDICES		294
BIBLIOGRAPHY		338

LIST OF TABLES

3.1	Description and sowing rates of the three seed mixtures.	86
3.2	Target and actual residual herbage masses (RHM) (Kg DM/ha) to achieve the lax (L) and hard (H) grazing intensities at each season (the actual RHM's are raw data means and their standard deviations).	88
3.3	Grazing dates for the frequently (F) and infrequently (I) grazed swards.	88
3.4	The effect of sward type on pre-grazing herbage composition (% dry weight) averaged across all seasons and grazing regimes.	89
3.5	The effect of grazing regime on pre-grazing herbage composition (% dry weight) averaged across all sward types and seasons.	89
3.6	The effect of season on pre-grazing herbage composition (% dry weight) averaged across all sward types and grazing regimes.	96
3.7	The effect of sward type on pre-grazing herbage dry matter digestibility (%), nitrogen concentration (%) and bulk density (Kg DM/ha per cm sward surface height), and on net herbage accumulation (Kg DM/ha daily) averaged across all grazing regimes and seasons.	96
3.8	The effect of grazing regime on pre-grazing herbage dry matter digestibility (%), nitrogen concentration (%), and bulk density (Kg DM/ha per cm sward surface height) and on net herbage accumulation (Kg DM/ha daily) averaged across all sward types and seasons.	97
3.9	The effect of season on pre-grazing herbage dry matter digestibility (%), nitrogen concentration (%), and bulk density (Kg DM/ha per cm sward surface height), and on net herbage accumulation (Kg DM/ha daily) averaged across all sward types and grazing regimes.	97
3.10	The effect of sward type on pre-grazing herbage mass components (Kg DM/ha) averaged across all grazing regimes and seasons.	105
3.11	The effect of grazing regime on pre-grazing herbage mass components (Kg DM/ha) averaged across all sward types and seasons.	105
3.12	The effect of season on pre-grazing herbage mass components (Kg DM/ha) averaged across all sward types and grazing regimes.	114

- 4.3.1 The effect of grazing intensity in spring on the total pre-grazing herbage mass (Kg DM/ha) and composition (% dry weight), and on sward surface height (cm) and herbage bulk density (Kg DM/ha per cm of sward surface height) in the experimental period (early summer). 133
- 4.3.2 The effect of grazing intensity in spring on the pre-grazing mass of total green and leaf matter (Kg DM/ha) and digestible dry matter (DDM) (Kg DDM/ha) in the experimental period (early summer). 133
- 4.3.3 The effect of grazing intensity in spring on the (a) in vitro dry matter digestibility (DMD) (%) of the pre-grazing total herbage, grass leaf, and grass stem and (b) in vivo dry and organic matter digestibility (DMD and OMD respectively) (%) of the pre-grazing total herbage in the experimental period (early summer). 135
- 4.3.4 The effect of sward type and daily dry matter allowance (DA) on the daily allowance of green and leaf matter (GA and LA respectively) (Kg DM/cow daily), on dry matter intake (DMI) (Kg DM/cow daily), and on the composition of the diet (% dry weight) in the experimental period (early summer). 136
- 4.3.5 The effect of sward type and daily dry matter allowance (DA) on the residual herbage mass (Kg DM/ha), residual herbage height (cm) and in vitro dry matter digestibility of the residual herbage (%) in the experimental period (early summer). 137
- 4.3.6 The effect of sward type and daily dry matter allowance (DA) on milk, milk fat, and milk protein yield (Kg/cow daily) in week 2 of the experimental period (early summer). 137
- 4.3.7 The effect of sward type and daily dry matter allowance (DA) on the composition of milk fat (% weight of short and long chain fatty acids) at the end of week 2 of the experimental period (early summer). 141
- 4.3.8 The effect of sward type and daily dry matter allowance (DA) on unfasted liveweight (Kg/cow) and condition score at the end of the experimental period and on changes in unfasted liveweight (Kg/cow over 16 days) over the experimental period (early summer). 141
- 4.3.9 The effect of sward type and daily dry matter allowance (DA) in the experimental period (early summer) on milk, milk fat, and milk protein yield in the first week of the post experimental period (early summer) (Kg/cow daily). 142

- 4.3.10 The effect of grazing intensity in spring and of daily dry matter allowance (DA) in the experimental period on the sward characteristics of pre-grazing herbage in the post experimental period (February/March). 143
- 4.4.1 The effect of defoliation intensity in spring on the total pre-grazing herbage mass (Kg DM/ha) and composition (% dry weight), and on sward surface height (cm), herbage bulk density (Kg DM/ha per cm sward surface height) and tiller density (no. tillers/m) in the experimental period - Round 1 (early summer). 151
- 4.4.2 The effect of defoliation intensity in spring on the pre-grazing mass of total green and leaf matter (Kg DM/ha) and digestible dry matter (DDM) (Kg DDM/ha) in the experimental period - round 1 (early summer). 152
- 4.4.3 The effect of defoliation intensity in spring on the (a) in vitro dry and organic matter digestibility (DMD and OMD respectively) (%) of the pre-grazing total herbage, grass stem, grass leaf, clover, and senescent matter, and (b) in vivo dry and organic matter digestibility (%) of the total pre-grazing herbage in the experimental period - round 1 (early summer). 154
- 4.4.4 The effect of defoliation intensity in spring on (a) the nitrogen concentration (N%) and (b) the in vitro dry and (c) organic matter digestibility (%) of the pre-grazing total herbage in each of five vertical strata, in the experimental period - round 1 (early summer). 155
- 4.4.5 The effect of sward type and daily dry matter allowance (DA) on the residual herbage mass (Kg DM/ha), residual herbage height (cm) and in vitro dry and organic matter digestibility (%) of the residual herbage in the experimental period - round 1 (early summer). 156
- 4.4.6 The effect of defoliation intensity in spring on the total pre-grazing herbage mass (Kg DM/ha) and composition (% dry weight), and on sward surface height (cm), herbage bulk density (Kg DM/ha per cm of sward surface height) and tiller density (no. tillers/m²) in the experimental period - round 2 (early summer). 157
- 4.4.7 The effect of defoliation intensity in spring on (a) net herbage accumulation (Kg DM/ha daily) between rounds 1 and 2 in the experimental period in early summer, and (b) the pre-grazing mass of total green and leaf matter (Kg DM/ha) and digestible dry matter (DDM) (Kg DDM/ha) in the experimental period - round 2 (early summer). 158

- 4.4.8 The effect of defoliation intensity in spring on the in vitro dry and organic matter digestibility (DMD and OMD respectively) (%) of pre-grazing total herbage, grass leaf, clover, and senescent matter in the experimental period - round 2 (early summer). 158
- 4.4.9 The effect of defoliation intensity in spring on the (a) nitrogen concentration (%) and the in vitro (b) dry and (c) organic matter digestibility (%) of the pre-grazing total herbage in each of five vertical strata in the experimental period - round 2 (early summer). 159
- 4.4.10 The effect of sward type and daily dry matter allowance (DA) on the daily allowance of green (GA) and leaf (LA) matter (Kg DM/cow daily), dry matter intake (DMI) (Kg DM/cow daily), and on the composition of the diet (% dry weight) in the experimental period - round 1 (early summer). 160
- 4.4.11 The effect of sward type and daily dry matter allowance (DA) on the daily allowance of green (GA) and leaf (LA) matter (Kg DM/cow daily) and on dry matter intake (DMI) (Kg DM/cow daily) in the experimental period - round 2 (early summer). 161
- 4.4.12 The effect of sward type and daily dry matter allowance (DA) on the residual herbage mass (Kg DM/ha), residual herbage height (cm) and in vitro dry and organic matter digestibility (%) of the residual herbage in the experimental period - round 2 (early summer). 161
- 4.4.13 The effect of sward type on milk, milk fat and milk protein yield (Kg/cow daily) in (a) week 3 of round 1 and (b) week 2 of round 2 of the experimental period (early summer). 162
- 4.4.14 The effect of sward type on the composition of milk fat (% weight of short and long chain fatty acids) at (a) the end of week 3 of round 1 and (b) the end of week 2 of the experimental period (early summer). 162
- 4.4.15 The effect of sward type on unfasted liveweight (Kg/cow) and condition score at the end of the experimental period, and on changes in unfasted liveweight (Kg/cow over 35 days) and condition score over the experimental period (early summer). 166
- 4.4.16 The effect of sward type in the experimental period on milk, milk fat, and milk protein yield (Kg/cow daily) in the first week of the post experimental period (early summer). 166

4.4.17 The effect of defoliation intensity in spring on pre-grazing sward characteristics in the post experimental period (late summer).	167
4.5.1 Pre-grazing sward characteristics at the commencement of the first round of differential grazing in spring (October).	188
4.5.2 Post-grazing sward characteristics of swards that were grazed laxly (L), moderately (M), or intensely (I) during the sward preparation (Oct-Nov) and experimental (Nov-Dec) periods.	195
4.5.3 The effect of grazing intensity in spring on (a) net herbage accumulation (Kg DM/ha daily), (b) sward surface height (cm) and (c) herbage bulk density (Kg DM/ha per cm sward surface height) during the sward preparation (Oct-Nov), experimental (Nov-Dec) and post experimental (Feb-March) periods.	196
4.5.4 The effect of grazing intensity in spring on the pre-grazing masses of total (a) dry, (b) green (c) leaf and (d) digestible dry matter during the sward preparation (Oct-Nov), experimental (Nov-Dec) and post experimental (Feb-March) periods (Kg DM/ha).	197
4.5.5 The effect of grazing regime in spring on the weights (mg dry weight) of individual (a) reproductive and (b) vegetative tillers and on the (c) percentage of reproductive tillers in the sward (% by no. of total tillers) before grazing during the sward preparation (Oct-Nov) and experimental periods (Nov-Dec).	198
4.5.6 The effect of grazing intensity in spring on the number of visible inflorescences (no. per m ²) during the sward preparation (Oct-Nov) and experimental (Nov-Dec) periods.	198
4.5.7 The effect of grazing intensity in spring on the <u>in vitro</u> dry (DMD) and organic (OMD) matter digestibility (%) of the pre-grazing total herbage during the sward preparation (Oct-Nov) and experimental (Nov-Dec) periods.	199
4.5.8 The effect of grazing intensity in spring on the <u>in vitro</u> dry (DMD) and organic (OMD) matter digestibility (%) of the total herbage within each of five vertical strata in the pre-grazing herbage during (a) round 1 and (b) round 2 of the experimental period (Nov-Dec).	200
4.5.9 The effect of grazing intensity in spring on the <u>in vitro</u> dry (DMD) and organic (OMD) matter digestibility (%) of (a) grass stem, (b) grass leaf and (c) senescent matter in the pre-grazing herbage during the experimental period (Nov-Dec).	201

4.5.10	The effect of grazing intensity in spring and daily leaf allowance (LA) (Kg DM/cow daily) on the allowance of green (GA) and total dry (DA) matter) (Kg DM/cow daily) and on dry matter intake (DMI) (Kg DM/cow daily) during the experimental period (Nov-Dec) (a) round 1 and (b) round 2.	202
4.5.11	The effect of sward type on the composition of the diet (% dry weight) during the experimental period (Nov-Dec) (a) round 1 and (b) round 2.	203
4.5.12	The effect of sward type on the contribution (% dry weight) of each of five vertical strata to the diet during the experimental period (Nov-Dec) in (a) round 1 and (b) round 2.	204
4.5.13	The effect of sward type on the behaviour of cows in the experimental period (Nov-Dec) - round 1.	204
4.5.14	The effect of observation day on the behaviour of cows in the experimental period (Nov-Dec) - round 1.	205
4.5.15	The effect of sward type on milk, milk fat, and milk protein yield (Kg/cow daily) in (a) week 3 of round 1 and (b) week 2 of round 2, of the experimental period (Nov-Dec).	205
4.5.16	The effect of sward type on the composition of milk fat (% weight of short and long chain fatty acids) at (a) the end of week 3 of round 1 and (b) the end of week 2 of round 2 of the experimental period (Nov-Dec).	209
4.5.17	The effect of sward type on unfasted liveweight (Kg/cow) at the end of the experimental period, and on changes in unfasted liveweight (Kg/cow over 35 days) over the experimental period (Nov-Dec).	210
4.5.18	The effect of sward type in the experimental period on milk, milk fat, and milk protein yield (Kg/cow daily) in the first week of the post experimental period (Dec).	210
4.6.1	A comparison of ME intake calculated using diet composition, component organic matter digestibility, and dry matter intakes obtained in T1, T2 and T3, with that calculated using milk yield and unfasted liveweight data.	235
4.6.2	Results of stepwise regression of sward characteristics and herbage allowance on dry matter intake (Kg DM/cow daily) and milk yield (Kg/cow daily).	236
4.6.3	Correlation matrix for pre- and post-grazing (BG and AG respectively) total herbage mass, height, and dry matter digestibility (DMD), dry green, and leaf matter	237

- allowance (DA, GA, and LA respectively), dry matter intake (DMI) and milk, milk fat, and milk protein yield.
- 5.1 The effect of regrowth interval in autumn/winter on net herbage accumulation over May to September (Kg DM/ha daily). 266
- 5.2 The effect of regrowth interval in autumn/winter on pre-grazing herbage mass (Kg DM/ha), sward surface height (cm) and herbage bulk density (Kg DM/ha per cm sward surface height) in early spring. 266
- 5.3 The effect of regrowth interval in autumn/winter on the composition (% dry weight), in vitro (DMD) and organic (OMD) matter digestibility (%), and nitrogen concentration (N%) in early spring. 267
- 5.4 The effect of regrowth interval in autumn/winter on the pre-grazing mass of herbage components in early spring (Kg DM/ha). 268
- 5.5 The effect of regrowth interval in autumn/winter on pre-grazing herbage in vivo dry (DMD) and organic (OMD) matter digestibility (%) in early spring (all numbers are raw data means and their SD's). 268
- 5.6 The effect of regrowth interval in autumn/winter on the percentage contribution of each vertical stratum to the total pre-grazing herbage mass in early spring (% dry weight). 270
- 5.7 The effect of regrowth interval in autumn/winter on the in vitro dry (DMD) and organic (OMD) matter digestibility of the total herbage within each vertical stratum of pre-grazing herbage present in early spring (%). 271
- 5.8 The effect of sward type on the allowance (Kg DM/cow daily) of total green and leaf matter when dry matter allowance was kept constant; on the dry matter intake (Kg DM/cow daily) of cows grazing those swards; and on the residual herbage mass (Kg DM/ha). 272
- 5.9 The effect of sward type on the percentage contribution of each vertical stratum to the total diet of cows grazing those swards in early spring (%). 272
- 5.10 The effect of sward type on the composition of the diet of cows grazing those swards in early spring (% dry weight). 273
- 5.11 The effect of sward type on milk, milk fat, and milk protein yield (Kg/cow daily), and on the fatty acid composition of milk fat (% by weight) in week 3 of the 273

- experimental period, and on unfasted liveweight and changes in unfasted liveweight over the experimental period (Kg).
- 5.12 The effect of sward type on the amount of time cows spent at each activity during (a) daylight and (b) darkness (in hours). 277
- 5.13 The effect of observation day on the amount of time cows spent at each activity during (a) daylight and (b) darkness (in hours). 278
- 5.14 The effect of sward type in the experimental period on milk and milk fat yield in week 1 of the post experimental period (Kg/cow daily). 278
- 6.1 A comparison of dry matter intakes (Kg DM/cow daily) measured (by difference) in chapter 4 and 5 and predicted using the equation of MAFF (1975). 291
- 6.2 A comparison of organic matter intakes (Kg OM/cow daily) measured (by difference) in chapters 4 and 5 and predicted using the equation of Caird and Holmes (1986). 292
- 6.3 A comparison of dry matter intakes (Kg DM/cow daily) measured by difference) in chapters 4 and 5 and predicted using the equation of Stockdale (1985). 293

LIST OF FIGURES

1.1	Relationships between herbage mass (Kg DM/ha), sward height (cm) and LAI, and rates of herbage growth (G), senescence (S) and net production (NP) (all Kg DM/ha daily) in swards continuously grazed by sheep (Bircham and Hodgson, 1983).	8
1.2	Conceptual illustration of the plant-animal interface in grazed pastures: I. Illustrating the combined effects of herbage quality and character on the behavioural, physical and metabolic limits to intake. The effects of current intake (quantity and composition) on subsequent herbage quality and character are also illustrated.	24
3.1	Diagram of experimental area.	87
3.2	The effect of season and sward type on the percentage of clover in the pre-grazing herbage, averaged across all grazing regimes.	90
3.3	The effect of season and grazing regime on pre-grazing herbage composition, averaged across all sward types.	92
3.4	The effect of season and grazing regime on the percentage of prairie grass in Matua swards.	94
3.5	The effect of season and grazing regime on net herbage accumulation, averaged across all sward types.	98
3.6	The effect of season and grazing regime on the dry matter digestibility of the pre-grazing herbage, averaged across all sward types.	99
3.7	The effect of season and grazing regime on the nitrogen concentration of the pre-grazing herbage, averaged across all sward types.	101
3.8	The effect of season and grazing regime on the bulk density of the pre-grazing herbage, averaged across all sward types.	103
3.9	The effect of season and sward type on the pre-grazing masses of total dry, green and senescent matter, averaged across all grazing regimes.	106
3.10	The effect of season and sward type on the pre-grazing mass of total digestible dry matter, averaged across all grazing regimes.	108

3.11 The effect of season and grazing regime on the pre-grazing masses of total dry, green and senescent matter, averaged across all sward types.	110
3.12 The effect of season and grazing regime on the pre-grazing mass of total digestible dry matter, averaged across all sward types.	112
4.3.1 The effect of grazing intensity in spring on the pre-grazing mass of weed, clover, grass leaf, grass stem and senescent matter in early and late summer.	134
4.3.2 The effect of sward type and daily dry matter allowance on milk yield in the experimental and post experimental periods.	138
4.3.3 The effect of sward type and daily dry matter allowance on milk fat yield in the experimental and post experimental periods.	139
4.3.4 The effect of sward type and daily dry matter allowance on milk protein yield in the experimental and post experimental periods.	140
4.4.1 The effect of defoliation intensity in spring on the pre-grazing mass of weed, clover, grass leaf, grass stem and senescent matter in rounds 1 and 2 of the experimental period (early summer) and in the post experimental period (late summer).	153
4.4.2 The effect of sward type on milk yield in the experimental and post experimental periods.	163
4.4.3 The effect of sward type on milk fat yield in the experimental and post experimental periods.	164
4.4.4 The effect of sward type on milk protein yield in the experimental and post experimental periods.	165
4.5.1 The effect of grazing intensity in spring on the percentage of grass stem, grass leaf, clover stem, clover leaf and senescent matter in the total pre-grazing herbage in spring and summer.	189-190
4.5.2 The effect of grazing intensity in spring on the percentage of grass stem, grass leaf, clover stem, clover leaf and senescent matter in the total pre-grazing herbage in each of five vertical strata, and of the percentage contribution of total herbage in each stratum to that of the total herbage mass over all strata.	191-194

4.5.3	The effect of sward type on milk yield in the experimental and post experimental periods.	206
4.5.4	The effect of sward type on milk fat yield in the experimental and post experimental periods.	207
4.5.5	The effect of sward type on milk protein yield in the experimental and post experimental periods.	208
5.1	Diagram of experimental area.	265
5.2	The effect of regrowth interval in autumn/winter on the pre-grazing mass of clover, grass leaf, grass stem and senescent matter in each of five vertical strata in the sward in early spring.	269
5.3	The effect of sward type on milk yield in the experimental and post experimental periods.	274
5.4	The effect of sward type on milk fat yield in the experimental and post experimental period.	275
5.5	The effect of sward type on milk protein yield in the experimental period.	276

LIST OF APPENDICES

2.1	Meteorological data for each month from April 1982 to March 1985.	294
2.2	Measurement techniques.	295
3.1	Statistical analysis - split plot in space and time.	311
3.2	Statistical analysis - percentage and mass of prairie grass present in M swards.	314
3.3	Analysis of variance of pre-grazing herbage composition (% dry weight). All values are F-values.	316
3.4	Analysis of variance of the pre-grazing percentage and total mass of prairie grass in the M swards only. All values are F-values.	316
3.5	Analysis of variance of pre-grazing herbage bulk density and of net herbage accumulation. All values are F-values.	317
3.6	Analysis of variance of pre-grazing masses of total digestible dry matter and nitrogen, and pre-grazing herbage dry matter digestibility and nitrogen concentration. All values are F-values.	318
3.7	Analysis of variance of pre-grazing masses of total dry, green, and senescent matter. All values are F-values.	319
4.2	An illustration of the method of division of each experimental paddock in (a) Trial 1 (1982/83), (b) Trial 2 (1983/84), and (c) Trial 3 (1984/85).	320
4.3.1	Details of cow age (yrs) and milk fat yield (Kg/cow daily) and unfasted liveweight (kg) in the preparation period (trial 1).	321
4.3.2	A t-test of the hypothesis that the mean percentage of a component in the diet comes from the same population as the mean percentage of a component in the herbage on offer (SoKal and Rohlf, 1981).	322
4.4.1	Details of cow age (yrs) and milk fat yield (Kg/cow daily) and unfasted liveweight (Kg/cow) in the preparation period (trial 2).	323

- 4.4.2 A t-test of the hypothesis that the mean percentage of a component in the diet comes from the same population as the mean percentage of a component in the herbage on offer (SoKal and Rohlf, 1981). 323
- 4.5.1 Details of cow age (yrs) and milk fat yield (Kg/cow daily) and unfasted liveweight (kg/cow) in the preparation period (trials 3). 324
- 4.5.2 The effect of grazing intensity in spring on the percentage contribution of each of five vertical strata to the pre-grazing total herbage mass (% dry weight) in the experimental period (Nov-Dec). 325
- 4.5.3 The effect of grazing intensity on the composition (% dry weight) of the pre-grazing total herbage mass in the sward preparation (Oct-Nov), experimental (Nov-Dec), and post experimental (Feb-March) periods. 326
- 4.5.4 A t-test of the hypothesis that the mean proportion of a component in the diet comes from the same population as the mean proportion of that component in the herbage on offer (Sokal and Rohlf, 1981). 327
- 4.5.5 A t-test of the hypothesis that the mean percentage contribution of a stratum to the diet comes from the same population as the mean percentage contribution of that stratum to the total herbage on offer (SoKal and Rohlf, 1981). 328
- 4.5.6 Meteorological data for the days when cow behaviour was monitored. 329
- 4.6.1 Simple regression of the percentage of a component in the diet on the percentage of that component in the herbage on offer in T1, T2, and T3. 330
- 4.6.2 Simple regression of dry matter intake (DMI) (Kg/cow daily) on dry, green, and leaf allowance (DA, GA and LA respectively) (Kg DM/cow daily) in T1, T2, and T3; after adjustment for year, cow type and grazing round. 330
- 5.1 Details of cow age (years) and milk fat yield (Kg/cow daily) and unfasted liveweight (kg) in the preparation period. 331
- 5.2 Details of sward characteristics and management during the sward preparation period (May - September 1984). 332
- 5.3 The effect of regrowth interval in autumn/winter on the pre-grazing mass of herbage components in each vertical stratum in early spring (Kg DM/ha). 333

- 5.4 A t-test of the hypothesis that the mean of the percentage contribution of each stratum to the diet comes from the same population as the percentage contribution of each stratum to the total pre-grazing herbage mass (Sokal and Rohlf, 1981). 334
- 5.5 A t-test of the hypothesis that the mean of the percentage of a component in the diet comes from the same population as the percentage of a component in the pre-grazing herbage mass (Sokal and Rohlf, 1981). 335
- 5.6 Meteorological data for the days when cow behaviour was monitored. 336
- 5.7 Sample calculation of the ME concentration of herbage ingested and of total ME ingested (per cow daily). 336
- 5.8 Sample calculation of ME intake needed to sustain production levels measured in the experimental period (per cow daily). 337

CHAPTER 1 REVIEW OF LITERATURE AND OBJECTIVES

1.1 INTRODUCTION

Permanent grasslands constitute 97 % of the total land area used for agriculture and horticulture in New Zealand (FAO, 1985). Animal products derived from the pastoral industry are responsible for 66 % of the country's total export income, 24 % of which comes from the dairy industry (New Zealand Department of Statistics, 1985). Management of grazing systems to promote maximal and efficient animal production from these pastures is thus of great importance to the New Zealand economy.

A grazing system is comprised of grazing animals, the pastures on which they feed, the associated micro-organisms, the soil, and the climate in that area; together forming an ecosystem. Each component within that ecosystem affects and is affected by each of the other components. An understanding of the interactions and interdependencies within a grazing system is therefore important in the development of effective grazing management strategies aimed at increasing animal production.

The present study concentrates on the animal and plant components of a grazing system; specifically, the lactating dairy cow grazing predominantly ryegrass/white clover pastures. Consideration of the role of the remaining components in this

ecosystem, although of equal importance (Till, 1981; Snaydon, 1981), are beyond the scope of this study.

This chapter will review, firstly, the response of pasture plants to defoliation regime in terms of net herbage accumulation (NHA), and sward morphology. The effects of sward characteristics and herbage allowance on animal intake will then be considered and this will be followed by a discussion on the influence of the level of herbage intake on dairy cow production. Finally, the scope and aims of the present study will be presented.

1.2 SWARD RESPONSE TO DEFOLIATION REGIME

INTRODUCTION

The frequency and intensity with which a sward is grazed has long been advocated as a means of manipulating the amount of herbage produced over a given period (Johnstone-Wallace and Kennedy, 1944; Smith, 1956). The effects of grazing regime on pasture production have been studied on numerous occasions and the results have been summarized by several authors (Davidson, 1969; Harris, 1978; Curll, 1982; Vickery, 1981). Generally, a more frequent and intensive defoliation results in a reduction in NHA for temperate pastures (Brougham, 1959b; Appadurai and Holmes, 1964; Agyre and Watkin, 1967; Pineiro and Harris, 1978a; and Bircham and Hodgson, 1983). Net herbage production may also

decrease as a result of very lax and/or infrequent defoliation (Brougham, 1970; Baars et al, 1981).

Conflicting results between studies on the effects of grazing regime on NHA do exist however (Davidson, 1969). Some of these conflicting results can be attributed to differences in, and interactions between environments, species composition of the pastures, species of animal used to graze the pastures, the definition of grazing frequencies and intensities, and soil nutrient status. Within a study, the interaction of season with grazing regime can also result in differences in the relationship between frequency and intensity of grazing and NHA (Tainton, 1974; Parmenter and Boswell, 1983).

Under set stocked conditions, within the range of stocking rates generally found on the farm, NHA appears to be unrelated to grazing intensity (Bircham, 1981; Hodgson et al, 1981a; Hodgson and Maxwell, 1982). NHA has also been found to be similar for set stocked and intermittently grazed swards when similar stocking rates have been applied (Chapman et al, 1983; Parsons et al, 1983; O'Sullivan, 1984a). Occasional intense grazing or spelling of a set stocked sward resulted in no difference in long term rates of herbage accumulation over swards that were set stocked throughout (Grant et al, 1985). However, the majority of studies monitoring the effects of grazing regime on NHA have been conducted with sheep or beef cattle, while studies with lactating dairy cows are scarce.

The effects of grazing regime on NHA, as well as the apparently conflicting reports of the effect of grazing regime on NHA between some studies, can be understood from a general appreciation of the process by which herbage accumulates in a sward. These have been summarized in a particularly succinct manner by Hodgson et al (1981a), namely: "The rate at which herbage accumulates for harvesting represents the balance between the rate of growth of new plant tissue and the rate of loss of established tissue to senescence and decomposition. In theory both the rate of growth and the rate of loss can be controlled by cutting or grazing management, but in practice the effects of defoliation on the sward characteristics which determine these rates tend to be self-compensating."

This does not mean, however, that grazing management is irrelevant to pastoral farming (Johnson and Parsons, 1985). Regardless of the apparent lack of effect of grazing regime on annual NHA, the seasonal distribution of NHA relative to animal requirements, as well as the presentation of that herbage to the grazing animal are affected by grazing regime, and these factors in turn affect animal production from those pastures. In addition, the effects of changes in grazing regime on short term NHA have yet to be studied closely, particularly over a range of environments and with the range of pasture species and grazing regimes commonly found on farms (Grant et al, 1985; Hodgson, 1985b).

The influence of grazing management on pasture production will be considered here in terms of its effects on the components of NHA. Since the physical presentation and quality of herbage in a sward affect the amount and quality of herbage ingested (section 3) and therefore animal production (section 4), the effects of grazing regime on sward structure and composition will also be considered.

The influence of grazing regime on NHA also include the effects of treading on pasture plants and the soil, and the recycling of ingested nutrients in the form of dung and urine. These effects on NHA have been reviewed by several authors (Watkin and Clements, 1978; Charles, 1979; Wolton, 1979; Snaydon, 1981; Curll, 1982) and will not be discussed here.

1.2.1 THE EFFECTS OF DEPOLIATION ON NET HERBAGE ACCUMULATION

The rate at which herbage accumulates in a pasture is a function of plant tissue growth, death, and decay, and that amount eaten by the grazing animal. Plant tissue flow from the live pool to the dead pool is described as senescence. Thus, growth can be considered as potential production, and decay can be regarded as a measure of the inefficiency of the grazing process. Net herbage accumulation can thus be described as:

$$\text{NHA} = G - (D + C)$$

where G = herbage grown

D = decayed herbage

C = consumed herbage

In a grazed pasture G, D, and C interact to different degrees depending on management and environmental factors. A change in NHA between different grazing treatments could be due to differences in rate of growth alone, the rate of senescence alone, or to changes in both (Hodgson and Wade, 1978; Hodgson et al, 1981a). The measurement of NHA merely accounts for the net result of those processes. Few studies have been conducted to date on grazed temperate grasslands in which the growth, senescence, and decay components of tissue flow have been determined (Leafe et al, 1979; Bircham, 1981; Chapman et al, 1983; Parsons et al, 1983). However, a greater understanding of the way in which plant tissue growth, death, and decay in a sward respond to different grazing regimes is necessary in order for efficient grazing systems to be developed.

Factors affecting herbage growth, death, and decay will be discussed here, while the consumption component of NHA will be considered in section 3.

1.2.1.1 HERBAGE GROWTH

The pattern of NHA after defoliation in an intermittently grazed sward has been shown to be sigmoidal with respect to time (Brougham, 1955; 1959a; Hunt 1970; Leafe et al, 1974; Wilman, et al, 1976d). Three phases are recognized: an initial period of exponential NHA, followed by a period of linear NHA, and finally a period when NHA declines exponentially until the ceiling (maximum) herbage mass has been reached.

During the initial phase the increasing rate of NHA is due to the ever increasing mass of actively photosynthesising tissue. In the second phase the effects of an increasing mass of photosynthetic tissue are offset by an increasing rate of tissue respiration and senescence (Tainton, 1974), and NHA is linear. During the third phase NHA decreases exponentially until it reaches zero, at which point the ceiling herbage mass has been reached. The exponential decrease in NHA in the third phase is due to the increasing rate of herbage senescence as herbage mass increases (Hunt, 1970). At ceiling herbage mass the rate of senescence equals that of growth. Figure 1.1 illustrates the relationship between herbage growth, senescence, and NHA in a set stocked pasture as herbage mass, height, and leaf area index (LAI) increase.

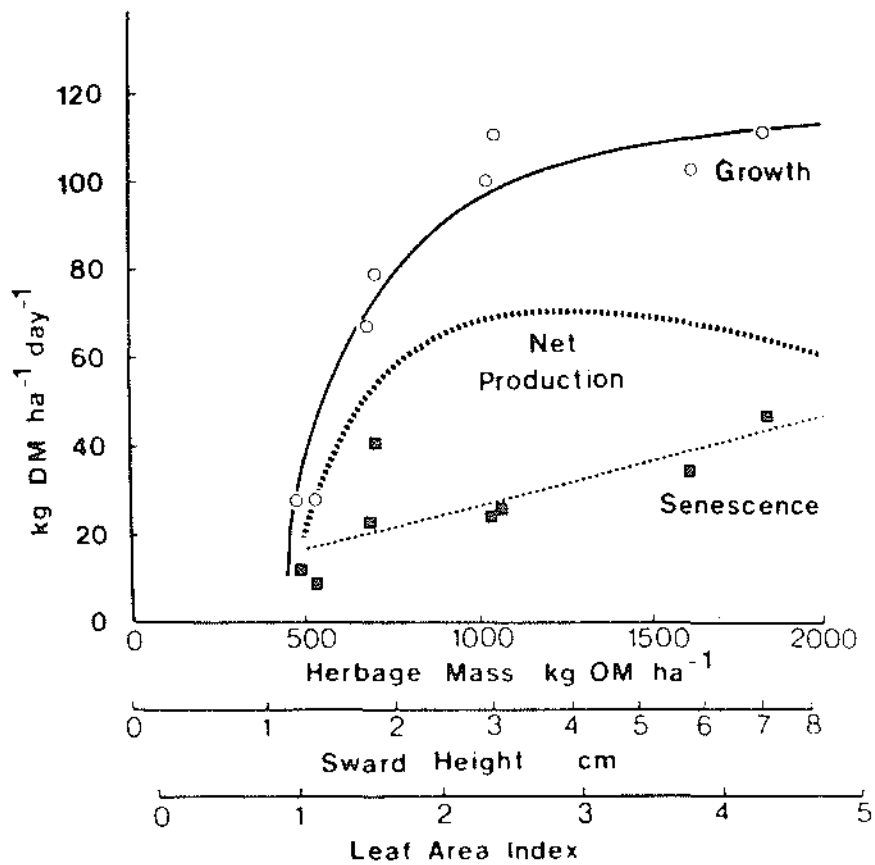


Figure 1.1 : RELATIONSHIPS BETWEEN HERBAGE MASS (KG OM/HA), SWARD HEIGHT (CM) AND LAI, AND RATES OF HERBAGE GROWTH (G), SENESCENCE (S) AND NET PRODUCTION (NP) (ALL KG DM/HA DAILY) IN SWARDS CONTINUOUSLY GRAZED BY SHEEP (BIRCHAM AND HODGSON, 1983)

The Tiller as a Unit of Growth

In temperate grasses the primary unit of growth is the tiller, consisting of a pseudostem (leaf sheath) surrounded by leaf blades (lamina) (Davies, 1977). Leaf growth and senescence are closely linked to maintain a relatively constant number of live leaves on established tillers; approximately three in the case of perennial ryegrass (ibid).

The number of tillers present per unit area at any one time depends on the relative rates of formation and death (Langer, 1963). Ryegrass tiller density on sheep grazed pastures has been reported to be greatest in late winter/early spring, declining during reproductive growth and then increasing again in autumn (Harris, 1971; Hill, 1971; Hunt and Field, 1978; Korte, 1981). On ryegrass/white clover/paspalum pastures grazed by dairy cows, Bryant and L'Huillier (1986) noted that tillering activity was greatest during late spring/ early summer (November-December), and not in the autumn period as commonly stated. More detailed studies of tillering in dairy pastures are needed before valid comparisons with tillering in sheep grazed pastures can be made. The seasonal pattern of tiller density is reported to be unaffected by grazing management, irrespective of stocking rate; grazing management merely affects the rate and/or extent of the change (Tallowin, 1981).

The longevity of tillers is influenced by time of year at which they first appear. Tillers appearing immediately following anthesis tend to survive in a vegetative condition through the following winter and form the bulk of inflorescences the following year and then die (Holmes, 1980). Tillers developing at a later date are subject to competition from previously established tillers (Jewiss, 1966), and a proportion of the tillers established in late winter and early spring may succumb to the competitive effects of shading before flowering.

The rate of tiller death is usually the greatest during reproductive growth due initially to the death of vegetative tillers surrounding the reproductive tillers, and then due to death of the reproductive tillers post anthesis. The death of vegetative tillers is caused by the failure of larger tillers (mainly reproductive) to supply assimilate to smaller heavily shaded vegetative tillers (Ong et al, 1978).

In general, more frequent or intense defoliations result in a higher tiller density due to greater tiller appearance and survival in conditions of light (Hodgson and Wade, 1978; Grant and King, 1984). The inhibiting effect of shading on tiller production was demonstrated by Davies et al (1983). Shading tiller bases decreased the appearance of new tillers, but the size of the tillers which were shaded at the base increased. This increase in tiller size was attributed to the absence of competition for light, nutrients, moisture, and assimilate by new

tillers. Removal of the shades from the tiller bases to expose tiller buds in the leaf axils stimulated tiller production. However, since developing tillers also depend on assimilates supplied by the parent tiller, too frequent and intense a defoliation reduces assimilation and thus tillering, resulting in a lower tiller density (Brougham, 1959b; Huokuna, 1966; Bircham and Hodgson, 1983).

The decline in the number of new tillers appearing during anthesis is due to the developing inflorescence exerting an inhibitory effect on the growth of tiller buds (Jewiss, 1972; Laidlaw and Berrie, 1974). Defoliation of the developing inflorescence stimulates development of new tillers from previously dormant axillary buds on the basal nodes of cut stubs, and results in increased survival of vegetative tillers (Davies, 1977). A reduction in assimilate demand by the recently defoliated reproductive tiller, in addition to decreased shading due to defoliation of the reproductive tiller, are likely to be responsible for the increased survival of the vegetative tillers (ibid).

Tiller density is also influenced by the species of animal grazing the sward, and by the nitrogen status of the soil. Greater tiller densities are found with sheep than cattle grazing at similar intensities (Briseno da la Hoz and Wilman, 1981; Arosteguy et al, 1983). Cattle appear to uproot tillers to a greater extent than sheep do (Briseno da la Hoz and Wilman, 1981),

which may be a function of the difference in method of prehension between the two species. Although tiller density generally increases with nitrogen application (Wilman et al, 1976b; Davies, 1977; Nelson and Zarrouh, 1981), the effect is dependent on the grazing regime imposed. An infrequent defoliation will result in a decreased tiller density presumably due to increased shading with fertilized compared to unfertilized swards.

In a vegetative sward tiller density and weight per tiller are inversely related (Bircham, 1981; Briseno de la Hoz and Wilman, 1981; Chapman et al, 1983; Grant and King, 1984; Butler, 1986). This relationship does not apply on very short and intensely grazed swards, where tiller density declines due to frequent uprooting and a decreased rate of tiller formation (Hodgson et al, 1981a; Grant and King, 1984). While tiller size and density appear to compensate for one another in terms of NHA per unit area of sward, maintaining a high growing point density in a sward is of importance. Swards with a high growing point density are able to better maintain NHA and prevent ingress of less desirable species in times of environmental stress and/or overgrazing, than swards with a lower growing point density (Sheath and Boom, 1985a,b).

Reproductive Growth

In a mixed ryegrass/white clover sward NHA increases rapidly during the reproductive phase of growth. Depending on the degree of dominance of either species, this period can vary from late October for ryegrass dominant swards, to late December for clover dominant swards (Rickard and Radcliffe, 1976).

Apart from the temperature, moisture, and light levels being conducive to high levels of NHA at this time of year, two factors appear to be important in contributing to the increased growth of reproductive tillers over that of vegetative tillers, namely; photosynthetic efficiency, and an increased assimilate demand. Leaves on elongating reproductive tillers develop in high light intensities at the top of the sward, while those on vegetative tillers develop in the shade of older leaves, and consequently have a lower photosynthetic efficiency (Woledge, 1977). McCall (1984), using data from Leafe *et al* (1974), calculated that the critical LAIs for reproductive and vegetative growth were 6 and 3.5 respectively, reflecting the difference in growth habit between the two swards (the critical LAI being the LAI at which 95 % light interception occurs). Silsbury (1965) and Deinum (1976) postulated that the high photosynthetic capacity of reproductive tillers was due to their increased demand for assimilates for stem elongation and inflorescence growth. Ryle (1970) has shown that reproductive tillers partition 8 % and 92 % of assimilate to root and shoot respectively while vegetative tillers partition 17 % and

83 % respectively. However, assimilate demand appears to be less important than the light environment of the developing leaves in determining the photosynthetic efficiency of individual leaves (Woledge, 1979; Parsons and Robson, 1981).

The number of reproductive tillers in a sward is largely determined by the number of tillers vernalized over the winter period, and is relatively unaffected by the grazing managements imposed in spring (Johnson and Parsons, 1985). The intensity of grazing in spring does, however, affect the number of new vegetative tillers appearing, and thus the proportion of reproductive tillers in the sward (ibid). Grazing intensity in spring also affects that proportion of the reproductive tillers in the sward which reach maturity.

The frequency of defoliation before the emergence of reproductive growth influences the timing of reproductive growth in perennial ryegrass swards, with more frequent defoliation delaying inflorescence emergence (Brougham, 1961). Brown (1980) noted that grazing a sward once in the winter and in late September delayed inflorescence emergence compared to swards that had been ungrazed all winter.

Defoliation of the developing meristem results in death of the remaining stub (Davies, 1977). However, defoliation of reproductive tillers above the meristem results in continuing development of the tiller. If defoliation occurs close to the

developing meristem or apex, the tiller will develop in a virtually leafless state (Davies, 1976). Since not all tillers in a sward are at similar stages of development at any one point in time, the defoliation of a sward at some time during the period of reproductive growth will reduce the subsequent proportion of mature reproductive tillers in that sward. (Davies et al, 1972).

The timing and frequency of defoliation during the reproductive growth period may affect the long term accumulation of herbage in a sward. Arresting the development of reproductive growth at an early stage caused a 20 to 30 % reduction in annual NHA on those swards compared to swards defoliated at full flower emergence (Austenson, 1963; Mislevy et al, 1977). Defoliation post anthesis did not increase annual NHA further (Austenson, 1963; Bonin and Tomlin, 1968 a,b). Korte et al (1984) reported no effect on NHA over a 38 week measurement period of defoliation at early culm elongation versus at 30 % inflorescence appearance. The composition of the herbage accumulated was, however, affected. The defoliation of swards at early culm elongation resulted in swards containing a greater proportion of leaf and clover than those defoliated at 30 % inflorescence appearance.

Apart from the timing of defoliation, increasing the frequency of defoliation during reproductive growth may result in a decreased annual NHA (Wilman et al, 1976 a,c). Most of the increase in NHA with less frequent grazing during this period can be attributed to increased growth of the stem and inflorescence

(Wilman et al, 1976a).

1.2.1.2 HERBAGE DEATH

Dead herbage has no photosynthetic capacity, yet its presence within a sward reduces the light available for photosynthesis of living tissue and for tiller bud development. A satisfactory definition of senescence (death) is not easily given, and for practical purposes it is usually related to chlorophyll loss in leaves (Brady, 1973). While there is a substantial amount of information on the chemical and biochemical changes which occur in leaves as they undergo senescence (*ibid*), there is little understanding of the type of regulatory functions which are involved in initiation and regulation of the degradative changes.

Photosynthetic efficiency of leaf tissue decreases with leaf age and this may be a predisposition to death (Woledge, 1973). Leaf death appears to be directly related to leaf age since the rate of leaf appearance in a perennial ryegrass pasture is equal to that of leaf death (Thomas and Norris, 1977; Bircham, 1981). Leaf appearance, leaf death, leaf longevity, and the number of live leaves supported per grass tiller have been found to be closely related under both continuous and intermittent grazing regimes (Chapman et al, 1983). Thus, any defoliation regime which allows a tiller to remain ungrazed for more than three plastochrons (the interval between appearances of successive leaves), by way of defoliation interval and/or intensity, will

result in increased senescence and death in the sward.

When plants are shaded the net photosynthetic rate of individual leaves declines, as does their dark respiration rate (Ludlow, 1978). The reduced respiration rate of individual shaded plants is unable to compensate for the lowered photosynthetic rate, and net assimilation declines, leading to senescence (ibid). Increasing the grazing interval and/or decreasing the severity of grazing will also increase the amount of shading in the lower portions of the sward, and hence senescence and death in the sward.

Although dead herbage is often seen as a waste of herbage grown, the process of death involves the translocation of some of the minerals, nitrogen, and carbohydrates present in the senescing tissue to that of the remaining living tissue of the plant (Brady, 1973). In addition, the decomposition and incorporation of senescent herbage into the organic fraction of the soil plays an important role in nutrient cycling in a grazing system (Till, 1981). Thus, while the process of herbage senescence may be considered as a measure of the inefficiency of the grazing process, it cannot be termed a complete wastage of herbage grown.

The disappearance of litter (senescent material) occurs through microbial activity, leaching, and earthworm activity; the rate being dependent on moisture, temperature, amount of litter present, pH of litter, and carbon/nitrogen ratio of litter, as

well as the presence of adequate numbers of micro-organisms (Hunt, 1977). The rate of litter disappearance increases with increased litter pH, nitrogen status of the senescent material, temperature, and moisture (ibid). Daily rates of litter disappearance have been reported to be up to 30 kg DM/ha daily for ryegrass/white clover pasture in New Zealand in spring (Hunt, 1971).

1.2.2 THE INFLUENCE OF DEFOLIATION REGIME ON SWARD STRUCTURE AND COMPOSITION

The frequency and intensity with which a sward is defoliated will affect sward composition and the spatial distribution of sward components. Increasing the frequency and intensity with which a sward is grazed will lead to a reduction in pseudostem length and tiller and leaf angle, resulting in an increasingly prostrate sward (Curll, 1982; Grant and King, 1984). Conversely, a lenient and less frequent defoliation will increase the pseudostem length and thus the depth of the leaf layer in the sward (Jackson, 1974,1976; Wilman and Shrestha, 1985). In addition, increasing the time between defoliations will increase the proportion of senescent material in the sward (Korte and Sheath, 1979; Francis and Smetham, 1985; Butler, 1986), accumulating largely in the base of the sward (Hughes et al, 1984; Butler, 1986).

The ratio of leaf to stem decreases with increasing interval between grazings (Hunt and Brougham, 1966), and this is most marked during reproductive growth (Korte et al, 1982, 1984; Butler, 1986). Vegetative growth consists almost entirely of leaf and sheath whereas with reproductive growth, once stem elongation begins, most of the increase in dry matter (DM) mass is from stem rather than leaf growth (Wilman et al, 1976d). The proportion of green leaf in the sward has been reported to decline from 80 % to 5 % of the total tiller mass during stem elongation (ibid). Nevertheless, an increase in the defoliation interval will result in a decrease in the leaf to stem ratio irrespective of season.

Under infrequent defoliation erect species such as the perennial ryegrasses are able to grow taller and thus shade and suppress more prostrate species such as clovers, whereas under frequent defoliation the competitive advantage of the erect species is removed and the more prostrate species can dominate the sward (Brougham, 1959b, 1960; Vickery, 1981). The physiological basis of variation in the yield of grass/clover mixtures and the relative competitive abilities of the components is reviewed by Rhodes (1981). There are some conflicting reports on the effects of defoliation regime on the relative yielding and competitive abilities of pasture species (Baines et al, 1983; Grieshaber-Otto, 1984). These are attributed to interactions between soil type, soil fertility status, and species present (Grieshaber-Otto, 1984), although it is difficult to account for all of these factors in grazing experiments.

In general, the proportion of clover in the sward decreases with a lax and/or infrequent defoliation (Curll, 1982; Sheath and Bircham, 1983). Clover morphology does change, however, in that clover petioles increase in length in an attempt to carry the developing leaves to the top of the sward canopy (Wilman and Shrestha, 1985). The shading of clover plants by the more competitive grasses also decreases stolon length and branching (ibid), and thus clover yield (Baines et al, 1983; Woledge and Dennis, 1983; Hay et al, 1983; Hay and Chapman, 1984; Hay and Baxter, 1984).

As a plant matures, the digestibility of its tissues decreases due to an increase in the proportion of structural carbohydrates (cellulose, lignin, and hemicellulose) and a decrease in the proportion of non-structural carbohydrates (mainly fructans) (Osbourn, 1980; Ulyatt, 1981a). This occurs mainly in the stems, with leaves remaining relatively more constant in digestibility as the plant matures (Raymond, 1969; Wilman et al, 1976d). The presence of an increased proportion of stem in the herbage during reproductive growth, along with the maturation of plant tissue, results in a sharp decrease in the dry matter digestibility (DMD) of the total herbage in a sward at this time (ibid).

Changes in the proportion of nitrogen (N %) in the total herbage are closely correlated with changes in DMD (Raymond, 1969). The N % of a plant does, however, tend to decrease sooner

than the DMD, as the plant matures. In the fully expanded leaf the total amount of nitrogen remains relatively constant. However, there is a temporary storage of carbohydrates in the form of starch, fructosan, or sucrose in the plant at this time, causing a widening of the carbon/nitrogen ratio while the DMD remains constant (Brady, 1973). Thus the N % of herbage decreases with sward age sooner than herbage DMD. High values for N % are reported for herbage that is composed of predominantly young and growing tissue, and where leaf and clover proportions are high (Wilman et al, 1976d).

In general, a frequent and/or intensely grazed sward will have a greater proportion of young and actively growing plant tissue than swards that are less frequently and more leniently grazed, and thus the DMD and the N % of the frequently and/or intensely grazed swards would be expected to be higher. In addition, any grazing regime which results in an increased proportion of dead material in the sward will result in a concomitant decrease in DMD and N % since the DMD of senescent material is low (40-50 %)(Francis and Smetham, 1985).

Sufficiently detailed information about the influence of defoliation regime on the sward characteristics of temperate pastures when grazed by lactating dairy cows is scarce (Campbell, 1966; Bryant and Trigg, 1982; Bryant and L'Huillier, 1986). This is true even in New Zealand, where dairy cows rely solely on pastures for their feed supply. Extrapolation of results from

grazing studies done on pastures grazed by sheep to that of dairy pastures may not be valid.

1.3 FACTORS AFFECTING THE INTAKE OF GRAZING ANIMALS

Traditionally accepted theories on the mechanisms of intake control in stall fed ruminants apply to the grazing animal (McClymont, 1967; Freer, 1981). However, the grazing animal is faced with the additional tasks of searching for, prehending, and harvesting the herbage. These activities are influenced by sward characteristics, and in the case of intermittent grazing, the daily amount of herbage available for each animal.

The physical and metabolic factors affecting intake in ruminants have been extensively reviewed by a number of authors (eg. Campling, 1970; Jones, 1972; Baile and Forbes, 1974). Physiological factors such as age, sex, and productive state of the animal which affect herbage intake have been discussed by Bines (1976), and Weston (1982). Management factors (other than herbage allowance), and environmental factors such as climate, which may affect the intake of grazing animals have been reviewed by Webster (1976) and Weston (1982).

The present review will concern only the effects of sward characteristics and herbage allowance on the herbage intake of grazing ruminants. A conceptual illustration of the plant/animal

interface is presented below (Figure 1.2). This figure illustrates the interactions between sward characteristics (quantity and character), the grazing process, and the physical and metabolic processes within the animal. When the quantity of herbage available is high enough for ad libitum intake, the character (ie nutritive value, percentage of leaf in the herbage, leaf/stem ratio) of the herbage is most important in determining intake through its effects on grazing behaviour and the distension mechanism. Where abundant herbage with a very high nutritive value is present, metabolic mechanisms are most likely to control intake. When the quantity of herbage available is low, herbage character may have little effect on intake, and intake is most likely to be limited by grazing behaviour constraints. Note that the effects of present intake levels on sward characteristics in the subsequent grazing are also included.

Herbage intake in a grazing situation can be partitioned into its behavioural components (Allden and Wittaker, 1970), namely:

$$I = IB * RB * GT$$

where the intake of herbage (I) is a product of the amount of herbage eaten per bite (IB), the number of bites taken per unit time (RB), and the amount of time spent grazing (GT). Unless otherwise indicated I refers to the amount of herbage ingested per 24 hr period. The rate of intake can refer either to I/GT or IB * RB, depending on the method of measurement.

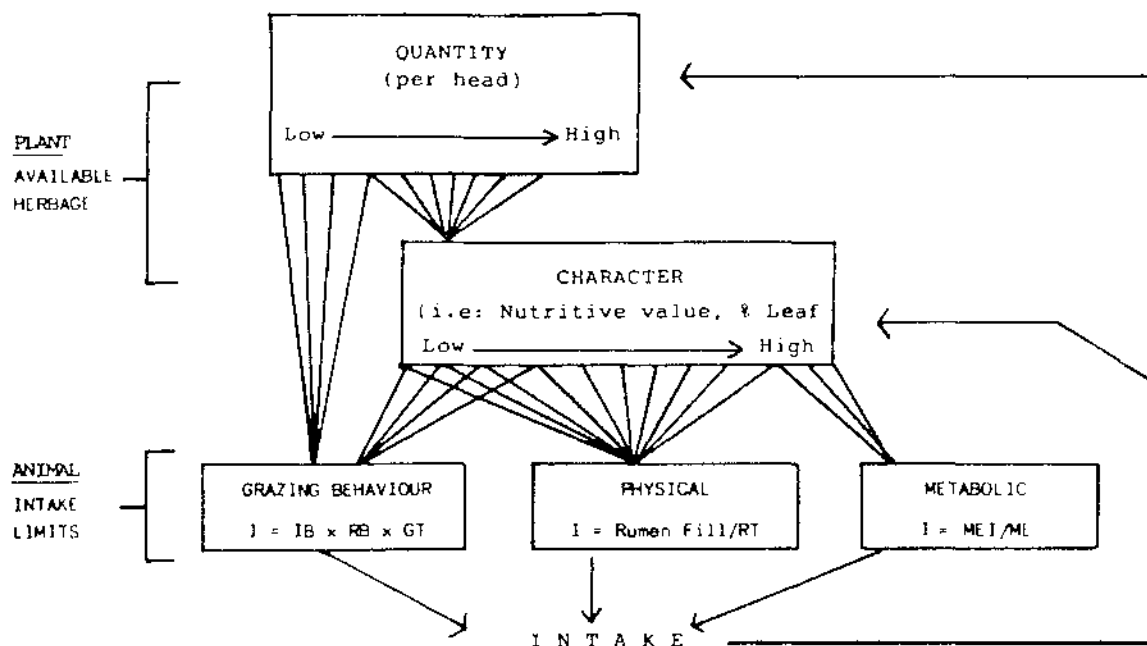


Figure 1.2 : CONCEPTUAL ILLUSTRATION OF THE PLANT-ANIMAL INTERFACE IN GRAZED PASTURES; ILLUSTRATING THE COMBINED EFFECTS OF HERBAGE QUALITY AND CHARACTER ON THE BEHAVIOURAL, PHYSICAL AND METABOLIC LIMITS TO INTAKE. THE EFFECTS OF CURRENT INTAKE (QUANTITY AND COMPOSITION) ON SUBSEQUENT HERBAGE QUALITY AND CHARACTER ARE ALSO ILLUSTRATED

(I = intake; IB = intake per bite; RB = rate of biting; GT = grazing time; RT = retention time; MEI = metabolizeable energy intake; ME = metabolizeable energy concentration of the diet (MJ/Kg DM))

(Adapted from Moore, 1983)

Intake per bite will largely depend on mouth size and prehensive behaviour of the species in question (Dudzinski and Arnold, 1973), and on the density of the preferred component at the biting site (Hodgson, 1982). The RB will be dependent on the speed at which the animal canprehend, shear, masticate, and ingest the herbage offered, and on the state of satiety of the animal. Grazing time is influenced by the need for the animal to engage in other essential activities and by fatigue (Freer, 1981). In cases of extreme pasture shortage or restriction of dry matter allowance the absence of grazeable herbage will limit GT.

Of the behavioural parameters mentioned, IB can vary tenfold while variability in RB and GT appear to be limited to twofold changes (Hodgson, 1985a).

The influence of sward structure, herbage composition, and herbage allowance on intake will be considered here in the context of their modification of the behavioural components of intake.

1.3.1 HERBAGE MASS

Differences in pre-grazing herbage mass (kg DM/ha) influence IB and RB as well as the opportunity for selection. Intake per bite has been found to decrease sharply as herbage mass declines in both sheep and cattle on temperate and tropical swards (Allden

and Whittaker 1970; Stobbs, 1973a; Chacon and Stobbs, 1976; Jamieson and Hodgson, 1979a,b; Hendrickson and Minson, 1980; Zoby and Holmes, 1983; Forbes and Hodgson, 1985). The RB has been observed to increase as mass declines but the increase is not sufficient to compensate for the decrease in IB (Allden and Whittaker, 1970; Chacon and Stobbs, 1976; Jamieson and Hodgson, 1979b; Hodgson, 1981; Zoby and Holmes, 1983), and the rate of intake thus declines (Curll and Davidson, 1983). Biting rate appears to decrease again below a critical herbage mass (Allden and Whittaker, 1970; Hodgson, 1981). The ability or willingness of the animal to make compensatory changes in GT to offset decreases in the rate of intake appear to be limited (Chacon and Stobbs 1976; Stockdale and King, 1983).

Daily herbage intake usually increases at a progressively decreasing rate as the available herbage mass per unit area increases, and declines at an increasing rate below a critical mass (Hodgson, 1977). Between experiment variation exists, however, in the pattern of intake response by animals to differences in herbage mass.

Increases in intake associated with increases in pre-grazing herbage mass have been reported by Johnstone-Wallace and Kennedy (1944), Hodgson (1975) Jamieson and Hodgson (1979b), Curll and Davidson (1983), Stockdale and King (1983), Zoby and Holmes (1983), Forbes and Hodgson (1985), and Stockdale (1985) with both set stocking and intermittent grazing. Conversely, decreases in

herbage intake have been observed in association with increases in pre-grazing herbage mass in other studies (van der Kley, 1956; Hodgson et al, 1977; Reardon, 1977; Bartholomew et al, 1981; Birrell, 1981) at both set stocking and intermittent grazing. Others have reported no influence of herbage mass on intake with lactating dairy cows, where mass ranged from 1400 - 4800 kg DM/ha (Meijs, 1983), or with young cattle grazing a range of temperate pastures (Hodgson, 1977). For cattle grazing temperate pastures, determinations of the critical mass below which herbage intake declines have been reported over a two-fold range (1100 - 2800 kg DM/ha) (*ibid*).

Several reasons for the apparent disagreement amongst the studies cited have been proposed. The variation may reflect, in part, the confounding effect of concomitant changes in nutritive value of the herbage consumed. It is likely that in some of the more extreme examples of an asymptotic relationship between herbage mass and intake, there is a progressive decline in herbage digestibility with increased mass. This would tend to artificially limit the response to variations in mass alone. Furthermore, with intermittent grazing, herbage allowance is often confounded with herbage mass present and it has been suggested that the effect of herbage mass on intake is dependent on allowance (Jamieson and Hodgson, 1979a).

1.3.2 HERBAGE HEIGHT

Intake usually increases with increasing sward surface height in temperate swards (Alden and Whittaker, 1970; Hodgson, 1982; Milne et al, 1982; Burlison and Hodgson, 1985), although a decreased intake may be observed in particularly long herbage (Waite et al, 1950). Hodgson et al (1977) reported a maximum daily intake at an extended sward height of 40-45 cm.

If the extended height of the sward is measured then the relationship between sward height and intake may be quadratic, with intake declining on either side of an optimum extended height (Hughes, 1983). This is presumed to be due to increased difficulty in prehending and severing both excessively long and short swards. The sward surface height below which intake decreases irrespective of allowance or stocking rate has been reported to be around 8 to 9 cms for lactating cows on rotational grazing and approximately 7 cms for set stocked cows (Le Du et al, 1979). Similar results were obtained with beef cows (Nichol et al, 1976).

The increase in intake with increasing sward surface height in temperate swards is due mainly to increased IB (Hodgson, 1982). Burlison and Hodgson (1985) noted a positive relationship between sward surface height and bite volume, bite depth, and bite weight. Milne et al (1982) found a positive linear relationship between the depth of the grazed horizon and sward surface height. Higher

intakes have been measured on spring swards compared to summer and autumn regrowth of similar digestibility and herbage mass, which may be due to the more erect spring swards encouraging a greater depth and size of bite (Hodgson, 1982).

The RB and GT are also affected by sward surface height. The RB tends to decrease as sward surface height increases due, in part, to the greater ratio of manipulative to ingestive jaw movements (Chambers et al,1981). However this decline in RB is more than offset by the concomitant increase in IB (Hodgson, 1982). The GT of cattle on a intermittent grazing system tends to increase with short versus long swards (Hancock, 1954; Allden, 1962), presumably in an attempt to compensate for a decreased IB. Since the ability of animal to make compensatory changes in GT to offset changes in IB and /or RB are limited, intake usually declines.

1.3.3 BULK DENSITY

Where sward bulk density and sward surface height have not been varied independently in an experimental situation herbage intake appears to be insensitive to changes in bulk density (Hodgson, 1982). Since sward surface height and bulk density are often negatively correlated, the apparent lack of response to changes in bulk density may simply reflect the inability to separate the dominant effect of sward surface height.

Where sward surface height and bulk density have been varied independently, each was found to be positively correlated with intake (Black and Kenney, 1984). The short term rate of intake was best described by bulk density if herbage mass was greater than 1000 kg DM/ha, while the rate of intake was best predicted by the mass per unit area covered by one bite. The above study was conducted with sheep housed in individual cages grazing artificial swards for very short (10 min) periods and thus the relationships reported may not apply to grazing dairy cows.

In a caged trial with sheep grazing real swards, where a reasonable disassociation of sward surface height and density was achieved, sward surface height was found to have a greater influence than herbage density on short term bite weight, depth, and volume (Burlison and Hodgson, 1985).

1.3.4 HERBAGE QUALITY

Daily intake is positively correlated with digestibility (Baker et al, 1973). The relationship has been shown to be rectilinear up to 83 % DMD in experiments with grazing animals (Hodgson, 1977), although exceptions do exist (Curran and Holmes, 1970; Holmes et al, 1972). Digestibility exerts its influence on herbage intake mainly through the rate of disappearance of digesta from the reticulorumen (Thornton and Minson, 1973).

At similar levels of digestibility the intake of legume species is higher than that of grasses (Ulyatt, 1981a,b). This has been attributed to legumes having a shorter retention time in the rumen than grasses due to the lower proportion of structural carbohydrates to fermentable carbohydrates in legumes compared to grasses at similar digestibilities (ibid; Thornton and Minson, 1973). Legumes were also found to have a higher packing density in the rumen than grasses (Thornton and Minson, 1973).

Sheep and cattle fed separated leaf and stem fractions of similar DMD ate more leaf than stem (Laredo and Minson, 1973; Poppi et al, 1980). This was true for both temperate and tropical pasture species used and was attributed to a shorter retention time of the leaf in the rumen. The shorter retention time of leaf was associated with an apparent higher rate of digestion of neutral detergent fibre (NDF) in vivo and a higher rate of passage of NDF from the rumen (Poppi et al, 1981a).

The retention time of large particles in the rumen was found to have no effect on the rate of disappearance of digesta from the rumen, whereas the retention time of small particles (<1.18mm) was found to be the most important factor influencing dry matter retention time in the rumen (Poppi et al, 1981b). However the physical capacity of the reticulorumen will only be important in limiting intake if the protein and mineral concentrations in the pasture are adequate (Minson, 1982), since these factors affect rumen fermentation and health of the animal.

When the crude protein concentration of the herbage drops below 6 to 8 %, intake is depressed and is less than would be predicted from the physical composition of the herbage (Minson, 1982). Addition of nitrogen to a herbage diet low in protein has been shown to increase intake (Morris, 1966). A depression in intake with low protein forages is due to decreased activity of the rumen bacteria and thus a decreased rate of breakdown of ingesta in the reticulorumen. Since the protein concentration of temperate dairy pastures rarely decreases below 6 to 8 % (Minson, 1982), it is unlikely that protein per se would be the factor limiting intake in lactating cows. The effects of protein supplementation on the intake of herbage-fed cows appear to be inconclusive (Brookes, 1982). Any increase in intake of pasture with an increased protein content can be completely accounted for by the lower fibre content of the herbage (Minson, 1982).

A number of minerals have been shown to affect intake if inadequately or excessively supplied by the diet. This subject has been adequately reviewed by both Weston (1982) and Grace (1983) and will not be considered here.

1.3.5 SPATIAL DISTRIBUTION OF SWARD COMPONENTS

The herbage consumed by grazing animals usually contains a greater proportion of leaf and clover and a lesser proportion of stem and dead material than the herbage on offer (Arnold, 1981; Hodgson, 1982). It has been suggested that there is active

selection by the animal for the 'preferred' components and against the 'undesirable' components (Guy et al, 1981). The active selection has been attributed to the effects of smell and/or innate nutritional wisdom on intake in the form of euphagia and hedyphagia (McClymont, 1967). Differences in shearing strength between sward components has also been reported to be a reason for greater proportions of leaf than stem in the diet (Hendrickson and Minson, 1980).

The extent to which the 'selection' for or against certain components in the sward is an active process is, in many cases, confounded by the accessibility of these components in the sward (Hodgson, 1985a). Animals grazing temperate vegetative swards have been reported to eat unselectively in the upper horizons of the sward (Milne et al, 1982; Barthram and Grant, 1984). The upper horizons of a vegetative sward usually contain very little dead material or stem (Milne et al, 1982; Hughes et al, 1984). Nevertheless, animals grazing rank, stemmy pastures are likely to exert some active selection if allowance permits (Hodgson, 1985a). The degree of selection will depend on the relative proportions of sward components present, their distribution in space, and the opportunity for selection (*ibid*). However, an appreciation of the spatial distribution of sward components in the sward canopy is important if the interpretation of any differences between the composition of the sward and the diet of the grazing animal is to be attempted (Hodgson, 1985b).

Much of the research attempting to relate the behavioural components of grazing to intake has been done under rather artificial conditions, using sheep, young ruminants, or older non-productive cows. The behavioural components of intake are usually monitored over very short periods of time, and these results tend to be extrapolated to a longer term basis. The applicability of results obtained in this manner to the likely effects of sward characteristics on the behavioural components of intake with high producing dairy cows grazing temperate swards is uncertain.

1.3.6 THE INFLUENCE OF HERBAGE ALLOWANCE ON INTAKE

In New Zealand, herbage allowance (kg DM/cow daily) is probably the most important single factor responsible for the differences in production per animal between farms, between years, and between stocking rates (Rattray and Jagusch, 1978). The amount of herbage on offer daily to the grazing animal is generally accepted as being the major factor affecting herbage intake (Leaver, 1976). The importance of herbage allowance in affecting intake and thus animal productivity has been demonstrated with sheep (Rattray and Jagusch, 1978; Jagusch et al, 1979), steers (Reardon, 1977; Trigg and Marsh, 1979), and lactating dairy cows (Bryant and Trigg, 1979; Bryant, 1980; Glassey et al, 1980; Mitchell, 1985).

The relationship between herbage allowance and herbage intake is curvilinear (Greenhalgh et al, 1966; Combellas and Hodgson, 1979, Le Du et al, 1979). When less herbage is offered than the animal is expected to consume, increasing increments in herbage allowance are likely to result in increments of almost equal magnitude in herbage consumed. As allowance is increased, further response is likely to become progressively smaller and a point is reached beyond which further increments have no effect on gross intake.

An increase in allowance, however, may affect the quality as well as the quantity of the herbage consumed, since it increases the opportunity for selective (site and/or bite) grazing. Furthermore, residual herbage mass tends to be positively correlated with herbage allowance and as allowance increases there is less need for the animal to graze into the less digestible base of the sward. Combellas and Hodgson (1979) varied herbage mass and allowance independently and reported no interaction between mass and allowance. However, both of the herbage masses were relatively high (3790 versus 5770 kg DM/ha).

Stockdale (1985) found that with dairy cows on temperate pastures, when other sward characteristics were taken into account herbage allowance was the most important factor affecting animal intake. However, Hodgson (1984) stated that herbage allowance is seen to affect intake indirectly, through its influence on the rate of change in sward conditions, rather than by determining

intake directly. While this may be true when herbage allowance is generous, at more restrictive herbage allowances, herbage allowance is probably the most important factor determining intake.

When working with calves, Jamieson and Hodgson (1979a) noted that intake per bite, rate of biting, and grazing time were greater for animals on the low compared to high herbage allowance on entry to a fresh break. However, near the end of the day the situation was reversed. Reduced daily intake on the low allowance could be explained by reductions of approximately equal magnitude in mean daily IB, RB, and GT. This was attributed to increased difficulty in prehending and ingesting shorter pasture (1430 kg DM/ha residual herbage mass) for animals on the lower allowance.

Although herbage allowance per se will affect herbage intake, at a given allowance there will be a difference in absolute intake due to the effect of sward canopy structure, herbage digestibility, and chemical and botanical composition of herbage on intake. At a similar herbage allowance, a sward canopy with a high leaf to stem ratio and a high bulk density will encourage a greater intake per bite compared to a sparse sward with a low leaf to stem ratio (Stobbs, 1973a,b).

It is virtually impossible to disentangle the independent effects of variations in gross sward characteristics on intake since these occur simultaneously in the sward. As well,

concomitant changes in nutritive value occur as gross sward characteristics change. The grazing animal is simultaneously presented with these factors, and given the present state of knowledge, it is not possible to establish universally applicable relationships between independent sward characteristics and herbage intake. Hodgson (1985a) stated that there is a need for an objective definition of behaviour and intake response patterns to manipulation of sward variables, as well as information on the range of sensitivity of intake to particular sward variables and the relative importance of these variables in specific circumstances. The realization of these objectives is crucial to improving current knowledge of the sward/animal interface. However, the practicalities of realizing these objectives with lactating dairy cows under relatively realistic conditions is likely to be extremely difficult to achieve.

1.4 THE RELATIONSHIP BETWEEN INTAKE AND MILK YIELD IN THE LACTATING COW

1.4.1 THE EFFECTS OF LEVEL OF HERBAGE INTAKE ON MILK YIELD AND LIVEWEIGHT

Milk yield response to an increased level of DM intake, and thus energy intake, is negatively curvilinear, while the concomitant change in body weight is positively curvilinear (Burt, 1957; Broster, 1972;1976). The declining response in milk yield

with successive increments in energy intake can be explained by an increased rate of diversion of nutrients to tissue deposition (Broster, 1972). The combined milk and body tissue energy responses to an increase in energy intake are linear (Broster, 1976).

Not all cows respond in a similar manner to changes in energy intake in terms of milk yield and tissue dynamics, nor do they do so to a similar extent throughout lactation (ibid). Broster (1976) noted that cows of high genetic merit were more sensitive to changes in energy intake in terms of milk yield than cows of low genetic merit. Evidence concerning the sensitivity of high versus low breeding index cows to changes in energy intake under New Zealand conditions is contradictory (Bryant and Trigg, 1981; Grainger, 1982; Ngarmsak, 1984; Mitchell, 1985).

The production response by cows to different levels of energy intake has been extensively reviewed by Broster (1972; 1976). The data reviewed concern, almost exclusively, work done in the northern hemisphere, where concentrates and conserved forages make up the bulk of the diet. The type of diet can, however, affect partitioning of energy by the cow (Grainger and McGowan, 1982), and so emphasis here will be placed on Australasian research.

1.4.1.1 IMMEDIATE RESPONSE

The immediate response to a change in intake level refers to the change in milk yield, milk composition, and liveweight during the period of variable intake. Although the term 'immediate' is used, the development of milk yield response to a change in intake level is exponential; with 60-70 % of the effect being apparent after seven days and the full effect not being apparent until approximately the twelfth or fourteenth day (Broster, 1972; Stobbs, 1974; Combellas and Hodgson, 1979).

Early New Zealand work conducted at Ruakura has been summarized by Gerring and Young (1961). Underfeeding in early lactation resulted in a reduced yield of milk fat during the experimental period. However, since intake was not recorded relationships between intake and milk fat yield could not be established. Summarizing more recent work conducted in Australasia, Bryant and Trigg (1982) concluded that in early lactation a 38 % restriction in DM intake (compared to well-fed cows) resulted in a 24 % decrease in milk fat yield. For each 1kg DM increase in intake, milk fat yield increased by 0.039 kg and liveweight by 0.174 kg per day.

The relationship between intake and milk yield increases in curvilinearity as lactation advances (Bryant, 1980). This is presumably due to the animals partitioning less intake energy to milk yield than to body weight gain as lactation advances (Hutton,

1963). Bryant (1978) noted that restricting pasture intake by 47 % (7.5 versus 14.1 kg DM/cow daily) in late lactation resulted in a 21 % decrease in milk fat yield and a decrease in liveweight. In a stall feeding experiment King and Stockdale (1981) reported that milk yield declined linearly during two 28-day periods of underfeeding in the eighth and ninth months of lactation, when intakes were reduced from 14.7 to 7.3 and 15.2 to 8.2 kg DM/cow daily respectively. Liveweight decreased in a curvilinear manner.

Unless liveweight lost near the end of lactation is replaced during the dry period, the effects of underfeeding in late lactation will affect production in the subsequent lactation (Grainger and McGowan, 1982). Thus, while Hutton (1962) found that a restriction of fresh cut pasture at 10 % ad libitum intake throughout lactation resulted in no change in milk fat yield over the season, liveweight was lower for the restricted group at drying off, presumably affecting subsequent production.

1.4.1.2 SUBSEQUENT EFFECTS

The subsequent effect of a period of differential feeding refers to the effect which is measured after that period of differential feeding. The subsequent effect is expressed relative to the immediate effect measured during the period of differential feeding (Gordon, 1976). This term is also referred to as a 'residual' or a 'post experiment' effect in the literature.

The effects of various levels of feeding on milk yield following their return to a common level of feeding have been reviewed for 46 experiments worldwide (Broster and Thomas, 1983). When low and medium planes of nutrition were evident in early lactation, subsequent effects on milk yield were 55 % of the immediate effects, provided the immediate effects exceeded 1.5 kg milk/cow daily. No residual effect occurred when cows were fed a high plane of nutrition during the experimental period. A review of Australasian research indicates that similar trends exist for cows on pasture (Bryant and Trigg, 1982). However, significant effects of underfeeding during the experimental period on subsequent milk production were noted in only three of the eleven studies cited (Bluett, 1977; Grainger and Wilhelms, 1979; Stockdale et al, 1981). Considerable between cow variation in the ability to recover from underfeeding was an explanation for the non-significant results despite large differences in production between the well-fed and underfed cows (Hutton and Parker, 1966). Complete recovery in production of milk constituents has been found to occur between 50 and 80 days after differential feeding (Broster and Thomas, 1983).

Bryant and Trigg (1982) concluded that the subsequent effects of underfeeding in early lactation were one half or less than the immediate effects. Studies at Massey University indicate that subsequent effects of underfeeding in early lactation range from 1.3 (Grainger, 1982) to 0.1 (Ngarmsak, 1984) times the immediate effects. Conflicting results amongst the studies reported are

probably due to variations in both the level and duration of underfeeding during the treatment period and to the level of feeding during the post treatment period (Gordon, 1976; Grainger and Wilhelms, 1979; Broster and Thomas, 1983).

The rate of liveweight gain following underfeeding in early lactation is generally higher in previously underfed than in previously well fed cows (Bryant and Trigg , 1982; Mitchell, 1985). Previously underfed cows have been reported to gain 0.15 kg/day more in mid-lactation than those which had been well fed (Broster and Thomas, 1983).

The subsequent effects of underfeeding in late lactation on milk yield are less well documented, because cows are usually dried off shortly after the period of underfeeding. However, the extra liveweight gain by those animals receiving the higher plane of nutrition could have subsequent effects on milk yield in the following lactation (Wilson and Davey, 1982).

1.4.2 THE EFFECTS OF LEVEL OF HERBAGE INTAKE ON MILK COMPOSITION

1.4.2.1 IMMEDIATE RESPONSE

A summary of a number of trials conducted at Ruakura indicates that in general, a 50 % reduction in ad libitum intake resulted in an 8 % increase in milk fat concentration and a 6 % decrease in milk protein concentration, while milk lactose

concentration decreased by 2 % (Bryant, 1979). Reports of the effects of level of feeding on the composition of milk do vary, however. While the physiology of milk component synthesis and secretion is well known (Rook and Thomas, 1983), the changes in milk composition and constituent yield in response to level of feeding are less well known and are variable (Johnson, 1983; Thomas and Chamberlain, 1984). In addition, there are changes in milk composition due to stage of lactation irrespective of plane of nutrition, with both milk fat and protein concentration declining in early lactation and then increasing again in late lactation (ibid).

In a review of the effects of feeding level on milk composition in early lactation, Bryant and Trigg (1982) concluded that a reduction in intake had a variable effect on milk fat concentration but that the 'solids not fat' (SNF) proportion in the milk decreased. Grainger and Wilhelms (1979), Bryant and Trigg (1979), Glassey et al, (1980); Grainger et al, (1982) and Mitchell (1985) all reported an increase in milk fat concentration as a result of restricting feed intake in early lactation. On the contrary, Stockdale et al (1981) working with a greater range of feeding levels, found that there was no difference between groups in fat concentration of the milk at this time, even though milk protein concentration decreased at lower levels of feeding.

Wilson and Davey (1982), reviewing recent Australasian trials on the effects of feed restriction in mid/late lactation noted that with an average reduction in intake of 30 % ad libitum, milk fat concentration increased and protein concentration decreased. With studies conducted in late lactation where milk yield was below 12 kg/cow daily, changes in milk composition were associated with drying off, overriding the effects of the level of feeding (ibid).

1.4.2.2 SUBSEQUENT EFFECTS

Subsequent effects of level of feeding on milk composition are inconclusive (Bryant and Trigg, 1982), with several workers reporting a rapid return to normal (Flux and Patchel, 1954,1957; Glassey et al, 1980; Grainger et al, 1982; Mitchell, 1985) while others have reported residual effects (Grainger and Wilhelms, 1979; Bryant and Trigg, 1979). Differences in the length and severity of restriction between experiments may account for some of the variability noted.

The increased liveweight gain occurring as a result of increased intake in late lactation may result in a carryover effect to the subsequent lactation. Rogers et al (1979) found that cows calving at a higher condition score had a greater milk fat concentration and a lower protein concentration than cows calving at a lower condition score.

Summarizing the effects of intake level on milk composition, Bryant (1979) concluded that any great change in intake will result in small changes in milk composition in absolute terms when compared with the effects of breed, lactation stage, or with the effects that reduced intake has on yield.

1.4.3 THE EFFECTS OF HERBAGE QUALITY ON MILK YIELD

Experimental evidence on the effects of herbage quality on milk yield are inconsistent. Direct evidence of differences in milk yield with cows grazing either grass, clover, or grass/clover swards of different digestibilities is scant (Greenhalgh and Reid, 1969; Brookes and Lancashire, 1979). Nevertheless, an increase in herbage quality has been shown to result in an increase in milk yield in some cases (Santamaria et al, 1979; Beilhartz et al, 1980; Rogers et al, 1982). The increased milk yield with increased DMD is usually accounted for by an accompanying increase in DM intake as herbage quality increases (section 1.2). However, an increase in the DMD of herbage ingested will also result in both an increased concentration of metabolizable energy (ME) per kg of DM intake and an increase in the efficiency with which that ME is used for milk yield and body tissue synthesis (Raymond, 1969). Trigg et al (1982) found that when cows were fed fresh cut grass indoors, the efficiency of utilization of ME for energy balance (milk and tissue production), was 56 and 50 % respectively in early and mid lactation. This decrease in the efficiency of utilization of ME for productive purposes was partly attributed to

the decrease in herbage quality with time and to a change in herbage composition. However, no values for either herbage composition or quality were quoted, and this limits appraisal of the conclusions drawn.

The effect of herbage quality on milk composition is variable (Brookes and Lancashire, 1979). Different herbage species have been noted to have a slight but inconsistent effect on milk composition (Wilson, 1970; Bryant, 1979). The change in milk composition with different species may be due to differences in quantity eaten between the two species rather than to differences in intrinsic properties of the species.

The effects of herbage quality on milk yield and composition for the grazing animal need to be assessed more carefully before any conclusive statements can be made (Bryant and Trigg, 1982).

1.4.4 CHANGES IN MILK FAT FATTY ACID COMPOSITION IN RESPONSE TO CHANGES IN ENERGY STATUS OF THE ANIMAL

Changes in the fatty acid composition of milk fat have been shown to be correlated to changes in the energy status of lactating ruminants on temperate (Payne et al, 1979) and tropical (Stobbs and Brett, 1974,1976) pastures. The short chain fatty acids ($C_{4:0} - C_{16:0}$) contained in milk fat are primarily synthesized in the mammary gland from acetate and 3-hydroxybutyrate of dietary origin (Rook and Thomas, 1983).

Small amounts of $C_{14:0}$, and approximately half of the $C_{16:0}$ fatty acids, along with the long chain fatty acids ($C_{18:0}$ and $C_{18:1}$) are supplied by plasma lipids derived from body fat (ibid). Thus, the proportion of short chain fatty acids decreases and that of the long chain fatty acids increases with a restriction in energy intake. The response to a change in energy intake is rapid, occurring within a week of intake restriction (Stobbs and Brett, 1974; 1976; Payne et al, 1979).

Although the fatty acid concentrations in milk fat may not be of economic importance to the dairy industry per se, changes in the fatty acid concentrations in milk fat can provide valuable information about the energy status of the lactating animal (Stobbs and Brett, 1974; 1976; Payne et al, 1979).

1.5 SCOPE AND OBJECTIVES OF THE PRESENT STUDY

The influence of changes in intake level on dairy cow performance has been studied extensively both in Australasia and in the northern hemisphere. There is, however, a lack of knowledge of the effects of sward factors on the intake of the grazing dairy cow. Research on the sward/animal interface using dairy cows has received little attention in New Zealand. Furthermore, the majority of grazing studies in New Zealand concerned with the response of swards to grazing regime use sheep as defoliators. There is at present no basis for suggesting that

sward response to grazing regime using sheep would be similar to that using dairy cows.

The primary objectives of this study were to provide basic information on the effects of grazing regime on sward characteristics over a range of seasons, and on the effects of sward characteristics on dairy cow performance in two of these, seasons. The first trial involved the assessment of the influence of grazing frequency and intensity on sward parameters over one year. The three subsequent trials focused on the effects of grazing intensity during the period of reproductive growth in spring on pasture parameters throughout spring and summer, and on cow performance from those pastures in early summer. The final trial dealt with the influence of autumn/winter grazing regime on sward and animal performance in early spring. The aims and objectives of each trial are described in greater detail in the relevant chapters.

CHAPTER 2 GENERAL MATERIALS AND METHODS

2.1 ENVIRONMENT

The five grazing trials presented in this study were conducted between September 1982 and April 1985, at Massey University's Dairy Cattle Research Unit, Palmerston North, New Zealand. The Unit, run as a seasonal supply dairy operation, was established primarily for research purposes in 1959. The farm area is 48 ha, supporting an average of 115 milking cows and their replacements, as well as surplus heifer and bull calves for 3 months in spring.

Monozygous twins (Friesian, Jersey and Friesian/Jersey cross) comprise approximately half of the milking herd. These twins are purchased at 2 - 3 weeks of age from dairy farms in the lower half of the North Island. The monozygosity of the twins is assessed before purchasing the calves, with no follow up assessment conducted. Approximately 15 % of the twins would therefore be expected to be dizygous (Johansson and Rendel, 1972). The remaining cows are Friesians of either high or low breeding index (having BIs of 125 and 100 respectively), purchased from farms in the North Island or raised at the Unit (those born after 1980).

The Unit is situated on a wet clay soil - Tokomaru silt loam - a soil which consists of a 15 - 30 cm layer of heavy silt above a mottled clay loam. The area is extensively drained with tiles and moles. The effective land area of the farm is divided into approximately 0.8 ha paddocks designed to serve as 12 hour grazing units for the milking herd. Surplus spring pasture is stored as silage, with hay requirements being purchased locally. All pastures are fertilized with approximately 375 kg/ha of 15 % potassic superphosphate annually, and approximately 100 kg/ha of urea nitrogen biannually (in early spring and autumn).

2.2 WEATHER

Meteorological data for the period of March 1982 - April 1985 are presented in Appendix 2.1. These data were collected at D.S.I.R. Grasslands Division, Palmerston North, approximately 1 km to the north east of the Dairy Cattle Research Unit.

2.3 SWARD AND ANIMAL MANAGEMENT

The management of both the experimental swards and animals varied from trial to trial. Specific management details are therefore given in each chapter.

2.4 SWARD AND ANIMAL MEASUREMENTS

The type and frequency of measurements made in each trial are presented in the appropriate chapters. The details of the techniques and equipment used to make each measurement are presented in Appendix 2.2.

2.5 STATISTICAL ANALYSES

Data analyses were performed on a main frame Prime computer at Massey University. The data in Chapter 3 were analyzed using a Fortran program developed specifically for handling data pertaining to a split plot in space and time design (Wewala, pers.comm.). All data in the remaining chapters were analyzed using a generalized linear models computing package (REG) (Gilmour, 1983).

Analyses of proportions were conducted on untransformed data, since the data did not violate the assumptions of normality for analysis of variance, and arcsine transformation of the data (Sokal and Rohlf, 1981) did not improve its distribution.

Sward Measurements

The data in Chapter 3 were analysed according to the model in Appendices 3.1 and 3.2. Sward data in the remaining chapters were subject to univariate analysis of variance according to the

general linear model:

$$Y_{ijk} = \mu + P_i + S_j + (PS)_{ij} + e_{ijk}$$

where:

Y_{ijk} = observation on sward type i in paddock j ;

μ = overall mean;

P_i = effect of the i th paddock;

S_j = " " " j th sward type;

$(PS)_{ij}$ = " " " interaction between sward type i
and paddock j ; and

e_{ijk} = random error associated with the k th sample
taken from the j th sward type in the i th paddock,
and is assumed to be normally distributed with
mean 0 and constant variance σ^2 .

Cow Measurements

The milk, milk fat, and milk yield data collected were multivariate in the sense that the variables were measured at different times on the same individuals. Repeated measurements analysis, which is a form of multivariate analysis, takes into account the different error structure that exists within and between animals across measurement periods (Gill and Hafs, 1971; Morrison, 1976; Bryant and Gillings, 1985). The null hypothesis that the treatment effects are similar is tested within each time period. Repeated measurements analyses of covariance were performed on milk yield data according to the following general linear models:

(i) when monozygous twins were used:

$$Y_{ijkp} = \mu_p + T_{ip} + Bx_{ijk} + G_{kp} + GT_{ikp} + e_{ijkp}$$

(ii) when high breeding index cows were used:

$$Y_{ijp} = \mu_p + T_{ip} + Bx_{ij} + e_{ijp}$$

where:

Y_{ijkp} = observation on cow j in twin group k on sward type i
in period p;

Y_{ijp} = observation on cow j on sward type i in period p ;

μ_p = mean of the p th period;

T_{ip} = effect of the i th sward type in period p ;

$Bx_{ij(k)}$ = $x_{ij(k)}$ - initial observation of the variable concerned
before the experimental period commenced
 B - regression coefficient associated with $x_{ij(k)}$;

G_{kp} = effect of the k th twin group on y in period p where
identical twins were used in the trial;

GT_{ikp} = effect of the interaction between the k th twin group
and the i th sward type in period p where identical
twins were used in the trial; and

$e_{ij(k)p}$ = random error associated with the j th cow (in twin
group k) on sward type i during period p , and is
assumed to be normally distributed with mean 0 and
variance σ^2 .

Analysis of variance of milk fat composition, unfasted liveweight, condition score, and behaviour data were performed according to a univariate model which accounted for a covariate where applicable, treatment effects, twin group effects where applicable, and any interactions between these variables provided the number of degrees of freedom were sufficient.

Treatment effects are considered to be different if the level of significance is less than 5 % ($p < 0.05$). Where significant differences between treatments existed tests for differences between means were made using the criterion of least significant difference (LSD) for univariate data, while the criterion of orthogonal contrasts were used in the case of multivariate data.

The symbols *, **, ***, and ****, are used throughout to indicate the significance levels of $p < 0.05$, $p < 0.025$, $p < 0.01$, and $p < 0.001$ respectively. Where $p > 0.05$, the term NS (not significant) is used. Where significant differences between treatments exist, and the number of treatments is greater than two, means followed by dissimilar letters are different at $p < 0.05$.

2.6 DATA PRESENTATION

Unless otherwise stated all data presented are least squares means (LSM) and their standard errors ($SE_{(LSM)}$). Figures and tables are presented at the end of each chapter or chapter

section.

2.7 TERMINOLOGY AND DEFINITIONS

The terminology and definitions recommended by Hodgson (1979) and Thomas (1980) are used in this thesis. Slight modifications to several terms are given below.

Stem	In grasses, the leaf sheaths (pseudostem) and true stem. In clovers, the petiole and stipule along with any above ground stolon protruding above the cutting height.
Leaf	In grasses, the lamina and ligule of a leaf; in clovers, the lamina.
Senescent/Dead Matter	Any of the measured components in a sward that are greater than 50 % chlorotic.

2.8 COMMON ABBREVIATIONS

The following abbreviations are used throughout the text.

DM dry matter

DMD dry matter digestibility (%)

OMD organic matter digestibility (%)

DDM digestible dry matter

N % percentage of nitrogen in the DM

NHA net herbage accumulation (kg DM/ha daily)

DMI dry matter intake (kg DM/cow daily)

DA daily allowance of total herbage DM
(kg DM/cow daily)

GA " " " green herbage DM
(kg DM/cow daily)

LA " " " leaf (grass leaf and
clover leaf) (kg DM/cow daily)

2.9 BOTANICAL NAMES OF PASTURE PLANTS

The common names of grasses and clovers are used throughout the text. The botanical name of any pasture plant mentioned in the text is given below.

cocksfoot: Dactylis glomerata L.

phalaris: Phalaris aquatica

Poa annua: Poa annua L.

prairie grass: Bromus catharticus Vahl

red clover: Trifolium repens L.

ryegrass (perennial): Lolium perenne L.

ryegrass (annual): Lolium (multiflorum * perenne)

red clover: Trifolium pratense L.

CHAPTER 3 THE INFLUENCE OF SEASON AND GRAZING REGIME ON THE
SWARD CHARACTERISTICS OF THREE SOWN MIXTURES

3.1 INTRODUCTION AND OBJECTIVES

The production of milk fat per cow and per hectare is influenced by the quantity of herbage grown, the percentage of herbage grown which is harvested by the cow, and the quality of the herbage ingested. In spite of the fact that pastures are the main feed source for dairy cows in New Zealand, detailed information on the seasonal changes in sward characteristics of ryegrass/white clover dominant pastures commonly found on New Zealand dairy farms is scarce (Hutton, 1961; Campbell, 1964; 1966; Bryant and Trigg, 1982; Bryant and L'Huillier, 1986). The effects of grazing management on these seasonal changes is unknown (Bryant and Trigg, 1982).

In addition to season and grazing management, the species and cultivar composition of pastures can also affect the quality and quantity of herbage grown (Goold et al, 1985), and animal production response per unit of feed intake (Ulyatt, 1981a,b). The effect of both herbage cultivar and species on dairy farm productivity is less well known (Goold et al, 1985; Thom et al, 1985).

Prairie grass (Bromus catharticus) has long been recognized as a valuable pasture species for New Zealand (Hill, 1915). The currently recommended cultivar 'Grasslands Matua' was bred by Grasslands Division D.S.I.R., New Zealand. This cultivar was bred from 2 populations selected out of 400 populations obtained from commercial sources within New Zealand and overseas, and from pastures and wastelands in New Zealand (Rumball, 1974). Selected and bred for high production, Matua is noted for its rapid establishment and resistance to insect pests (ibid), superior yield over ryegrass cultivars during summer, autumn, and winter (Lancashire, 1978; Sithamparanathan, 1979), and its ability to produce well in association with pasture legumes (Baars and Cranston, 1977; Watkin, 1975) and other pasture grasses (Sangakkara and Roberts, 1982). Although it has been suggested that prairie grass is particularly suited to the requirements of a dairying situation (Rumball, 1974; Wilson, 1977), there is no evidence to date of increased cow or farm productivity with the inclusion of this species in the grazing regime. There is no information on the comparative seasonal performance of conventional perennial ryegrass/clover and prairie grass/clover dominant swards subject to different grazing regimes by dairy cows.

The purpose of this experiment was to assess the effects of season and grazing regime on the sward characteristics of three first year swards when grazed by dairy cows. The three swards consisted of sown mixtures of (a) out-dated cultivars of

predominantly perennial ryegrass/clover (Lancashire 1985), (b) currently recommended cultivars of perennial ryegrass/clover (ibid), and (c) a mixture of currently recommended cultivars of predominantly prairie grass/annual ryegrass/clover (Table 3.1, page 86).

3.2 MATERIALS AND METHODS

The experiment was conducted from September 1982 to July 1983 at Massey University's Dairy Cattle Research Unit, Palmerston North, New Zealand.

3.2.1 PREPARATION PERIOD

In March 1982 a 0.8 ha paddock of predominantly ryegrass/white clover was ploughed and sown to the three different seed mixtures (Table 3.1). The swards resulting from these three sown mixtures will be referred to as 'sward types' throughout the remainder of this chapter. The three seed mixtures were sown in six strips, each 10 meters wide, along the length of the paddock, with each mixture being replicated twice (Figure 3.1). Fertilizer nitrogen in the form of urea was applied at the rate of 20 kg urea/ha in early May, and again at 25 kg/ha in late August. In late May the entire paddock was sprayed with a selective herbicide (MCPB (Ivon Watkins-Dov Ltd.) at 1.5 kg ae/ha) to control an infestation of twin cress (Coronopus didymus).

Grazing Regimes: HF - Hard Frequent grazing

HI - " Infrequent "

LF - Lax Frequent "

LI - " Infrequent "

The target grazing intensities at each season are given in Table 3.2, and the grazing dates are shown in Table 3.3.

Measurement Periods: Early Spring - September/October

Late Spring - October/November

Summer - December/January

Autumn - March/April

Winter - June/July

MANAGEMENT

At each grazing lactating cows (dry cows in winter) were given access to the appropriate plots after the morning milking and were removed from each plot when target RHM (by eye estimation) had been reached. Time spent on the plots ranged from two to seven hours depending on season, weather on the day of grazing, and state of satiety of the animals on entry to the plots.

Phosphate fertilizer was applied to each plot at the rate of 375 kg/ha in April 1983.

MEASUREMENTS

Unless otherwise indicated, the methods and equipment used to make the measurements described below are those detailed in Appendix 2.2.

Pre-grazing herbage mass and RHM (kg DM/ha) was determined by cutting herbage within a 0.1875 m² quadrat to ground level. Three such quadrats were placed at random in each plot at each measurement period.

Where herbage was cut before grazing, a subsample of bulked herbage was taken for separation into prairie grass, other grasses, clover, senescent material, and weed, and the percentage

of each in the sward calculated on a dry weight basis. No attempt was made to separate the red clover from the white clover. The percentage of weed present in all samples was always less than 5 % (dry weight) and thus, for simplicity, the weed fraction was added to the 'other grasses' fraction.

A subsample of dried herbage cut before grazing was ground to pass through a 2mm sieve and analysed for N % (nitrogen %) and in vitro DMD (dry matter digestibility %).

Sward surface height (cm) before grazing was taken at 20 points (10 points along each diagonal) in each plot to facilitate the calculation of herbage bulk density (kg DM/ha per cm sward surface height).

3.2.3 STATISTICAL ANALYSIS

The data collected were subject to analyses of variance according to a split plot in space and time design (Steel and Torrie, 1980). A brief explanation of this design along with the model used to analyse the data is given in Appendix 3.1.

The dependent variables analysed were:

- the percentage of total grass, clover and senescent matter in the sward before grazing
- NHA (net herbage accumulation) between grazings

- bulk density, N % and DMD of the herbage in the sward before grazing
- mass of total dry matter, green matter, senescent matter, DDM (digestible dry matter), and nitrogen in the sward before grazing

There was no prairie grass present in any of the R and N plots throughout the period of measurement (October, 1982 - July, 1983). Thus, both the percentage and total mass of prairie grass present in the pre-grazing herbage in the M plots only, were subject to analysis of variance according to a randomized complete block design (Appendix 3.2).

3.2.4 PRESENTATION OF RESULTS

Appropriate presentation of data from multiple factor experiments can present difficulties. It is common practice to consider first the main effects, and then to consider first and second order interactions. However, this can lead to misinterpretation, since main treatment effects need to be considered in the light of interactions. The method of presentation here is to consider the main effects together with their interactions.

3.3 RESULTS

The percentage of prairie grass in the M swards was low throughout the experiment (overall mean of 8.6 %). This can be attributed to poor establishment, since the M swards contained only 16 % prairie grass in early spring, 6 months after sowing (Table 3.6). The annual ryegrass cultivars included in the M mixture at sowing were identified as the dominant grasses present in the M swards. Thus, the comparison of M swards with the performance of out-dated cultivars in the R swards, and the currently recommended cultivars in the N swards is essentially a comparison with an annual ryegrass/clover mixture. Despite the lack of prairie grass in the M swards, these swards will continue to be referred to as Matua swards primarily for the sake of continuity of terminology throughout the chapter.

The proposed grazing intensities for the L and H grazing treatments were generally achieved in early spring, late spring, and winter (Table 3.2). In summer and autumn, however, RHMs were greater than desired, especially on the L grazed treatments. The small size of individual plots (200 m²) resulted in frequent agonistic encounters between cows as herbage mass declined within a grazing period. This was especially noticeable in the summer and autumn periods when the frequency of previously rejected sites in each plot was highest; further limiting the grazing area available to each cow. In order to minimize trauma to subordinate cows and to prevent damage to the fences, the cows tended to be

removed from their plots before the desired RHM had been reached.

3.3.1 NON-SIGNIFICANT INDEPENDENT VARIABLES

For twelve of the fourteen variables measured in this study, swards in the two blocks responded in a similar manner to the main, sub, and sub sub -plot treatments applied (Appendices 3.3 - 3.7). In addition, all of the three sward types responded in the same way to the grazing regimes applied, and did so to a similar extent across all seasons for ten of the twelve variables in which the further interaction with sward type was analysed (Appendices 3.3 and 3.6).

The effect of block will not be referred to again except when pertaining specifically to the two variables on which it had significant effects. Due to the problems inherent in meaningful interpretation of second order interactions in an experiment of the scope of the present trial, the sward type * grazing regime * season interaction will not be considered further.

3.3.2 HERBAGE COMPOSITION

Similar percentages of total grass and senescent matter were present in the herbage before grazing for all three sward types (Table 3.4) in all of the seasons monitored (Appendix 3.3). The percentage of clover in the M swards was, however, more than twice that in the R swards (12.1 % vs 5.3 % respectively)(Table 3.4).

The difference in the percentage of clover between the three sward types was not apparent until the summer period (Figure 3.2), and the magnitude in difference between the percentages of clover in the M and R swards was greatest in the winter measurement period, (24.4 % and 6.4 % respectively). In the N swards the percentage of clover was always intermediate to that in the M and R swards.

Those pastures that were L grazed throughout the experiment contained approximately twice the percentage of senescent matter compared to swards that were H grazed throughout (Table 3.5). Conversely, H grazed swards contained approximately 1.3 times the percentage of total grass compared to that in the L grazed swards. These differences were not apparent until the summer, and were most marked in the autumn, when L grazed swards had over twice the percentage of senescent matter and less than half the percentage of total grass compared to H grazed swards (Figure 3.3). The frequency of grazing had no effect on the percentage of total grass and senescent matter in the herbage for either L or H grazed swards in most seasons. The one exception being that in winter, HF grazing resulted in a greater percentage of total grass than HI grazing.

The overall percentage of prairie grass in the M swards was low (8.6 %). Of those swards containing prairie grass, herbage on the H grazed plots contained the greatest percentages of prairie grass present overall regardless of grazing frequency (Table 3.5). The herbage in the M swards that were LI grazed contained the

lowest percentage of prairie grass, approximately half that of the H grazed swards (4.9 and 11.0 % respectively). The ranking of the four grazing regimes in terms of the percentages of prairie grass in the herbage changed with season (Figure 3.4) (Appendix 3.4). In early spring the percentage of prairie grass was greatest in the F grazed swards, with the herbage in these swards containing approximately four times the percentage of prairie grass present in the I grazed swards. In late spring, summer, and winter, grazing regime did not affect the percentage of prairie grass in the sward, while in autumn the HI grazed swards had the greatest percentage of prairie grass.

The percentage of clover in the herbage was not significantly affected by grazing regime overall (Table 3.5), and within any of the seasons (Figure 3.3).

The seasonal patterns of herbage composition are given in Table 3.6. Over all grazing regimes and sward types the percentage of total grass in the herbage before grazing was greatest in early spring and late spring and least in autumn, while the percentage of senescent matter and clover in the herbage exhibited the opposite trend. In the M swards, the percentage of prairie grass was greatest in early spring and lowest in summer.

There was an effect of block on the percentage of clover present in the pre-grazing herbage (Appendix 3.3).

3.3.3 NET HERBAGE ACCUMULATION

There was no significant difference between the sward types in the overall rate at which herbage accumulated in the sward (Table 3.7) and at each season (Appendix 3.5). However the method of grazing did affect NHA (Table 3.8). A LF grazed sward had the highest overall NHA, followed by a HF grazed sward. Infrequent grazing at either intensity resulted in the lowest NHA overall.

The differences between the four grazing regimes in terms of NHA were further influenced by season (Figure 3.5). In late spring, a LF grazing regime resulted in the greatest NHA, while an HF regime had the lowest NHA. In summer, a LF grazing regime had between two and three times the NHA compared to the remaining grazing regimes. This trend was reversed in autumn, when an HF grazing regime had the highest NHA. Over the winter, all swards had a similar NHA.

There was a marked seasonal effect on NHA across all sward types and grazing regimes (Table 3.9). During the spring, NHA was highest, while in autumn the rates were lowest and actually negative (109 vs -38 kg DM/ha daily respectively).

3.3.4 HERBAGE QUALITY

While N % of the pre-grazing herbage mass was similar for all sward types at each season, the DMD of the herbage was greatest on the M swards and least on the R swards (Table 3.7) over all seasons (Appendix 3.6).

Both the DMD and N % of the herbage present before grazing were greatest on swards that were HF grazed throughout, and lowest on those swards that were LI grazed (Table 3.8). The effects of grazing regime on both DMD and N % were modified by seasonal effects (Figures 3.6 and 3.7 respectively). In early spring, the DMD was greatest on I grazed swards, while in the remaining seasons the H swards had a greater DMD. The N % was greatest on F grazed swards in early and late spring, with H swards having a greater N % at both grazing frequencies in late spring. During the remainder of the year HF grazed swards contained the greatest N % and LI grazed swards the least.

The highest values for both the N % and DMD of the pre-grazing herbage mass occurred in early spring (3.9 % and 77.7 % respectively) (Table 3.9). The DMD of the herbage was lowest in autumn (60.9 %), while the N % of the herbage was lowest in summer (2.6 %).

3.3.5 HERBAGE BULK DENSITY

The bulk density (kg DM/ha per cm of sward surface height) of the total herbage in the sward before grazing was unrelated to sward type (Table 3.7), at all of the measurement periods (Appendix 3.5).

Herbage on the LF grazed swards had a greater bulk density than herbage on swards subject to the remaining three grazing regimes (Table 3.8). The effect of grazing regime on herbage bulk density was apparent only in the summer and autumn, when LF grazed swards had the greatest herbage bulk density and HI grazed swards had the lowest herbage bulk density (Figure 3.8).

Herbage bulk density was greatest in summer, being almost three times that in winter when values for bulk density were at their lowest (179 vs 67 kg DM/ha per cm sward surface height respectively) (Table 3.9).

3.3.6 HERBAGE MASS COMPONENTS

The masses (kg DM/ha) of total dry matter, senescent matter and nitrogen present in the sward before grazing were similar for all sward types (Table 3.10). There were, however, differences in the masses of total dry matter and senescent matter between the three sward types in some seasons (Figure 3.9) (Appendix 3.7). R and N swards had greater masses of total dry matter present than M

swards in the early and late spring and summer periods, while the masses of senescent matter present in the R and N swards were almost twice that present on the M swards in summer.

Total green matter and DDM masses were greatest on the R and N swards, with M swards having approximately 77 % of the green matter and 90 % of the total DDM compared to the R and N swards (Table 3.10). The between sward type differences in the mass of green matter present in the sward were similar for all seasons (Figure 3.9)(Appendix 3.7). However, the total mass of DDM was greater on R than M swards in late spring, and in summer the N swards had a greater DDM mass than both the R and M swards (Figure 3.10).

In general, a LI grazing regime resulted in the greatest masses of total dry matter, green matter, DDM, and nitrogen present despite these swards also having the greatest mass of senescent matter present (Table 3.11). The HF grazed sward had the lowest masses of total dry matter, green matter, DDM, and nitrogen present; approximately half that present on the LI grazed swards. The mass of senescent matter present on the HF grazed swards was approximately one quarter that on the LI grazed swards.

The mass of prairie grass present in the M swards was not significantly affected by grazing regime (Table 3.11).

While the mass of nitrogen at each grazing regime showed similar trends across all seasons (Appendix 3.6), the effect of grazing regime on the remaining components of total herbage mass changed according to season (Figures 3.11 and 3.12) (Appendices 3.6 and 3.7). In general, the difference between grazing regimes in the mass of a component of the total herbage mass was greatest in the summer period, with the greatest differences occurring between the HF and LI regimes. In the M plots, the mass of prairie grass was similar for all grazing regimes at all of the five measurement periods (Appendix 3.4).

The seasonal changes in total herbage mass, and the various components of that mass are presented in Table 3.12. The masses of total dry matter, green matter, and DDM were greatest in late spring and summer, with over three times that present in winter, when these variables were at a minimum. Total nitrogen present was greatest in summer, being just twice that present during the winter period, when the mass of nitrogen in the sward was at its lowest. The mass of senescent matter present in the herbage before grazing was greatest during the summer and autumn, when almost five times the mass of senescent matter was present on these swards compared to early spring. The mass of prairie grass in the M swards was greatest in early spring, decreasing to a minimum in summer, and increasing again in autumn and winter.

There was an overall effect of block on the mass of green matter present in the herbage before grazing (Appendix 3.7).

3.4 DISCUSSION

3.4.1 SEASON AND GRAZING REGIME

The majority of sward variables monitored in this trial exhibited marked variation with season. Similar seasonal trends were reported for a limited number of these sward characteristics (ie DDM, N % and percentage of senescent matter in the herbage) in previous studies with temperate dairy pastures (Hutton, 1961, 1962; Campbell, 1966; Bryant and Trigg, 1982). The extent to which the sward variables changed with season was modified by the frequency and intensity with which a sward was grazed. In general, a HF grazing regime decreased the magnitude of these seasonal changes, while a LI grazing regime exacerbated the changes. Grazing management is therefore an effective means by which the seasonal changes in sward variables can be manipulated to better suit the nutritional needs (in terms of quality and quantity of herbage present) of stock on a farm.

In spite of the fact that herbage quality and the percentage of grass were at their lowest and the percentage of senescent matter was highest for LI compared to HF grazed swards in autumn (Figures 3.6, 3.7, and 3.3 respectively), the total masses of DDM,

N, and green matter were at their greatest on the LI grazed swards at this time (Figures 3.11 and 3.12 and Table 3.11). This can be attributed to the large differences in total dry matter present in the sward between the two grazing regimes (Table 3.11), even though greater than half the dry matter present on the LI grazed swards was senescent (Table 3.11 and Figure 3.11 respectively).

While LI grazed swards had a greater mass of total and component dry matter, the presence of large masses of senescent matter in the herbage on these swards would be expected to affect the accessibility/availability of the green matter present in those swards to the grazing animal (Hughes, 1983). The effects of sward structure and composition on dairy cow intake and production on temperate pastures are not well known and this subject will be addressed in greater detail in Chapters 4 and 5 of the present study.

In late spring, grazing intensity appeared to have a greater effect (both immediate and longer term) on sward characteristics than frequency. In winter time, the method of grazing did not have a great influence on the sward characteristics monitored. Both the spring and winter time are important periods for the dairy farmer in terms of pasture management (Bryant, 1982a; Bryant and L'Huillier, 1986), and the effects of grazing management during these periods on both subsequent sward and cow performance will be explored in greater detail in Chapters 4 and 5 in the present study.

The lack of a significant effect of grazing regime on the percentage of clover in the sward was unexpected (Table 3.5 and Figure 3.3)(Curll, 1982). The overall percentage of clover in the sward was, however, low (overall mean of 9 %); which may account in part for the lack of a significant effect of grazing regime on the percentage of clover in the sward. The low percentage of clover in the herbage measured in early spring is an indication of poor establishment. Although the seeding rate and fertilizer application were as recommended for both red and white clover (Brougham et al, 1978; Thom et al, 1985), defoliation during the establishment phase may have been too lenient to promote successful clover establishment (ibid). The control of ryegrass growth to promote establishment of clover during the establishing phase of a perennial ryegrass/clover sward is problematic especially in high fertility conditions common to intensive dairying areas. Although the establishment of clover was poor, the increase in the percentage of clover over the year (Figure 3.3) indicated that persistence was good.

The pattern of N % of the total pre-grazing herbage over the seasons (Table 3.9) was similar to that of ryegrass/white clover hill pastures grazed by sheep (Reay and Waugh, (1983), with high values for N % in early spring and autumn. The seasonal pattern of DMD of the herbage in the present study (Table 3.9) is also similar to that of the herbage OMD of set stocked sheep pastures reported by Frame and Dickson (1986), with the highest values for DMD being in the late spring and the lowest values in autumn. The

low DMD of herbage in autumn, while the N % of that herbage was high, is difficult to reconcile since high values for N % are reported to be associated with high values for DMD (Raymond, 1969).

The lack of an effect of grazing regime on the sward characteristics measured in early spring must be interpreted with caution. The sward measurements in early spring were taken 2 and 4 weeks after the initial differential defoliation for the F and I grazed swards respectively. Thus, an apparent lack of effect of grazing regime on a sward characteristic at this time must not be interpreted as unequivocal evidence of a lack of effect of grazing regime on sward characteristics at this time of year.

3.4.2 MIXTURE SOWN

In general, the type of pasture mixture sown had very little significant effect on the sward variables measured. Any effects of pasture mixture on animal production would therefore be expected to be even less (Snaydon, 1981); although others have taken a more optimistic view on the effects of mixture or cultivar sown on animal production (Munro and Walters, 1986). The absence of effects of mixture sown on most of the sward variables studied support the view of Anslow and Green (1967), Snaydon (1978;1979) and Goold et al (1985) that the effects of species composition of a sward on sward characteristics are minimal when compared to the effects of year, season, and grazing regime on these parameters.

Nevertheless, while there was no significant overall advantage to sowing currently recommended cultivars over outdated cultivars for many of the characteristics measured, the N swards did have a greater mass of total DM and DDM in the summer and autumn periods than the R swards (Figures 3.9 and 3.10), and the percentage of clover in the N swards in autumn and winter was also greater than that on R swards (Figure 3.2). Feed supply on the farm in summer is often a factor which limits cow production at this time (O'Connor, 1982), and thus the use of cultivars with greater summer growth are of importance in a farming situation. In terms of NHA, there was no significant difference between the R and N swards overall, or at each season. However, the mean NHA for the N swards was 26 % greater than the mean NHA for R swards (Table 3.7), and while this difference was not significant, a 26 % greater NHA over one year in a farming situation would be of importance.

The performance (% contribution to the total pre-grazing mass, as well as the absolute pre-grazing mass) of prairie grass in the M swards was disappointing, with the overall percentage and mass being low and the expected increase in performance over the summer/autumn period (Clark, 1985) not eventuating. The grazing regimes which consistently had the greatest percentage of prairie grass were the H grazed swards irrespective of grazing frequency (Figure 3.4), while the mass of prairie grass was not significantly affected by grazing regime (Table 3.11). This is contrary to the currently recommended grazing regime for this

species (Clarke, 1985; Thom et al, 1985). The majority of grazing studies on prairie grass have been done with sheep, which may account for differences between response to grazing regime of prairie grass in the present study, with that in the literature. There is clearly a need for more research on the response of prairie grass to grazing regime when grazed by dairy cows.

The poor establishment of prairie grass in the present study may be attributed to its rather lower seeding rate than recommended (20 vs 40 kg seed/ha respectively)(Clarke, 1985), as well as to the inclusion of a particularly aggressive annual ryegrass in the sown mixture (Harris, 1969; Harris and Lazenby, 1974). Both of the clover species included in the mixture have been shown to be compatible with prairie grass (Pineiro and Harris, 1978a,b; Hay and Ryan, 1983).

The increase in the percentage and mass of prairie grass in the M swards in the autumn and winter (Figure 3.4 and Table 3.12) may be a reflection of its increased growth over ryegrass as well as a reduction in growth of annual ryegrass, at this time (Rys et al, 1977).

3.4.3 METHODS AND DESIGN USED

The laxly grazed swards showed marked heterogeneity in that some areas of these plots were grazed laxly and some grazed hard. These differences became more exaggerated with time due to the

cows' reluctance to graze previously rejected sites. The technique of random sampling to measure herbage mass and composition may not, therefore, have been the best method to use. Some form of strategic sampling may have been more appropriate (Taylor et al, 1985; Cobby et al, 1985).

In spite of the obvious clumpy appearance of the laxly grazed plots as the season progressed, the bulk densities of the LF plots were actually greater than the bulk densities of the hard grazed plots (Table 3.8 and Figure 3.8). This is perplexing, and may be partially explained by the fact that sward surface height rather than extended sward height was taken. Visual assessment of sward 'clumpiness' is rather subjective, however, and clumpiness may have been overestimated on the LI and especially the LF swards and/or underestimated on the H grazed swards. Nevertheless, some form of strategic sampling may have been more appropriate than sampling herbage height at set intervals along the diagonals of a plot.

Gibb and Ridout (1986) have recently proposed the expression of sward surface height in long swards as the average height of long areas and the average height of short areas (a double normal distribution). The expression of herbage bulk density as a double normal distribution rather than as a single average value may provide a more useful description of long swards. More research on this subject is needed before this method would be expected to gain wide acceptance amongst researchers.

The likelihood of unequal amounts of excreta being deposited amongst plots could differentially affect the fertility status of the plots and hence affect the sward variables being measured. Attempts have been made by some workers to rectify this difference by adding nutrients to plots less frequently and/or intensely grazed than others (Harris, 1983). However, both the amount and the availability to plants of any nutrient applied would be open to debate given the present state of knowledge of the availability of both excreted and applied nutrients in grazed pastures. No attempt was made to supplement specific plots with additional nutrients since the effects of defoliation regime per se appear to have an overriding effect on sward composition and productivity, when compared to the effects of excreta return and treading (Curll and Wilkins, 1983).

The preponderance of a grazing regime * season interaction (Appendices 3.3 - 3.7) suggests that implementing a set grazing regime amongst seasons may not result in optimal annual production and quality of herbage, or optimal utilization of herbage grown, in a sward. Unfortunately, in the present experiment, the grazing regimes assigned to the plots at the beginning of the experiment were applied throughout the year. The resources necessary to conduct a grazing trial which would include a combination of grazing regimes between seasons on any one plot were beyond those available for this study. Nevertheless, the need for such a study does remain.

Year to year variation in herbage production is great (eg Radcliffe, 1976), and the effects of grazing regime, species/cultivar sown, and season on sward characteristics frequently interact with year (Vartha, 1975;1977; Baars and Cranston, 1977; Bartholomew et al, 1981; Percival and McClintock, 1982; Harris, 1983). The validity of extrapolating results obtained over one year with an establishing sward to that of a real farming situation with established swards is open to question. Nevertheless, the present study provides valuable and new information on the response of dairy swards to grazing management over one year.

3.5 CONCLUSIONS

(i) Great variations in sward characteristics existed between seasons on all sward types despite the inclusion of species with purported different seasonal activities, in two of the three sward types. The method of grazing had a marked effect on sward characteristics in most seasons, with the effect of a particular grazing regime on a characteristic usually changing with season.

(ii) In the present study the advantage of sowing currently recommended cultivars versus out-dated cultivars was difficult to demonstrate. Under dairy cow grazing, the performance of prairie grass, when included in a mixture with annual ryegrasses and clovers, was poor.

(iii) Within the bounds of this trial, a hard and frequent grazing regime appeared to be the most satisfactory grazing regime in terms of overall rates of NHA, herbage quality, high percentages of grass and low percentages of senescent matter, and a more constant mass of herbage components amongst seasons.

Table 3.1 : DESCRIPTION AND SOWING RATES OF THE THREE SEED MIXTURES

Mixture	Cultivar Name	Common Name	Botanical Name	Sowing Rate Kg/ha
R (out-dated cultivars)	'Grasslands Ruanui'	Perennial Ryegrass	<u>Lolium perenne</u> L.	10.0
	'Grasslands Apanui'	Cocksfoot	<u>Dactylis glomerata</u> L.	1.5
	'Grasslands Huia'	White Clover	<u>Trifolium repens</u> L.	1.5
	'Grasslands Hamua'	Broad Red Clover	<u>Trifolium pratense</u> L.	2.0
N (currently recommended cultivars)	'Grasslands Nui'	Perennial Ryegrass	<u>Lolium perenne</u> L.	10.0
	'Grasslands Kara'	Cocksfoot	<u>Dactylis glomerata</u> L.	2.0
	'Grasslands Pitau'	White Clover	<u>Trifolium repens</u> L.	1.5
	'Grasslands Pawera'	Tetraploid Red Clover	<u>Trifolium pratense</u> L.	3.0
M (currently recommended cultivars)	'Grasslands Matua'	Prairie Grass	<u>Bromus catharticus</u> Vahl	20.0
	'Grasslands Manawa'	Ryegrass (Short Rotation)	<u>Lolium (multiflorum x perenne)</u>	2.0
	'Grasslands 4708'	Tetraploid Hybrid Ryegrass	<u>Lolium [(multiflorum x perenne) x perenne]</u>	4.0
	'Grasslands Pitau'	White Clover	<u>Trifolium repens</u> L.	1.5
	'Grasslands Pawera'	Tetraploid Red Clover	<u>Trifolium pratense</u> L.	0.3

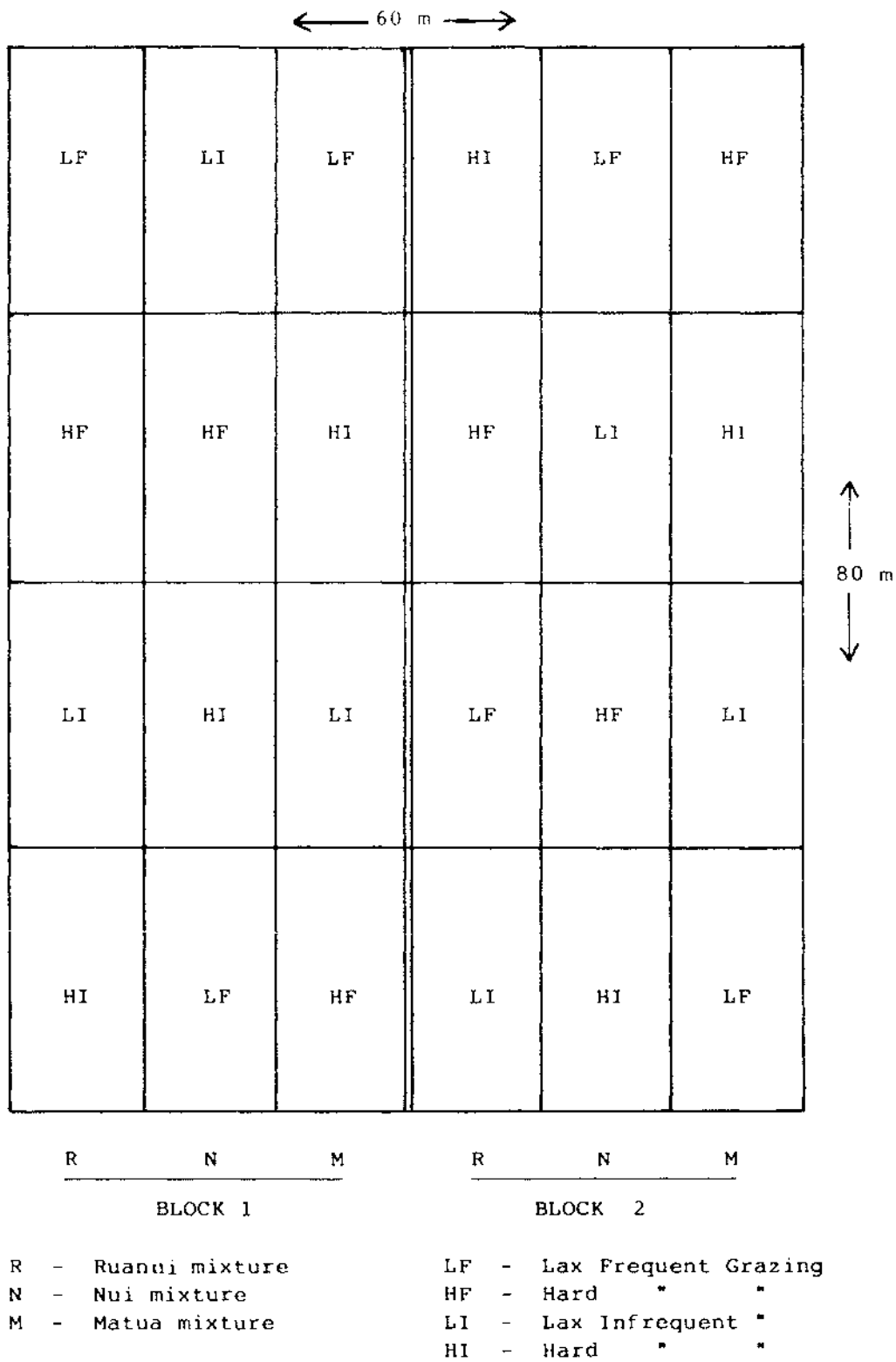


Figure 3.1 : DIAGRAM OF EXPERIMENTAL AREA

Table 3.2 : TARGET AND ACTUAL RESIDUAL HERBAGE MASSES (RHM) (KG DM/HA) TO ACHIEVE THE LAX (L) AND HARD (H) GRAZING INTENSITIES AT EACH SEASON
(The actual RHM's are raw data means and their standard deviations)

Season	Target RHM	L		H	
		Actual RHM	SD	Actual RHM	SD
		\bar{x}	SD	\bar{x}	SD
Early Spring	2500 Kg DM/ha	2126	45	1200	1275 50
Late Spring	2500	2646	33	1200	1357 48
Summer	3500	4799	400	2000	2560 50
Autumn	3000	5926	375	1500	2377 35
Winter	2000	2808	168	1000	1087 42

Table 3.3 : GRAZING DATES FOR THE FREQUENTLY (F) AND INFREQUENTLY (I) GRAZED SWARDS

F Grazing Date	I Grazing Date
September 20	September 20
October 3	
October 17	October 18
November 1	
November 15	November 15
November 29	
December 16	December 13
January 4	
January 26	January 16
February 16	
March 9	February 27
March 30	
April 19	April 10
May 10	
June 8	May 22
July 3	July 17

Table 3.4 : THE EFFECT OF SWARD TYPE ON PRE-GRAZING HERBAGE COMPOSITION (% DRY WEIGHT) AVERAGED ACROSS ALL SEASONS AND GRAZING REGIMES

Herbage Component (% dry weight)	R*	Sward Type		SE (LSM)	Sig. Level
		N	M		
Total Grass	69.5	67.1	67.3	1.0	NS
Clover	5.3 a**	9.4 b	12.1 c	1.0	****
Senescent Matter	25.2	23.6	21.1	1.0	NS

* In this table and in the remaining tables in this chapter, the following abbreviations are used:

R = Ruanui Sward type
 N = Nui " "
 M = Matua " "

** In this table and in the remaining tables in this chapter, means within rows which are followed by different letters are different at $p < 0.05$ (LSD) unless otherwise stated

Table 3.5 : THE EFFECT OF GRAZING REGIME ON PRE-GRAZING HERBAGE COMPOSITION (% DRY WEIGHT) AVERAGED ACROSS ALL SWARD TYPES AND SEASONS

Herbage Component (% Dry Weight)	LF*	Grazing Regime			SE (LSM)	Sig. Level
		HF	LI	HI		
Total Grass	59.3 a	75.3 b	61.1 a	76.1 b	1.2	****
Clover	9.2	8.5	9.8	8.2	1.2	NS
Senescent Matter	32.0 b	16.1 a	29.1 b	16.0 a	1.1	****
Prairie Grass (in M swards only)	8.0 ab	11.7 b	4.9 a	10.0 b	1.9	*

* In this table and in the remaining tables in this chapter, the following abbreviations are used:

LF = Lax Frequent grazing LI = Lax Infrequent grazing
 HF = Hard Frequent grazing HI = Hard Infrequent grazing

Figure 3.2 : THE EFFECT OF SEASON AND SWARD TYPE ON THE
PERCENTAGE OF CLOVER IN THE PRE-GRAZING HERBAGE,
AVERAGED ACROSS ALL GRAZING REGIMES

Where R = Ruanui, N= Nui and M = Matua Swards

25 —

20 —

15 —

10 —

5 —

0 —

LSD

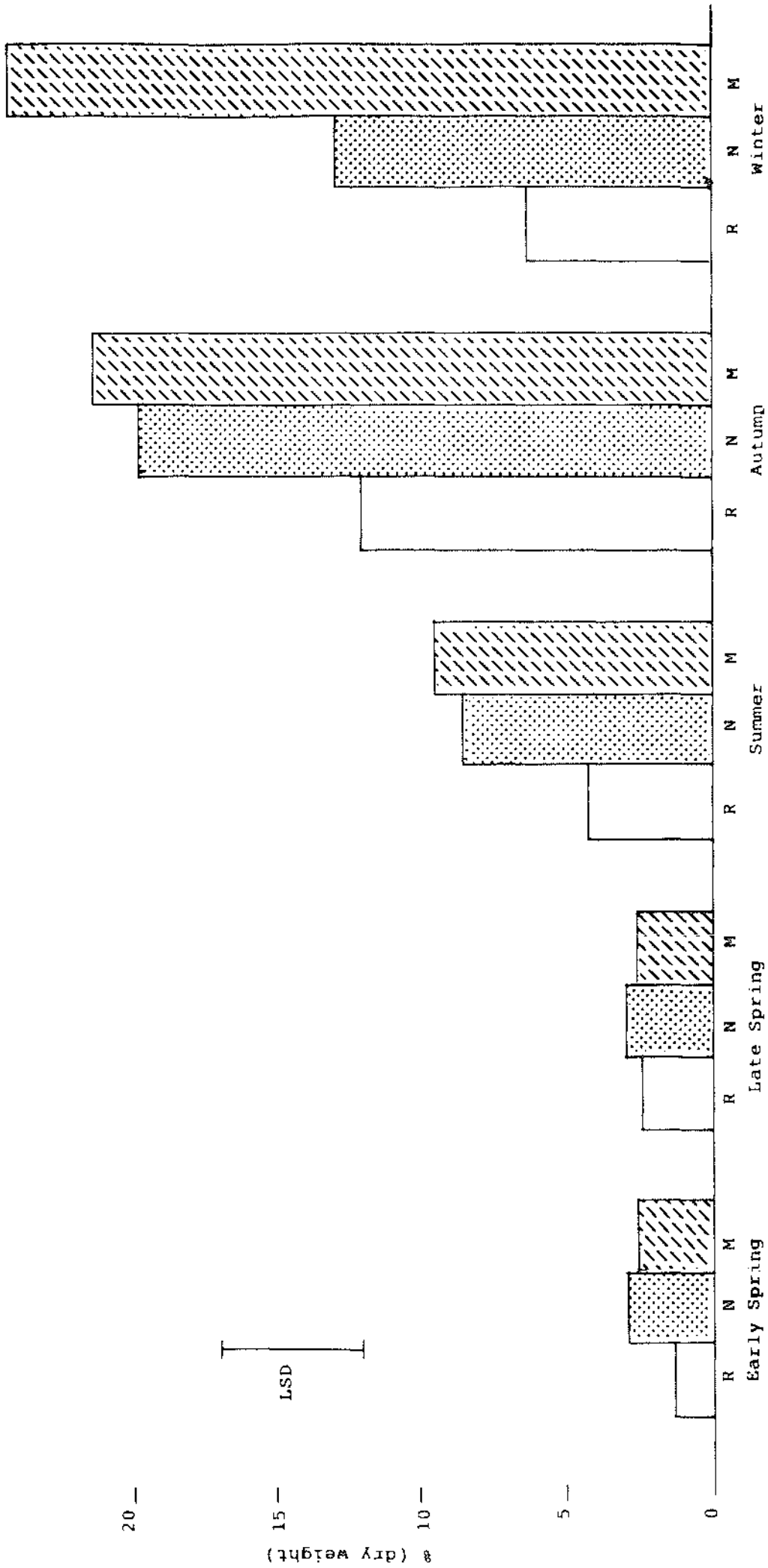


Figure 3.3 : THE EFFECT OF SEASON AND GRAZING REGIME ON PRE-GRAZING
HERBAGE COMPOSITION, AVERAGED ACROSS ALL SWARD TYPES

Where LF = lax frequent grazing
HF = hard frequent grazing
LI = lax infrequent grazing
HI = hard infrequent grazing

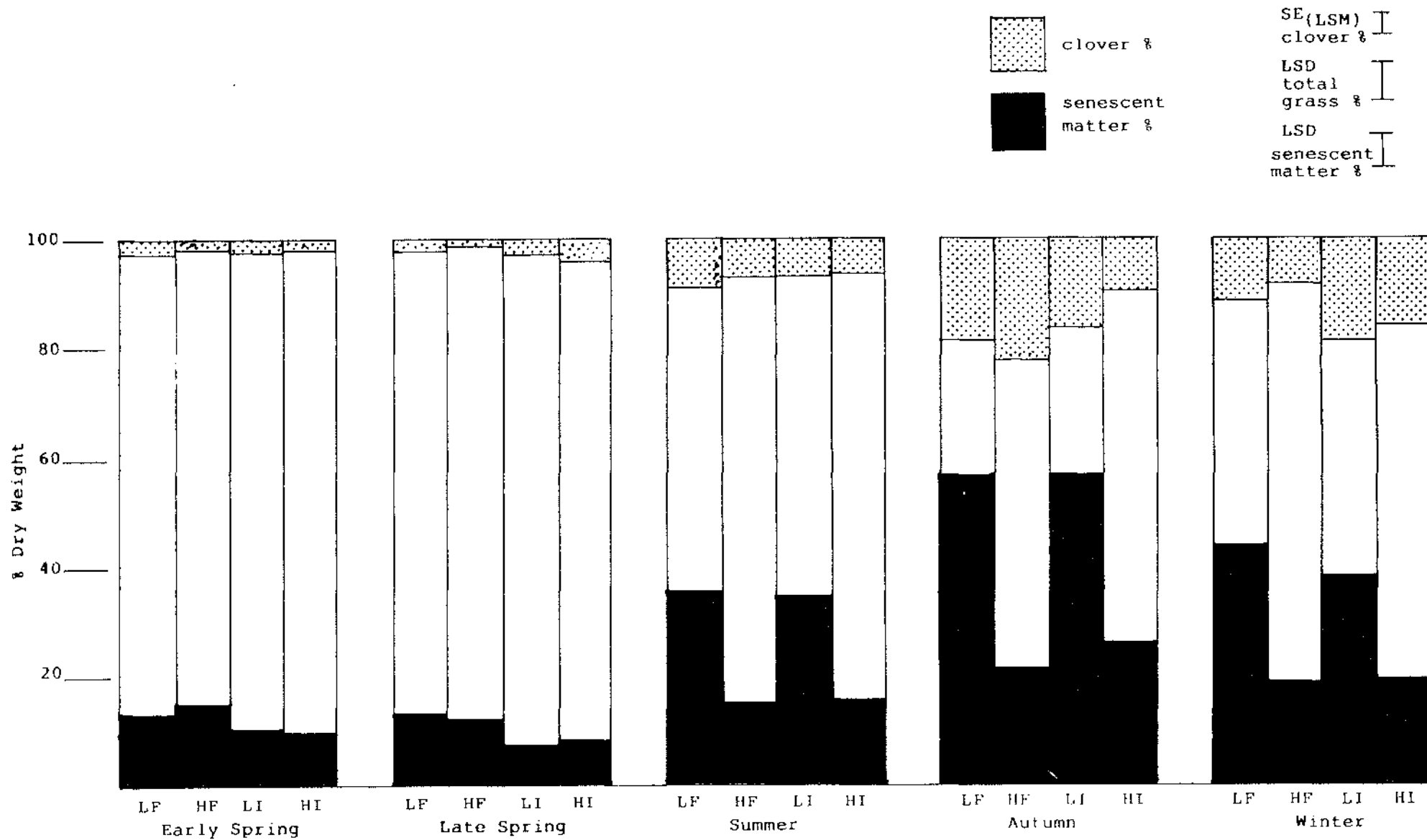
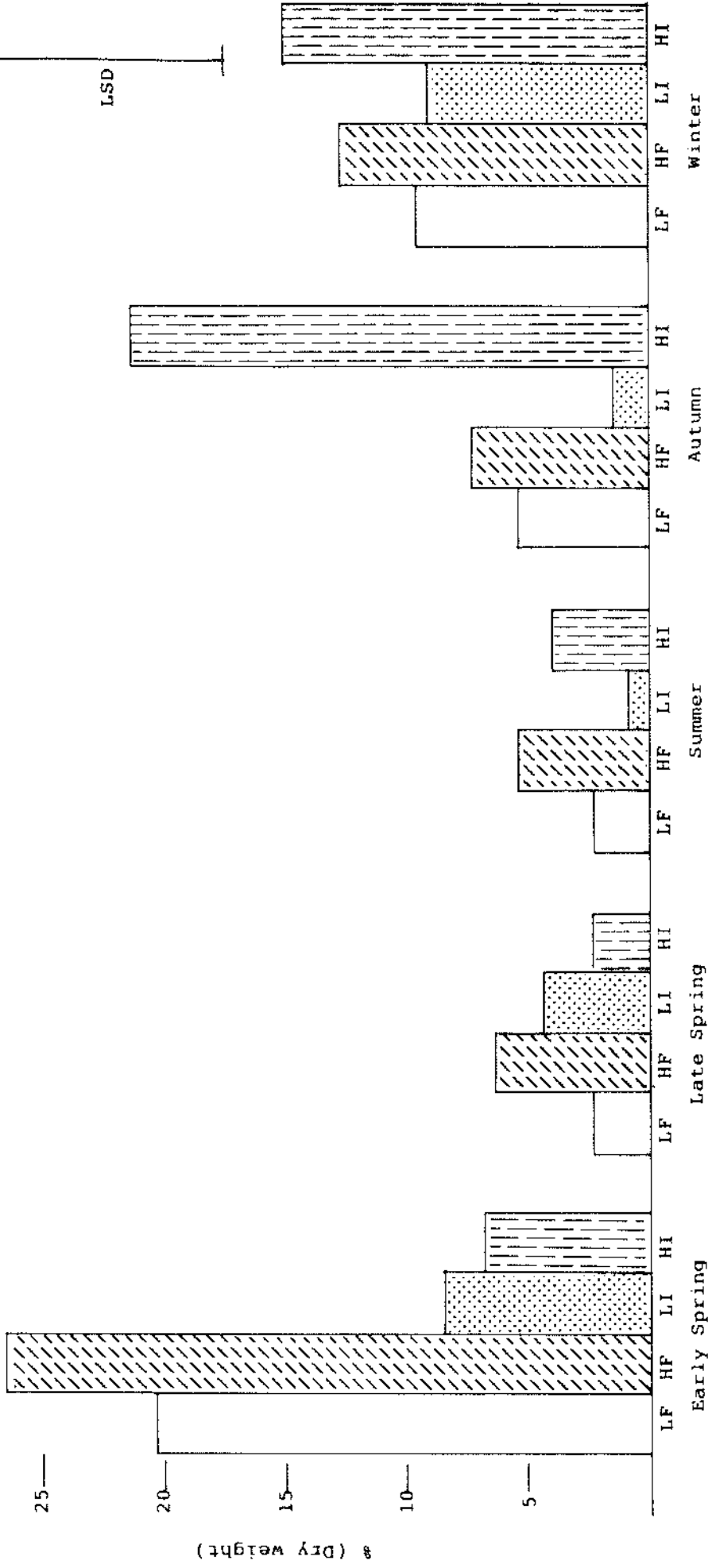


Figure 3.4 : THE EFFECT OF SEASON AND GRAZING REGIME ON THE
PERCENTAGE OF PRAIRIE GRASS IN MATUA SWARDS

Where LF = lax frequent grazing
HF = hard frequent grazing
LI = lax infrequent grazing
HI = hard infrequent grazing



LSD

Table 3.6 : THE EFFECT OF SEASON ON PRE-GRAZING HERBAGE COMPOSITION (% DRY WEIGHT) AVERAGED ACROSS ALL SWARD TYPES AND GRAZING REGIMES

Season	Herbage Component (% Dry Weight)			Prairie Grass (in M Swards Only)
	Total Grass	Clover	Senescent Matter	
Early Spring	85.9 d*	2.2 a	12.1 a	15.5 d
Late Spring	86.0 d	2.5 a	11.1 a	3.9 ab
Summer	67.4 c	7.4 b	25.2 b	3.2 a
Autumn	43.3 a	17.9 d	39.4 c	8.9 bc
Winter	57.1 b	14.6 c	28.7 b	11.7 cd
SE (LSM)	1.3	1.3	1.3	2.1
Sig. level	****	****	****	****

* Means followed by different letters within columns are different at $p < 0.05$ (LSD)

Table 3.7 : THE EFFECT OF SWARD TYPE ON PRE-GRAZING HERBAGE DRY MATTER DIGESTIBILITY (%), NITROGEN CONCENTRATION (%) AND BULK DENSITY (KG DM/HA PER CM SWARD SURFACE HEIGHT), AND ON NET HERBAGE ACCUMULATION (KG DM/HA DAILY) AVERAGED ACROSS ALL GRAZING REGIMES AND SEASONS

	R*	Sward Type		SE (LSM)	Sig. Level
		N	M		
Dry Matter Digestibility (%)	67.6 a	69.9 b	71.8 b	0.4	**
Nitrogen (%)	3.3	3.1	3.4	0.1	NS
Bulk Density (Kg DM/ha per cm sward surface height)	123	116	101	5	NS
Net Herbage Accumulation (Kg DM/ha daily)	31	39	44	6	NS

* See Table 3.4 for interpretation of abbreviations

Table 3.8 : THE EFFECT OF GRAZING REGIME ON PRE-GRAZING HERBAGE DRY MATTER DIGESTIBILITY (%), NITROGEN CONCENTRATION (%), AND BULK DENSITY (KG DM/HA PER CM SWARD SURFACE HEIGHT) AND ON NET HERBAGE ACCUMULATION (KG DM/HA DAILY) AVERAGED ACROSS ALL SWARD TYPES AND SEASONS

	LF*	Grazing Regime			SE (LSM)	Sig. Level
		HF	LI	HI		
Dry Matter Digestibility (%)	67.6 b	73.4 c	65.8 a	72.4 c	0.5	****
Nitrogen (%)	3.1 b	3.9 c	2.8 a	3.2 b	0.1	****
Bulk Density (Kg DM/ha per cm sward surface height)	135 b	113 a	111 a	94 a	6	***
Net Herbage Accumulation (Kg DM/ha daily)	60 b	41 ab	23 a	27 a	7	*

* See Table 3.5 for interpretation of abbreviations

Table 3.9 : THE EFFECT OF SEASON ON PRE-GRAZING HERBAGE DRY MATTER DIGESTIBILITY (%), NITROGEN CONCENTRATION (%), AND BULK DENSITY (KG DM/HA PER CM SWARD SURFACE HEIGHT), AND ON NET HERBAGE ACCUMULATION (KG DM/HA DAILY) AVERAGED ACROSS ALL SWARD TYPES AND GRAZING REGIMES

	Season					SE (LSM)	Sig. Level
	Early Spring	Late Spring	Summer	Autumn	Winter		
Dry Matter Digestibility (%)	77.7 e	75.5 d	70.6 c	60.9 a	64.3 b	0.5	****
Nitrogen (%)	3.9 d	2.9 ab	2.6 a	3.3 bc	3.5 cd	0.1	****
Bulk Density (Kg DM/ha per cm sward surface height)	97 ab	110 b	179 c	114 b	67 a	6	****
Net Herbage Accumulation (Kg DM/ha daily)		109 d	89 c	-38 a	-7 b	7	****

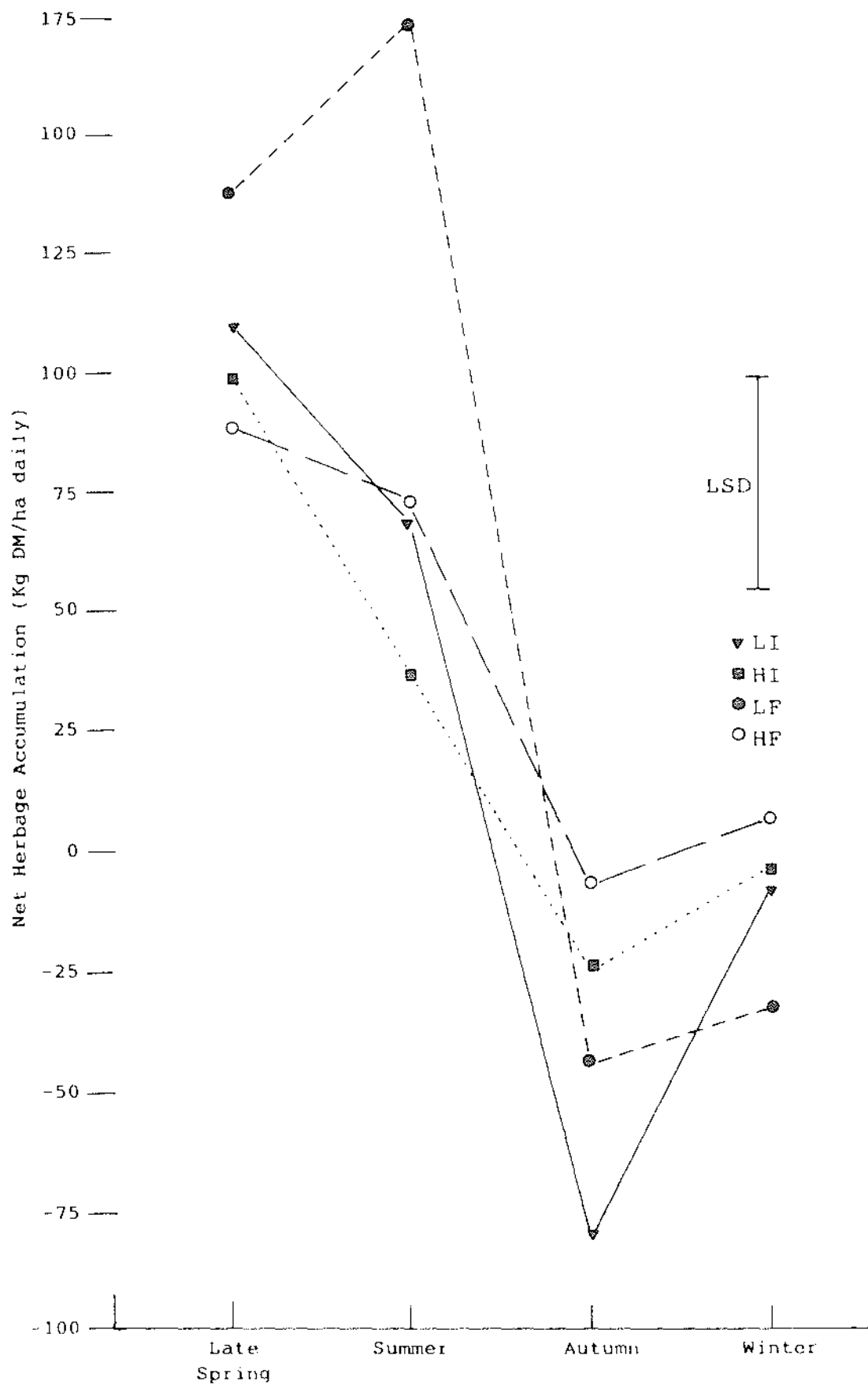


Figure 3.5 : THE EFFECT OF SEASON AND GRAZING REGIME ON NET HERBAGE ACCUMULATION, AVERAGED ACROSS ALL SWARD TYPES

(For interpretation of abbreviations see Figure 3.4)

Figure 3.6 : THE EFFECT OF SEASON AND GRAZING REGIME ON THE DRY MATTER DIGESTIBILITY OF THE PRE-GRAZING HERBAGE, AVERAGED ACROSS ALL SWARD TYPES

Where LF = lax frequent grazing
HF = hard frequent grazing
LI = lax infrequent grazing
HI = hard infrequent grazing

90 —

—

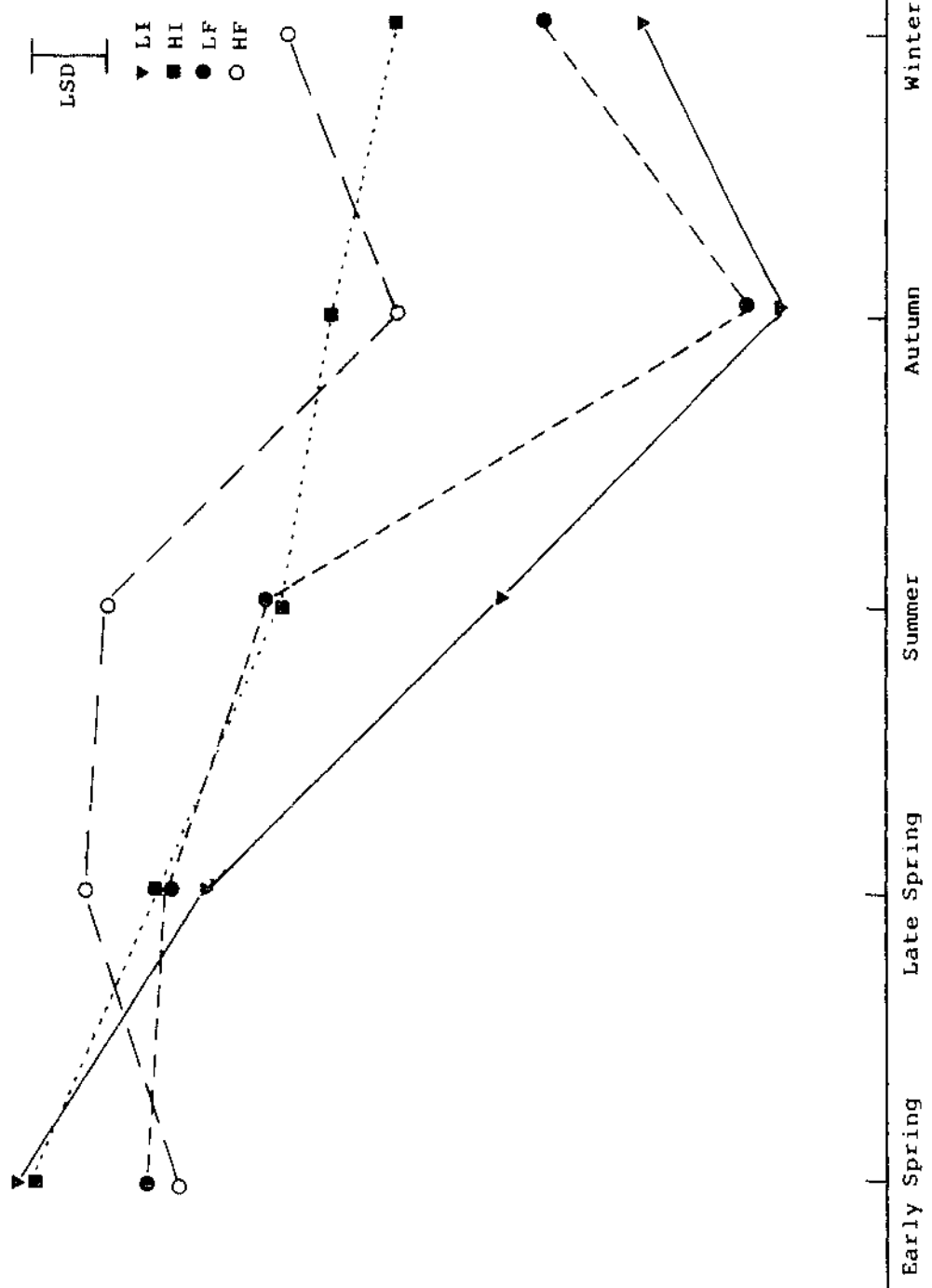
80 —

70 —

60 —

50 —

Dry Matter Digestibility (%)



LSD


- ▼ LI
- HI
- LF
- HF

Early Spring Late Spring Summer Autumn Winter

Figure 3.7 : THE EFFECT OF SEASON AND GRAZING REGIME ON THE
NITROGEN CONCENTRATION OF THE PRE-GRAZING HERBAGE,
AVERAGED ACROSS ALL SWARD TYPES

Where LF = lax frequent grazing
HF = hard frequent grazing
LI = lax infrequent grazing
HI = hard infrequent grazing

LSD



- ▼ LI
- HI
- LF
- HF

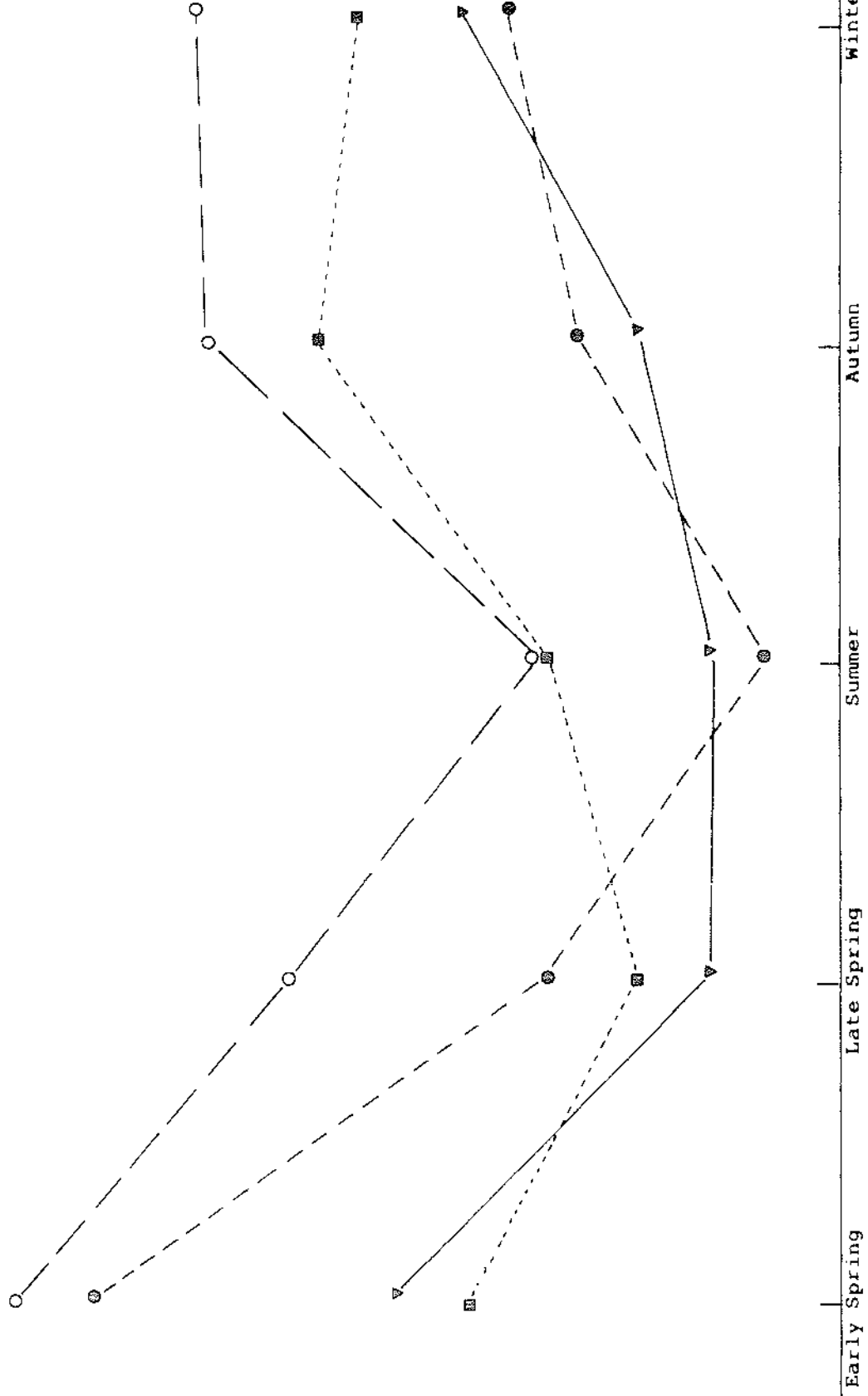
5.00 —

4.00 —

3.00 —

2.00 —

N % (dry weight)



Winter

Autumn

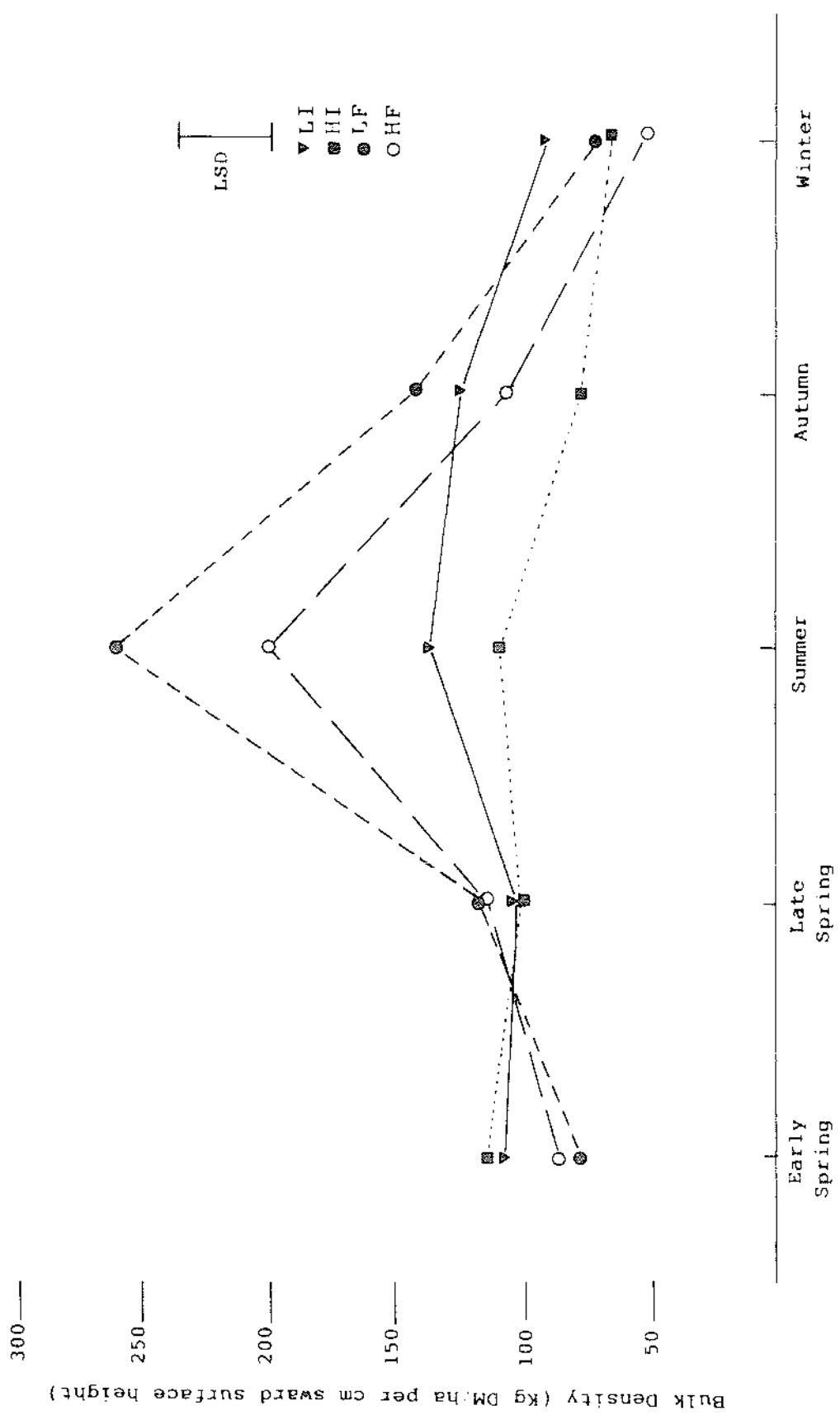
Summer

Late Spring

Early Spring

Figure 3.8 : THE EFFECT OF SEASON AND GRAZING REGIME ON THE BULK DENSITY OF THE PRE-GRAZING HERBAGE, AVERAGED ACROSS ALL SWARD TYPES

Where LF = lax frequent grazing
HF = hard frequent grazing
LI = lax infrequent grazing
HI = hard infrequent grazing



Bulk Density (kg DM/ha per cm sward surface height)

LSD

▼ LI
 ◻ HI
 ○ LF
 ◆ OLF
 ○ OHF

Early Spring Late Spring Summer Autumn Winter

Table 3.10 : THE EFFECT OF SWARD TYPE ON PRE-GRAZING HERBAGE MASS COMPONENTS (KG DM/HA) AVERAGED ACROSS ALL GRAZING REGIMES AND SEASONS

Herbage Mass Components	Sward Type			SE (LSM)	Sig. Level
	R*	N	M		
Total Dry Matter (Kg DM/ha)	2959	3066	2605	94	NS
Total Green Matter (Kg DM/ha)	2191b	2284b	2005a	78	**
Total Senescent Matter (Kg DM/ha)	768	782	600	43	NS
Total Digestible Dry Matter (Kg DDM/ha)	1995ab	2137b	1849a	64	*
Total Nitrogen (Kg N/ha)	90	86	80	3	NS

* See Table 3.4 for interpretation of abbreviations

Table 3.11 : THE EFFECT OF GRAZING REGIME ON PRE-GRAZING HERBAGE MASS COMPONENTS (KG DM/HA) AVERAGED ACROSS ALL SWARD TYPES AND SEASONS

Herbage Mass Components	Grazing Regime				SE (LSM)	Sig. Level
	LF*	HF	LI	HI		
Total Dry Matter (Kg DM/ha)	2997b	1742a	3995c	2773b	108	****
Total Green Matter (Kg DM/ha)	1994b	1456a	2835d	2356c	90	****
Total Senescent Matter (Kg DM/ha)	1003b	286a	1160b	417a	50	****
Total Digestible Dry Matter (Kg DDM/ha)	2021b	1288a	2630c	2036b	74	****
Total Nitrogen (Kg N/ha)	84b	65a	108c	84b	4	****
Total Mass of Prairie Grass (Kg DM/ha) (on M plots only)	142	154	148	200	29	NS

* See Table 3.5 for interpretation of abbreviations

Figure 3.9 : THE EFFECT OF SEASON AND SWARD TYPE ON THE PRE-GRAZING
MASSES OF TOTAL DRY, GREEN AND SENESCENT MATTER,
AVERAGED ACROSS ALL GRAZING REGIMES

Where R = Ruanui, N = Nui, and M = Matua Swards

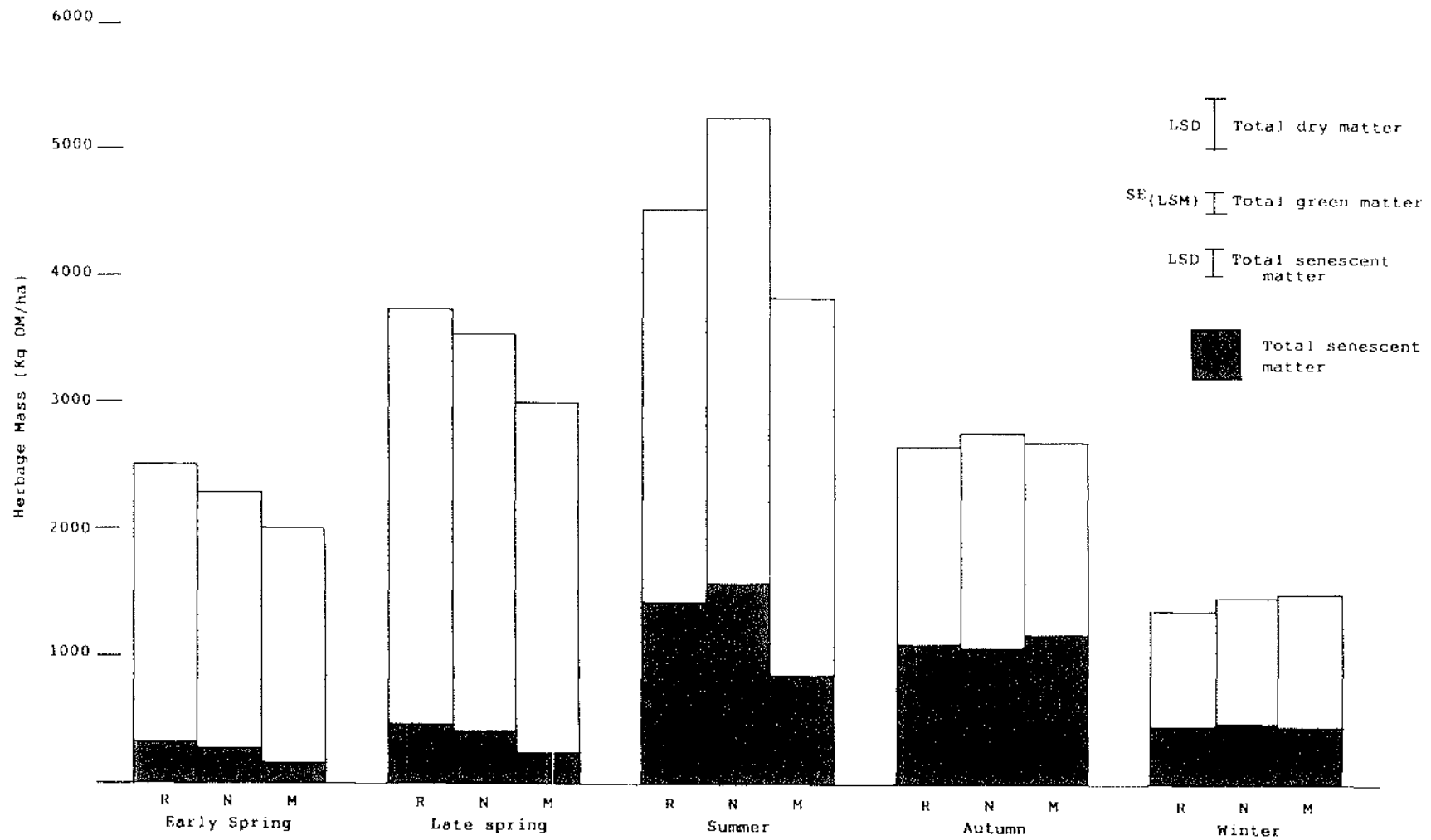


Figure 3.10 : THE EFFECT OF SEASON AND SWARD TYPE ON THE PRE-GRAZING MASS OF TOTAL DIGESTIBLE DRY MATTER, AVERAGED ACROSS ALL GRAZING REGIMES

Where R = Ruanui, N = Nui, M = Matua Swards

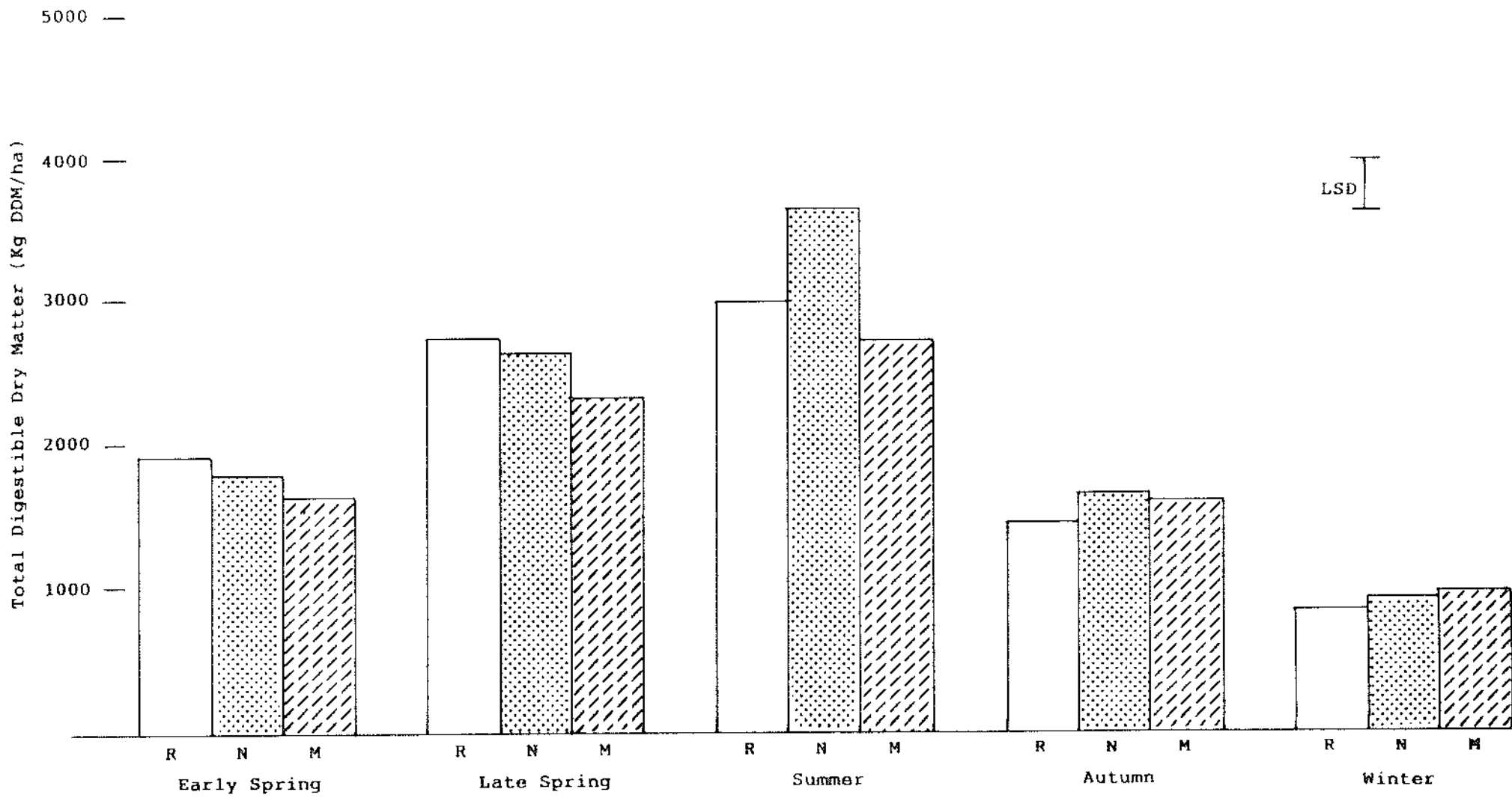


Figure 3.11 : THE EFFECT OF SEASON AND GRAZING REGIME ON THE
PRE-GRAZING MASSES OF TOTAL DRY, GREEN AND
SENESCENT MATTER, AVERAGED ACROSS ALL SWARD TYPES

Where LF = lax frequent grazing
HF = hard frequent grazing
LI = lax infrequent grazing
HI = hard infrequent grazing

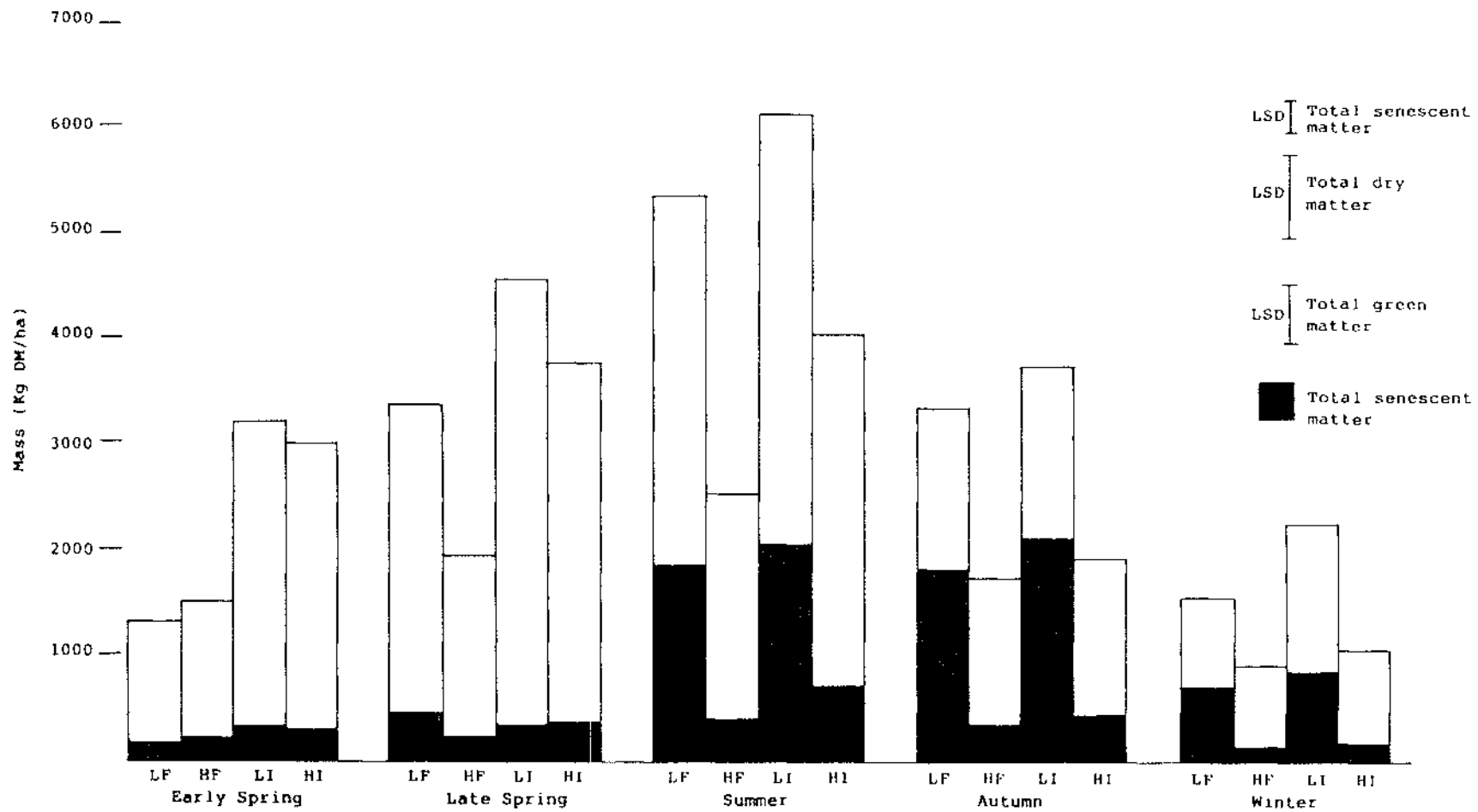


Figure 3.12 : THE EFFECT OF SEASON AND GRAZING REGIME ON THE
PRE-GRAZING MASS OF TOTAL DIGESTIBLE DRY MATTER,
AVERAGED ACROSS ALL SWARD TYPES

Where LF = lax frequent grazing
HF = hard frequent grazing
LI = lax infrequent grazing
HI = hard infrequent grazing

LSD

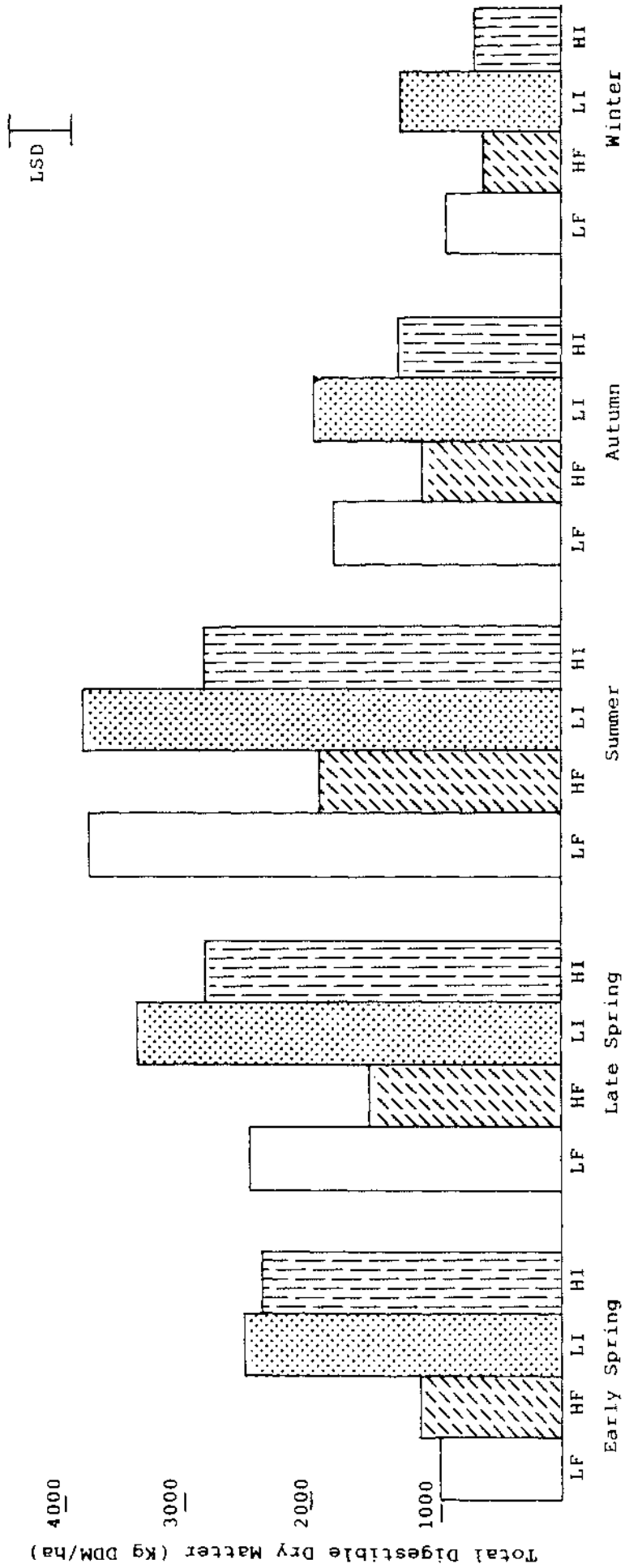


Table 3.12 : THE EFFECTS OF SEASON ON PRE-GRAZING HERBAGE MASS COMPONENTS (KG DM/HA) AVERAGED ACROSS ALL SWARD TYPES AND GRAZING REGIMES

Herbage Mass Components	Season					SE (LSM)	Sig. Level
	Early Spring	Late Spring	Summer	Autumn	Winter		
Total Dry Matter (Kg DM/ha)	2274 b	3436 d	4532 e	2701 c	1400 a	121	****
Total Green Matter (Kg DM/ha)	2012 c	3063 d	3252 d	1494 b	939 a	100	****
Total Senescent Matter (Kg DM/ha)	262 a	373 b	1280 c	1207 c	461 b	55	****
Total Digestible Dry Matter (Kg DDM/ha)	1786 b	2574 c	3125 d	1583 b	901 a	82	**
Total Nitrogen (Kg N/ha)	84 b	96 bc	115 c	83 b	49 a	4	****
Total Mass of Prairie Grass (Kg DM/ha) (on M plots only)	254 c	111 ab	87 a	189 bc	163 bc	33	*

CHAPTER 4 THE EFFECT OF DEFOLIATION INTENSITY IN SPRING ON
SWARD CHARACTERISTICS IN SPRING AND EARLY SUMMER
AND ON DAIRY COW PERFORMANCE WHEN GRAZING THOSE
SWARDS IN EARLY SUMMER

4.1 INTRODUCTION AND OBJECTIVES

The New Zealand dairy industry is based on a seasonal calving pattern with 92 % of all herds (>10 cows) calving in late winter/early spring (60th Farm Report, New Zealand Dairy Board, 1983/4). Hence peak nutrient demand by the animals coincides with the period of maximum herbage growth. In order for cows to realize their production potential during the period of peak nutrient demand, a generous herbage allowance is necessary (Bryant and Trigg, 1982).

Cows given access to a generous herbage allowance leave a high residual herbage mass (Le Du et al, 1979; Bryant, 1980; Glassey et al, 1980; Mitchell, 1985). High residual herbage masses in spring have been shown to affect subsequent sward structure and composition when grazed by sheep (Guy et al, 1981; Korte, 1981; Sheath and Boom, 1985a,b; Butler, 1986) or young beef cattle (Tallowin et al, 1986). The effects of defoliation intensity in spring on both immediate and subsequent liveweight gain for sheep (Campbell, 1969; Guy et al, 1981) and beef cattle (Tallowin et al, 1986), and milk production for dairy cows

(Bryant, 1982b; Thomson *et al*, 1984; Michell and Fulkerson, 1985; Bryant and L'Huillier, 1986) have been shown to be variable.

In spring time, a management dilemma exists on dairy farms; whether to feed cows at a generous herbage allowance during peak nutrient demand with possible consequent decreases in sward quality and in milk yield in summer, or to restrict herbage allowance at this time and risk an immediate decrease in cow performance in order to maintain future sward quality. The practice of topping (mechanical removal of excess residual herbage) after grazing in spring is often used as an alternative to restricting herbage allowance in an attempt to maintain sward quality throughout spring and summer. Topping, however, entails a waste of herbage grown.

There is no objective and sufficiently detailed information on the effects of grazing intensity by dairy cows in spring on subsequent sward and animal performance. The present study was undertaken to obtain information on sward response in spring and early summer to variations in defoliation intensity in the spring period, and to assess cow intake and production response to the resultant sward types in early summer.

The present study consisted of three grazing trials conducted during the spring/summers of 1982/83 (Trial 1 (T1)), 1983/84 (Trial 2 (T2)), and 1984/85 (Trial 3 (T3)). The general

materials, methods and statistical procedures common to all three trials are given below. The specific objectives, methods and results of each trial will be given separately and will be followed by a general discussion of all three trials.

4.2 GENERAL MATERIALS AND METHODS

4.2.1 MATERIALS

4.2.1.1 EXPERIMENTAL PADDOCKS

The same eight 0.8 ha paddocks were used in all three trials. The pastures consisted of primarily ryegrass species and white clover, with some cocksfoot, prairie grass, phalaris, and *Poa annua* present. These pastures had been sown between 1974 - 78 and were mole drained in 1979 and 1983. When not in use for this study the pastures were rotationally grazed by the milking herd and replacement stock. At no time during the three years were any of the paddocks cut for silage or hay. Any scotch thistles (*Cirsium vulgare*) or ragwort (*Senecio jacobaea*) appearing in the paddocks were manually removed.

4.2.1.2 EXPERIMENTAL ANIMALS

A different group of cows was used for each trial in this study. Twelve pairs of monozygous twins were used in T1, while in both T2 and T3, 16 and 24 high breeding index cows respectively were used. Details of age, milk fat yield and unfasted liveweight of each of the experimental cows at the commencement of the experimental period are given in the appendices of the relevant trial.

4.2.2 METHODS

Each trial was divided into three parts:

- (a) Sward Preparation - the differential grazing of swards in
 Period spring and collection of cow covariance
 data
 (October - mid November)
- (b) Experimental Period - the grazing of swards created in (a)
 in early summer by experimental animals
 and the collection of sward and animal
 performance data
 (mid November - December)
- (c) Post Experimental - (i) the monitoring of cow performance
 Period for eight weeks commencing one week

after the experimental period had ended

(December and January)

(ii) the measurement of pre-grazing sward characteristics of the experimental swards in late summer

(February/March)

4.2.2.1 EXPERIMENTAL DESIGN

In all three trials sward response to spring grazing intensity was assessed according to a completely randomized design, with paddocks as replicates (Chapter 2).

The response of cows to sward type and herbage allowance in early summer was assessed according to a balanced incomplete block design in T1 (Cochrane and Cox, 1957), and according to a completely randomized design in T2 and T3 (Chapter 2).

4.2.2.2 MANAGEMENT OF EXPERIMENTAL PADDOCKS

In early October each paddock was divided into the appropriate sections according to the specifications of that trial and each section randomly assigned to one of the defoliation intensities (Appendix 4.2). Paddocks were defoliated at

approximately 21 day intervals for 2 grazing rounds.

During the experimental period each paddock was grazed by the experimental cows for one complete round in T1 and for two complete rounds in T2 and T3.

During the post experimental period all paddocks were incorporated into the normal grazing round of the rest of the farm, with all sward types within a paddock having equal opportunity to be grazed.

4.2.2.3 MANAGEMENT OF EXPERIMENTAL ANIMALS

During the sward preparation period and throughout the post experimental period the experimental cows were grazed with the main milking herd which was offered a generous herbage allowance.

During the experimental period the experimental cows were managed in separate groups according to their designated treatments. Cows were milked at 0600 and 1500 hours, spending approximately 2.5 hours each day away from their paddocks. The cows were offered their daily herbage allowance as one 24 hr break after the afternoon milking. Each break was backfenced to prevent cows from having access to the preceding breaks. The groups were given equal access to water at all times by means of mobile water troughs.

All animals were drenched with Bloatenz (Economics Lab. N.Z. Ltd.) at the afternoon milking as a prophylactic treatment for bloat. Those cows exhibiting estrous were inseminated (T2 and T3) or served by the resident bull (T1) after the afternoon milking. Throughout the three trials the health of all cows was excellent.

4.2.2.4 MEASUREMENTS TAKEN

The following measurements were taken during the experimental period in all three trials, unless otherwise stated. The techniques used to make each measurement are described in detail in Appendix 2.2.

SWARD MEASUREMENTS

- (i) Pre-grazing herbage mass and composition - daily
- (ii) Residual herbage mass and composition - daily
- (iv) Sward surface height pre- and post grazing - daily
- (v) Tiller density (T2 only) - daily

- (vi) Tiller weights, the number of visible inflorescences and the percentage of reproductive tillers (T3 only) - daily
- (vii) Pre-grazing mass and composition of five vertical strata within the sward; post-grazing mass of five vertical strata within the sward - (T3 only) - 3 days/week
- (viii) In Vitro DMD and OMD of pre-grazing total herbage, herbage components, and of the total herbage in each of five vertical strata (the latter in T2 and T3 only) - 2 bulked samples per paddock
- (ix) In Vivo DMD and OMD of the pre-grazing total herbage (T1 and T2 only) - over 2 consecutive five day collection periods

COW MEASUREMENTS

The following cow measurements were taken during the experimental period (on an individual cow basis unless otherwise stated).

- | | | |
|-------|---|--|
| (i) | Milk, milk fat and milk protein yield | - 3 days/week |
| (ii) | Fatty acid composition of milk fat | - 2 consecutive days at the end of each round of grazing |
| (iii) | Unfasted liveweight and condition score (condition score in T1 and T2 only) | - 2 consecutive days immediately prior to the experimental period and 2 days 48 - 76 hrs after completion of the experimental period |
| (iv) | Dry matter intake using the Cr_2O_3 dilution method (T2 only) | - 2 consecutive 5 day periods during weeks 2 and 3 of Round 1 of the experimental period (on 4 cows per group only) |

- (v) Cow Behaviour - 1 day/week during Round
(T3 only) 1 of the experimental
period (on 4 cows per
group only)

4.2.2.5 STATISTICAL ANALYSES

All data were analysed as in the general statistical procedures outlined in Chapter 2. The effects of defoliation intensity in spring on sward characteristics in spring and early summer were subject to univariate analysis of variance. The effects of sward type and herbage allowance on milk, milk fat and milk protein yield were subject to repeated measurements analyses of covariance. The data collected on milk fat composition, unfasted liveweight, condition score, and cow behaviour were subject to univariate analysis of variance. The validity of analysing the cow data obtained using a balanced incomplete block design in T1, in the manner of a randomized block design, is discussed by Cochran and Cox (1957).

4.3 TRIAL 1 THE EFFECT OF GRAZING INTENSITY IN SPRING
(1982/83) ON SWARD CHARACTERISTICS IN EARLY SUMMER
AND ON COW PERFORMANCE WHEN GRAZING THOSE
SWARDS AT BOTH A GENEROUS AND RESTRICTED
DRY MATTER ALLOWANCE IN EARLY SUMMER

4.3.1 OBJECTIVES

The aim of T1 was to investigate sward response in early summer to a lenient (2000 kg DM/ha RHM) (PL) versus intense (800 kg DM/ha RHM) (PI) grazing intensity in spring, and to measure the performance of cows offered either a generous (48 kg DM/cow daily)(G) or restricted (12 kg DM/cow daily)(R) allowance of herbage DM (DA) on the resultant sward types in early summer.

4.3.2 METHODS

SWARD PREPARATION PERIOD

In each of two 21 day grazing rounds in spring, each of the eight experimental paddocks was grazed by the milking herd for approximately 8 hours. The one half of each paddock assigned the PI treatment was then grazed by yearling heifers to the appropriate RHM; the remaining half being left as grazed by the milking herd (PL treatment) (Appendix 4.2).

EXPERIMENTAL PERIOD

In early summer 12 sets of identical twins (Appendix 4.3.1) were assigned at random to the four treatment groups in the manner of a balanced incomplete block design. The cows were grazed in their appropriate groups for the 16 day experimental period.

4.3.3 RESULTS

The grazing of swards to either a low (PI) or high (PL) RHM for two grazing rounds in spring resulted in two vastly different swards types by early summer. The experimental period was shorter than anticipated (16 days actual versus 21 days planned), and this was due to an overestimation of the projected NHA on the PI swards during the sward preparation period.

4.3.3.1 EXPERIMENTAL PERIOD

PRE-GRAZING SWARD CHARACTERISTICS

The pre-grazing masses of total, green, leaf, and digestible dry matter were greater on the PL than the PI swards (Tables 4.3.1 and 4.3.2)(Figure 4.3.1) (commencing on page 133). While sward surface height was higher on the PL swards, the bulk density of the herbage was similar to that of the PI swards (Table 4.3.1).

The percentages of grass stem and senescent matter were greatest in the herbage on the PL swards, while the herbage on PI swards had greater percentages of grass leaf and weed present (Table 4.3.1). The percentage of clover in the herbage was unaffected by the previous grazing regime imposed.

The values for in vitro DMD of the total herbage and that of grass stem and grass leaf were greater for the PI swards (Table 4.3.3), with the values for grass leaf for both sward types being higher than that for grass stem or for the total herbage. Values for the in vivo DMD of the total herbage were also higher for the PI swards, although the absolute values of DMD for both sward types were lower than the in vitro values (Table 4.3.3).

HERBAGE ALLOWANCE AND DRY MATTER INTAKE

When cows were offered either a generous (48 kg DM/cow daily) or restricted (12 kg DM/cow daily) DA, those on the PI swards had access to a greater allowance of green matter (GA) and leaf matter (LA) than cows grazing the PL swards (Table 4.3.4).

At a generous DA, DMI (kg DM/cow daily) was greater on PI than PL swards (21.3 vs 16.1 kg DM/cow daily), although the DMIs measured for both groups were unrealistically high. At a restricted DA intakes were similar for cows grazing the PL and PI swards (Table 4.3.4). The effect of a restriction in DA was to reduce DMI on both the PL and PI swards.

At a generous DA, cows on the PI swards had greater percentages of grass leaf and smaller percentages of grass stem and clover in their diet than cows on the PL swards (Table 4.3.4). A similar trend existed at a restricted DA, with the exception that the percentage of clover in the diet was similar for both sward types.

On PI swards the effect of a restriction in DA was to decrease the percentage of grass leaf and increase the percentage of clover in the diet. For cows grazing the PL swards, a restriction in DA was associated with an increase in the percentage of senescent matter in the diet.

The diets of all 4 groups of cows contained a greater percentage of grass leaf and a smaller percentage of senescent matter compared to that which was on offer in their respective swards (Appendix 4.3.2). However, the percentage of grass stem in the diet was not different from that in the herbage on offer for all 4 groups. The percentage of clover in the diet was less than the percentage of clover in the herbage on offer for the PI-G group of cows only, while the remaining groups had similar percentages to that which was in the herbage on offer.

POST-GRAZING SWARD CHARACTERISTICS

A restriction in DA resulted in a lower RHM and residual herbage height for both sward types, with the RHM and residual herbage height being greater on the PL swards than the PI swards at both DAs (Table 4.3.5).

The values for in vitro DMD of the RHM and that of the remaining grass leaf and stem were higher for the PI than PL swards at both DAs (Table 4.3.5). For both PI and PL swards, the DMD of the RHM and the remaining leaf was greater on swards where a generous DA was given. The effect of a restriction in DA was a reduced value for the DMD of the residual grass stem for the PI swards only. The DMD of the residual grass stem on the PL swards was similar for both the restricted and generous DAs.

MILK, MILK FAT AND MILK PROTEIN YIELD

At both a restricted and generous DA, cows grazing the PI swards produced more milk, milk fat and milk protein than cows on the PL swards (Table 4.3.6) (Figures 4.3.2, 4.3.3, and 4.3.4 respectively).

A restriction in DA resulted in a lower milk, milk fat and milk protein yield on both sward types, however, the lower milk fat yield on the PL swards was not significant.

MILK FAT COMPOSITION

The effect of a restriction in DA for cows grazing both PI and PL swards was a decrease in the percentage of short chain fatty acids and an increase in the percentage of long chain fatty acids in the milk fat (Table 4.3.7).

At both a generous and a restricted DA, the milk fat of cows grazing the PI swards contained a greater percentage of short chain fatty acids and a smaller percentage of long chain fatty acids than that of cows grazing the PL swards, although the percentage of long chain fatty acids in the milk fat of cows offered a generous DA on PI swards was not significantly different from those offered a generous DA on PL swards.

UNFASTED LIVELWEIGHT AND CONDITION SCORE

Both unfasted liveweight and condition score at the end of the experimental period, as well as changes in liveweight and condition score over the 16 day experimental period, were unaffected by grazing treatment (Table 4.3.8).

4.3.3.2 POST EXPERIMENTAL PERIOD

MILK, MILK FAT AND MILK PROTEIN YIELD

Milk, milk fat, and milk protein yield was similar for all cows by the first week of the post experimental period (Table 4.3.9)(Figures 4.3.2, 4.3.3, 4.3.4), and remained similar throughout the eight week post experimental period.

PRE-GRAZING SWARD CHARACTERISTICS - LATE SUMMER

By late summer there were no visible differences between the swards that had been PI-G and PI-R grazed in the spring/early summer period, and thus these swards were sampled as one in the late summer measurement period. The PL-G and the PL-R swards were sampled separately.

Approximately 10 weeks after the experimental period, there were still some differences apparent between the PI and PL swards (Table 4.3.10) (Figure 4.3.1). The pre-grazing total dry and digestible dry matter mass and the percentages of senescent matter were greater on the PL-G swards than on the PL-R and PI-G/R swards (Figure 4.3.1), while the percentage of clover was greatest on the PI-G/R swards.

The percentages of grass stem and leaf and weed were similar for all sward types, as were the values for the in vitro DMD of the total herbage, the grass stem, and the grass leaf.

Table 4.3.1 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON THE TOTAL PRE-GRAZING HERBAGE MASS (KG DM/HA) AND COMPOSITION (% DRY WEIGHT), AND ON SWARD SURFACE HEIGHT (CM) AND HERBAGE BULK DENSITY (KG DM/HA PER CM OF SWARD SURFACE HEIGHT) IN THE EXPERIMENTAL PERIOD (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PL*	PI		
Total Herbage Mass (Kg DM/ha)	5306	2480	282	****
Grass Stem (%)	40.1	23.5	2.6	***
Grass Leaf	29.5	46.2	2.1	***
Clover	11.9	16.7	1.8	NS
Senescent Matter	17.6	9.8	1.3	***
Weed	1.2	3.8	0.5	**
Sward Surface Height (cm)	41	22	2	****
Herbage Bulk Density (Kg DM/ha per cm of sward surface height)	131	113	7	NS

* In this table and in the remaining tables in this section

PL = swards grazed laxly in spring (2000 Kg DM/ha RHM)

PI = swards grazed intensely in spring (800 Kg DM/ha RHM)

Table 4.3.2 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON THE PRE-GRAZING MASS OF TOTAL GREEN AND LEAF MATTER (KG DM/HA) AND DIGESTIBLE DRY MATTER (DDM) (KG DDM/HA) IN THE EXPERIMENTAL PERIOD (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PL*	PI		
Total Green Matter (Kg DM/ha)	4386	2236	269	***
Total Leaf Matter (Kg DM/ha)	1848	1339	106	**
Total Digestible Dry Matter (Kg DDM/ha)	3517	1846	210	***

* For interpretation of abbreviations see Table 4.3.1

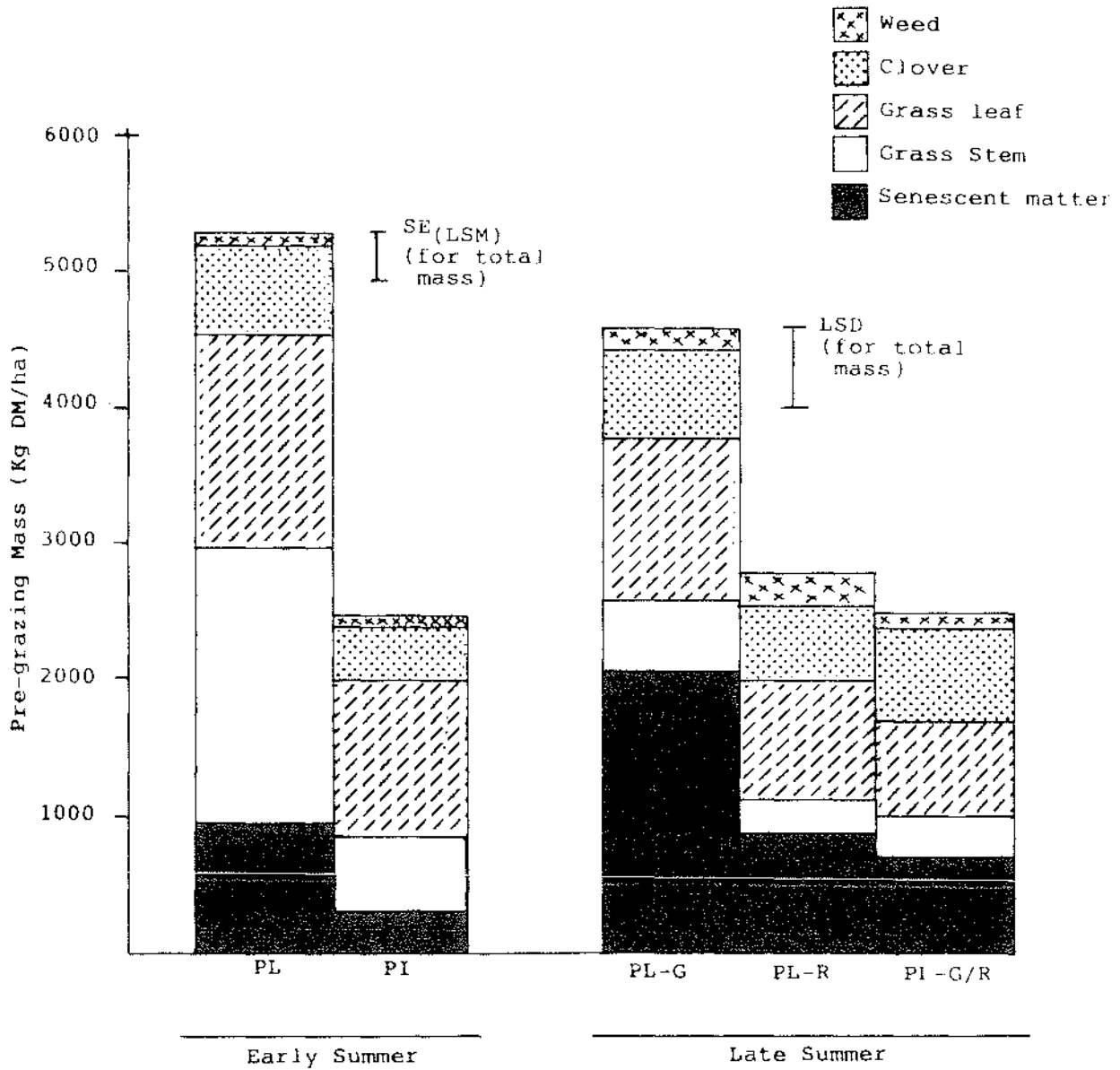


Figure 4.3.1 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON THE PRE-GRAZING MASS OF WEED, CLOVER, GRASS LEAF, GRASS STEM AND SENESCENT MATTER IN EARLY AND LATE SUMMER

(See Table 4.3.4 for interpretation of abbreviations)

Table 4.3.3 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON THE
 (a) IN VITRO DRY MATTER DIGESTIBILITY (DMD) (%) OF
 THE PRE-GRAZING TOTAL HERBAGE, GRASS LEAF, AND GRASS
 STEM AND (b) IN VIVO DRY AND ORGANIC MATTER
 DIGESTIBILITY (DMD AND OMD RESPECTIVELY) (%) OF THE
 PRE-GRAZING TOTAL HERBAGE IN THE EXPERIMENTAL PERIOD
 (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level		
	PL*	PI				
(a) <u>In vitro</u> DMD (%)						
Total Herbage	67.2	74.1	0.5	****		
Grass Stem	75.9	79.5	0.5	****		
Grass Leaf	65.5	73.1	0.7	****		
(b) <u>In vivo</u> DMD and OMD (%)						
Total Herbage	DMD	\bar{x}	64.8**	73.3	Not statistically analysed	
		(SD)	(1.0)	(0.8)		
"	"	OMD	\bar{x}	69.1	79.4	Not statistically analysed
			(SD)	(1.1)	(0.6)	

* For interpretation of abbreviations see Table 4.3.1

** In vivo DMD and OMD are raw means and their standard deviations

Table 4.3.4 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE (DA) ON THE DAILY ALLOWANCE OF GREEN AND LEAF MATTER (GA AND LA RESPECTIVELY) (KG DM/COW DAILY), ON DRY MATTER INTAKE (DMI) (KG DM/COW DAILY), AND ON THE COMPOSITION OF THE DIET (% DRY WEIGHT) IN THE EXPERIMENTAL PERIOD (EARLY SUMMER)

	Sward Type and DA				SE (LSM)	Sig. Level
	PL-G*	PL-R	PI-G	PI-R		
DA (Kg DM/cow daily)	47.5 b**	12.3 a	48.1 b	12.1 a	0.3	****
GA "	39.8 c	9.9 a	43.9 d	11.1 b	0.3	****
LA "	17.4 c	4.3 a	26.5 d	6.7 b	0.5	****
DMI "	16.1 b	7.9 a	21.3 c	7.1 a	0.7	****
Composition of Diet (% dry weight)						
Grass Leaf	41.5 a	35.6 a	69.1 c	59.1 b	3.3	****
Grass Stem	39.6 b	43.3 b	20.0 a	22.7 a	3.1	****
Clover	14.2 b	12.1 b	5.9 a	13.6 b	2.2	*
Senescent Matter	4.7 a	9.0 b	5.1 a	4.6 a	1.2	*

* PL-G : swards that had been grazed laxly in spring and were grazed by cows at a generous dry matter allowance in early summer

PL-R : swards that had been grazed laxly in spring and were grazed by cows at a restricted dry matter allowance in early summer

PI-G : swards that had been grazed intensely in spring and were grazed by cows at a generous dry matter allowance in early summer

PI-R : swards that had been grazed intensely in spring and were grazed by cows at a restricted dry matter allowance in early summer

** In this table and in the remaining tables in this section means within rows followed by different letters are significantly different ($p < 0.05$) (orthogonal contrasts or LSD) for the following comparisons only:

- (1) PL-G vs PL-R
- (2) PL-G vs PI-G
- (3) PI-G vs PI-R
- (4) PI-R vs PL-R

Table 4.3.5 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE (DA) ON THE RESIDUAL HERBAGE MASS (KG DM/HA), RESIDUAL HERBAGE HEIGHT (CM) AND IN VITRO DRY MATTER DIGESTIBILITY OF THE RESIDUAL HERBAGE (%) IN THE EXPERIMENTAL PERIOD (EARLY SUMMER)

	Sward Type and DA				SE (LSM)	Sig. Level
	PL-G*	PL-R	PI-G	PI-R		
Residual Herbage Mass (Kg DM/ha)	3942 d	1863 b	1914 c	1098 a	147	****
Residual Herbage Height (cm)	26 d	11 b	18 c	7 a	1	****
Dry Matter Digestibility (%)						
Total Residual Herbage	62.9 c	56.8 a	67.0 d	60.6 b	1.6	***
Grass Leaf	73.3 c	68.4 a	75.5 d	71.4 b	0.6	****
Grass Stem	62.4 a	59.6 a	69.0 c	65.4 b	1.2	****

* For interpretation of abbreviations see Table 4.3.4

Table 4.3.6 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE (DA) ON MILK, MILK FAT, AND MILK PROTEIN YIELD (KG/COW DAILY) IN WEEK 2 OF THE EXPERIMENTAL PERIOD (EARLY SUMMER)

	Sward Type and DA				SE (LSM)	Sig. Level
	PL-G*	PL-R	PI-G	PI-R		
Kg/cow daily)						
Milk yield	13.6 b	10.5 a	15.5 c	13.1 b	0.6	****
Milk fat yield	0.63 a	0.54 a	0.79 c	0.68 b	0.04	***
Milk protein yield	0.53 b	0.41 a	0.64 c	0.50 b	0.03	****

* For interpretation of abbreviations see Table 4.3.4.

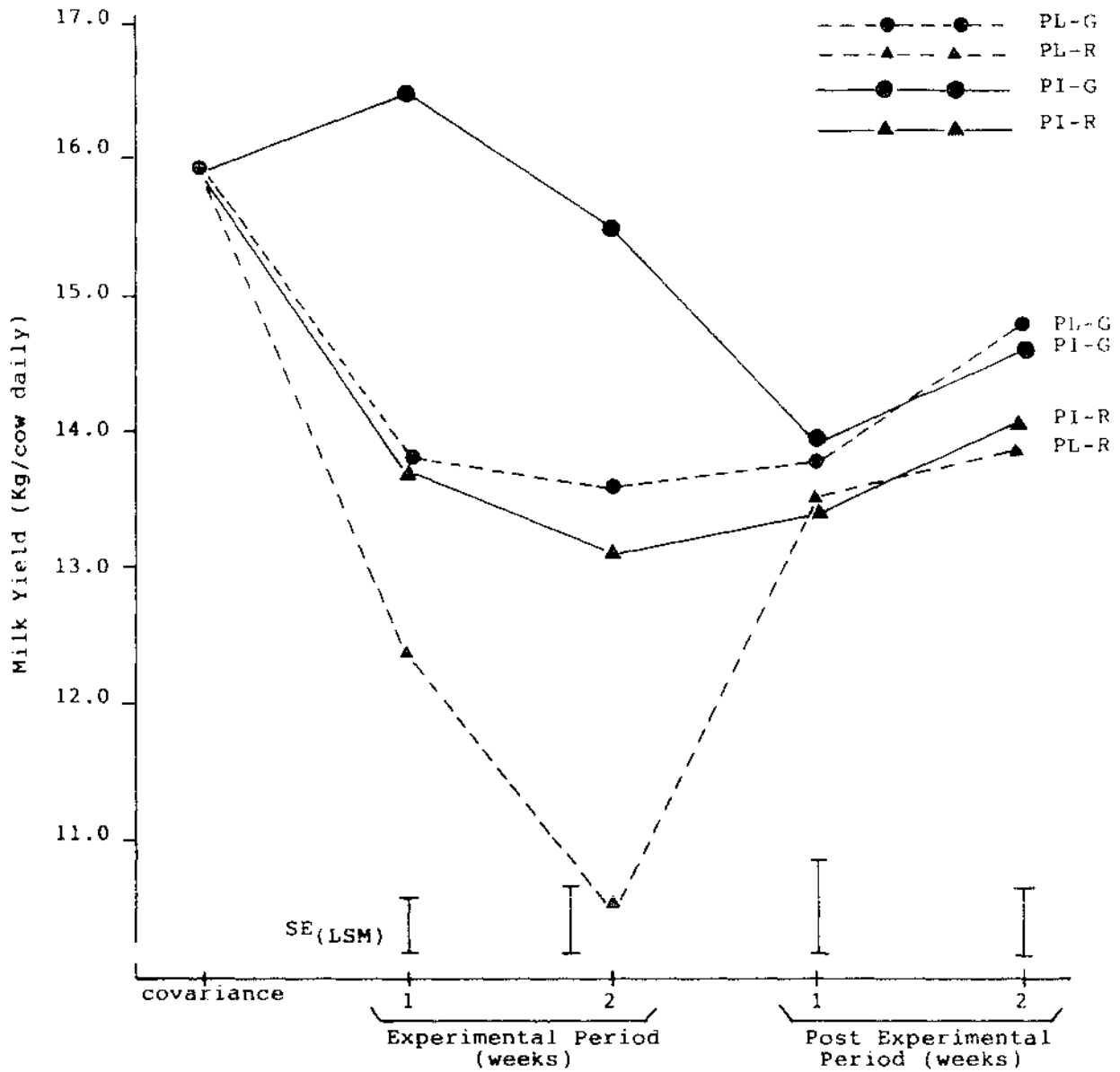


Figure 4.3.2 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE ON MILK YIELD IN THE EXPERIMENTAL AND POST EXPERIMENTAL PERIODS

(See Table 4.3.4 for interpretation of abbreviations)

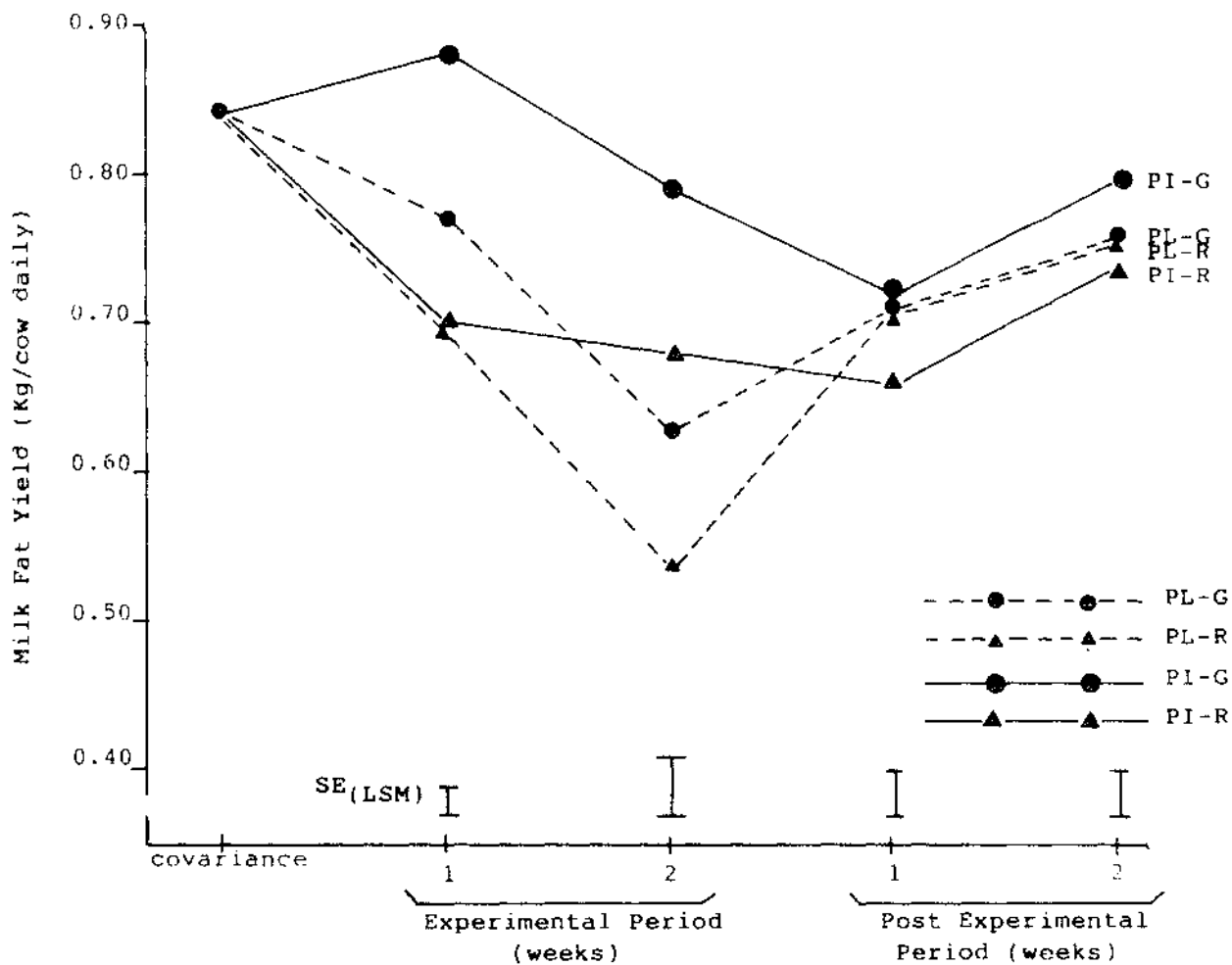


Figure 4.3.3 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE ON MILK FAT YIELD IN THE EXPERIMENTAL AND POST EXPERIMENTAL PERIODS

(See Table 4.3.4 for interpretation of abbreviations)

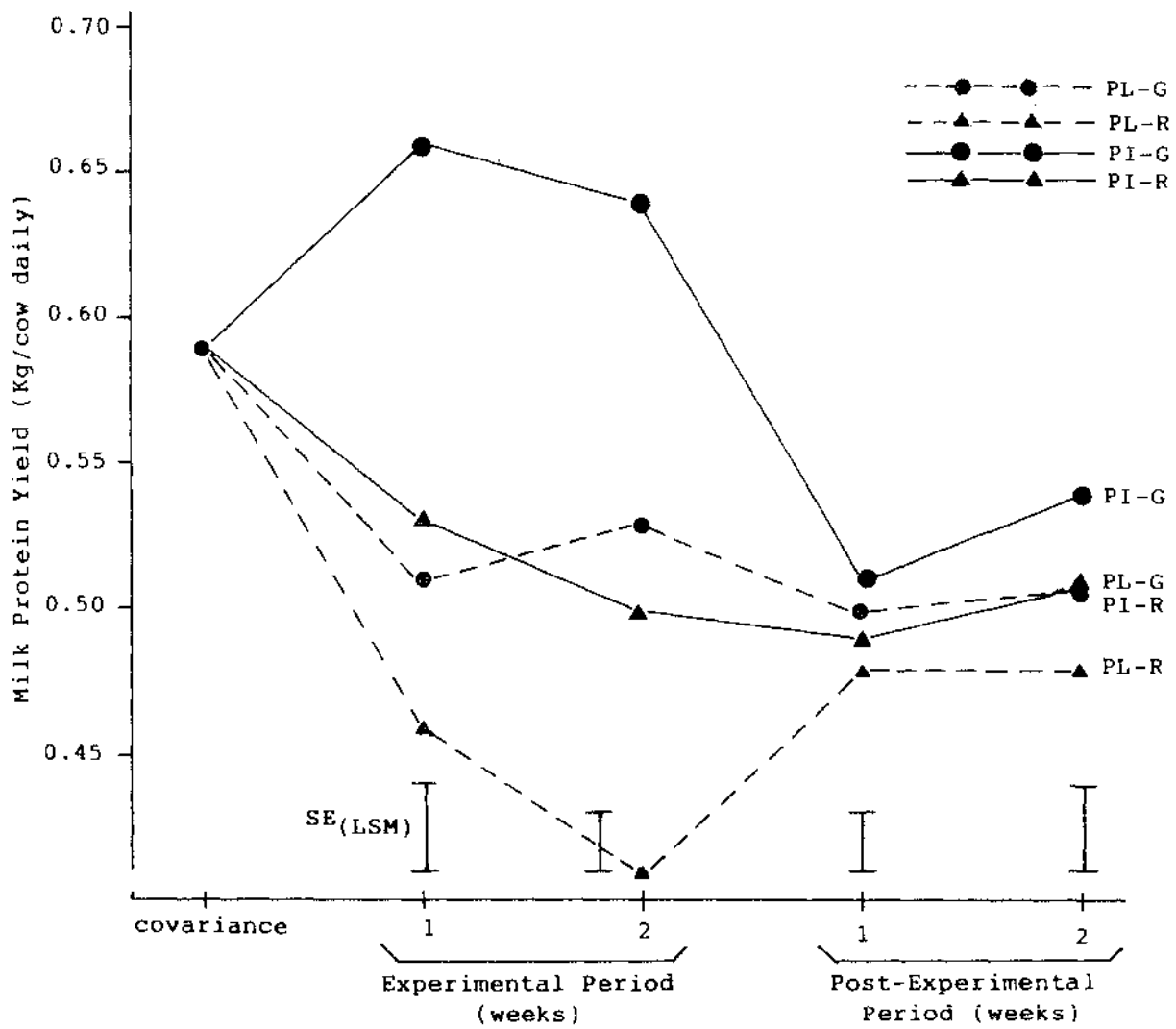


Figure 4.3.4 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE ON MILK PROTEIN YIELD IN THE EXPERIMENTAL AND POST EXPERIMENTAL PERIODS

(See Table 4.3.4 for interpretation of abbreviations)

Table 4.3.7 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE (DA) ON THE COMPOSITION OF MILK FAT (% WEIGHT OF SHORT AND LONG CHAIN FATTY ACIDS) AT THE END OF WEEK 2 OF THE EXPERIMENTAL PERIOD (EARLY SUMMER)

	Sward Type and DA				SE (LSM)	Sig. Level
	PL-G*	PL-R	PI-G	PI-R		
Fatty Acids						
Short Chain (C6:0 - C14:1)	28.12 b	25.88 a	29.73 c	27.87 b	0.43	***
Long Chain (C18:0, C18:1)	27.69 a	31.12 c	27.57 a	29.34 b	0.28	****

* For interpretation of abbreviations see Table 4.3.4.

Table 4.3.8 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE (DA) ON UNFASTED LIVWEIGHT (KG/COW) AND CONDITION SCORE AT THE END OF THE EXPERIMENTAL PERIOD AND ON CHANGES IN UNFASTED LIVWEIGHT (KG/COW OVER 16 DAYS) OVER THE EXPERIMENTAL PERIOD (EARLY SUMMER)

	Sward Type and DA				SE (LSM)	Sig. Level
	PL-G*	PL-R	PI-G	PI-R		
Unfasted Liveweight (Kg/cow)	374	370	377	372	5	NS
Condition score	4.6	4.6	4.7	4.6	0.1	NS
Change in Unfasted Liveweight (Kg/cow over 16 days)	2	-2	4	-1	4	NS
Change in Condition Score (over 16 days)	0	0	0.1	0.1	0.1	NS

* For interpretation of abbreviations see Table 4.3.4.

Table 4.3.9 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE (DA) IN THE EXPERIMENTAL PERIOD (EARLY SUMMER) ON MILK, MILK FAT, AND MILK PROTEIN YIELD IN THE FIRST WEEK OF THE POST EXPERIMENTAL PERIOD (EARLY SUMMER) (KG/COW DAILY)

	Sward Type and DA				SE (LSM)	Sig. Level
	PL-G*	PL-R	PI-G	PI-R		
Milk Yield (Kg/cow daily)	13.8	13.5	13.9	13.4	0.4	NS
Milk Fat Yield (Kg/cow daily)	0.71	0.71	0.72	0.66	0.03	NS
Milk Protein Yield (Kg/cow daily)	0.50	0.48	0.51	0.49	0.02	NS

* For interpretation of abbreviations see Table 4.3.4

Table 4.3.10 : THE EFFECT OF GRAZING INTENSITY IN SPRING AND OF DAILY DRY MATTER ALLOWANCE (DA) IN THE EXPERIMENTAL PERIOD ON THE SWARD CHARACTERISTICS OF PRE-GRAZING HERBAGE IN THE POST EXPERIMENTAL PERIOD (FEBRUARY/MARCH)

	Sward Type and DA			SE (LSM)	Sig. Level
	PL-G*	PL-R	PI-G/R**		
Herbage Mass (Kg DM/ha)					
Total Dry Matter	4576 a	2799 b	2566 b	311	***
Total Green Matter	2493	1917	1850	234	NS
Total Leaf Matter	1815	1350	1484	144	NS
Total Digestible Dry Matter (Kg DDM/ha)	2748 b	1783 a	1310 a	226	****
Herbage Composition (% dry weight)					
Grass Stem	11.5	13.6	11.5	2.8	NS
Grass Leaf	26.6	29.7	28.3	2.8	NS
Clover	13.7 a	19.6 a	29.0 b	2.7	**
Senescent Matter	45.5 a	31.2 b	28.5 b	3.1	***
Weed	2.8	6.0	2.7	2.2	NS
Dry Matter Digestibility (<u>in vitro</u>) (%)					
Total Herbage	60.3	63.9	63.5	1.2	NS
Grass Stem	68.6	69.4	69.5	1.7	NS
Grass Leaf	72.0	73.2	71.7	1.7	NS

* For interpretation of abbreviation see Table 4.3.4

** PI-G/R = the measurement of PI-G and PI-R swards were combined in late summer; see section 4.3.3.2

4.4 Trial 2 THE EFFECT OF DEFOLIATION INTENSITY IN SPRING
(1983/84) ON SWARD CHARACTERISTICS IN EARLY SUMMER, AND
ON THE PERFORMANCE OF COWS GRAZING THOSE SWARDS
AT A GENEROUS DRY MATTER ALLOWANCE IN EARLY SUMMER

4.4.1 OBJECTIVES

The objectives of T2 were to assess sward response, in early summer, to topping (1500 kg DM/ha residual) (PT) versus not topping (2000 kg DM/ha residual) (PU) swards that were grazed leniently during spring; and to evaluate the performance of cows grazing the resultant sward types at a generous DA (44 kg DM/cow daily) in early summer.

4.4.2 METHODS

SWARD PREPARATION

In each of two 21 day grazing rounds in spring, each of the eight experimental paddocks was grazed by the milking herd for approximately 8 hours. Within 24 hours after grazing, two thirds of each paddock was topped to approximately 6-7 cm residual height using a rotary mower (PT treatment). The remaining one third of each paddock was left as grazed by the milkers (PU treatment) (Appendix 4.2).

EXPERIMENTAL PERIOD

In early summer 16 high breeding index cows (Appendix 4.4.1) were assigned at random to one or the other of the two sward types, and grazed on their assigned swards at a generous DA for two grazing rounds (35 days total).

4.4.3 RESULTS

4.4.3.1 EXPERIMENTAL PERIOD

PRE-GRAZING SWARD CHARACTERISTICS - Round 1

Topping swards for 2 grazing rounds in spring resulted in those swards having a lower mass of total, green, and digestible, dry matter in early summer than swards which were untopped during this time period (Tables 4.4.1 and 4.4.2) (Figure 4.4.1) (commencing on page 151). The mass of leaf was, however, similar on both swards.

Sward surface height of the PT swards was approximately 10 cm shorter than that of the PU swards, while PT swards had a greater herbage bulk density (Table 4.4.1).

The density of grass tillers was greatest on the PT swards, being approximately 1.3 times that on PU swards (7707 vs 5983 tillers/m² respectively)(Table 4.4.1).

The percentage of grass stem was highest on PU swards, while the percentage of grass leaf was greatest on PT swards (Table 4.4.1). There was, however, no significant difference in the percentages of senescent matter, clover or weed between the two sward types.

The total herbage in PT swards had greater values for in vitro DMD and OMD than the PU swards, although this difference was not significant for OMD (Table 4.4.3a). Grass stem on PT swards had greater values for DMD and OMD than that on PU swards although the difference was not significant for DMD. The values for DMD and OMD for grass leaf, clover, and senescent matter were similar for both sward types.

The values for in vitro DMD, OMD, and N % of the total herbage in each of five horizontal strata were greater on PT than PU swards (Table 4.4.4). For both the PT and PU swards, the quality (DMD, OMD and N %) of herbage within each stratum increased from the sward base (0-4 cm) upwards, and then decreased again towards the top of the sward. The greatest values for DMD, OMD, and N % occurred in the 12-20 cm stratum of the sward, while the sward bases had the lowest values. Because of the small number of samples taken in Round 1 the interaction between sward

type and stratum could not be tested.

The in vivo DMD of the total herbage was higher on the PT swards, although the differences between the sward types for average OMD values were small (Table 4.4.3b). Although this trend was also noted when total herbage samples were subject to in vitro analysis (Table 4.4.3a), the absolute values for both DMD and OMD were lower than those obtained with the in vivo method.

PRE-GRAZING SWARD CHARACTERISTICS - ROUND 2

After being grazed to a similar RHM in early December (Table 4.4.5), the NHA over the following 2-3 weeks was similar for both PT and PU swards (Table 4.4.7). The structure, composition, and quality of the pre-grazing herbage of the two sward types were similar after this 2-3 week period of regrowth (Tables 4.4.6 - 4.4.9) (Figure 4.4.1).

The total dry, green, and digestible herbage masses on the PU swards decreased to that present on the PT swards, which were unchanged between the two grazing rounds. Although the total leaf mass on the PT swards was unchanged between the two rounds, that on the PU swards actually increased between the two rounds.

The similar tiller densities for both sward types was due to a large decrease in tiller density on PT swards and a smaller increase in tiller density on the PU swards, compared to the

previous round.

HERBAGE ALLOWANCE AND DRY MATTER INTAKE

During the first grazing round the cows grazing the PT swards were inadvertently offered a greater DA than those on the PU swards (44 vs 39 kg DM/cow daily respectively)(Table 4.4.10). The resultant GA and LA was also greater for those grazing the PT swards.

When DMIs were measured by the difference method, the cows grazing the PU swards had a greater DMI than cows on the PT swards (Table 4.4.10). However, when DMIs were estimated by the Cr_2O_3 dilution method there was no significant difference in DMI between cows grazing the PU or the PT swards (Table 4.4.10).

There was no difference between the two groups of cows in the percentages of grass stem, grass leaf, and clover in the diet (Table 4.4.10). Both groups did, however, have a greater percentage of grass leaf and smaller percentage of senescent matter in their diet than that which was on offer in their respective swards (Appendix 4.4.2).

In the second round of grazing, the target DA was successfully achieved in both sward types (Table 4.4.11). In this grazing round, a common DA also resulted in a common GA and LA, since pre-grazing sward characteristics of the PU and PT swards

were similar (Tables 4.4.6 - 4.4.9).

The DMIs of the cows were only measured by difference in the second round, and were similar for both groups (Table 4.4.11). No measurements of composition of the diet were made in the second round of grazing.

POST-GRAZING SWARD CHARACTERISTICS

The RHM and the in vitro DMD and OMD of the residual herbage was similar for both PT and PU swards in Rounds 1 and 2 (Tables 4.4.5 and 4.4.12 respectively). In both swards, the surface height of the residual herbage was always greater on the PI swards.

MILK, MILK FAT AND MILK PROTEIN YIELD

In both Rounds 1 and 2 those cows grazing the PT swards produced more milk, milk fat and milk protein than those on the PU swards, although the difference for milk fat was not significant (Table 4.4.13) (Figures 4.4.2 - 4.4.4).

MILK FAT COMPOSITION, UNFASTED LIVWEIGHT, AND CONDITION SCORE

Data for milk fat composition (Table 4.4.14), unfasted liveweight and condition score at the end of the experimental period, and changes in both unfasted liveweight and condition

score over the experimental period (Table 4.4.15) showed no significant differences between treatment groups.

4.4.3.2 POST EXPERIMENTAL PERIOD

MILK, MILK FAT, AND MILK PROTEIN YIELD

By the first week of the post experimental period milk, milk fat, and milk protein yield were similar for both groups of cows (Table 4.4.16) (Figures 4.4.2 - 4.4.4) and remained similar for the 8 week post experimental period. While milk and milk fat yield increased when the animals were returned to the main herd, milk protein yield decreased.

PRE-GRAZING SWARD CHARACTERISTICS - LATE SUMMER

The NHA and the pre-grazing sward structure and composition of the two sward types was measured in late summer (February/March) (Table 4.4.17). Of all the sward characteristics measured, sward surface height was the only characteristic that exhibited a difference between PU and PT swards, with herbage on PU swards being taller than on PT swards.

Table 4.4.1 : THE EFFECT OF DEFOLIATION INTENSITY IN SPRING ON THE TOTAL PRE-GRAZING HERBAGE MASS (KG DM/HA) AND COMPOSITION (% DRY WEIGHT), AND ON SWARD SURFACE HEIGHT (CM), HERBAGE BULK DENSITY (KG DM/HA PER CM SWARD SURFACE HEIGHT) AND TILLER DENSITY (NO. TILLERS/M²) IN THE EXPERIMENTAL PERIOD - ROUND 1 (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
Total Herbage Mass (Kg DM/ha)	4341	3493	74	****
Grass Stem (%)	37.4	27.4	1.9	***
Grass Leaf	28.7	33.1	1.2	***
Clover	17.2	19.0	2.0	NS
Senescent Matter	14.8	17.4	1.1	NS
Weed	2.3	3.3	0.9	NS
Sward Height (cm)	39	27	1	****
Herbage Bulk Density (Kg DM/ha per cm of sward surface height)	114	133	5	*
Tiller Density (no./m ²)	5983	7707	190	***

* In this table and in the remaining tables in this section

PU = swards grazed laxly in spring (2000 Kg DM/ha RHM)
PT = swards topped following lax grazing in spring (1500 Kg DM/ha RHM)

Table 4.4.2 : THE EFFECT OF DEFOLIATION INTENSITY IN SPRING ON THE PRE-GRAZING MASS OF TOTAL GREEN AND LEAF MATTER (KG DM/HA) AND DIGESTIBLE DRY MATTER (DDM) (KG DDM/HA) IN THE EXPERIMENTAL PERIOD - ROUND 1 (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
Total Green Matter (Kg DM/ha)	3709	2904	69	****
Total Leaf Matter (Kg DM/ha)	1599	1474	57	NS
Total Digestible Dry Matter (Kg DDM/ha)	2787	2329	32	****

* For interpretation of abbreviations see Table 4.4.1

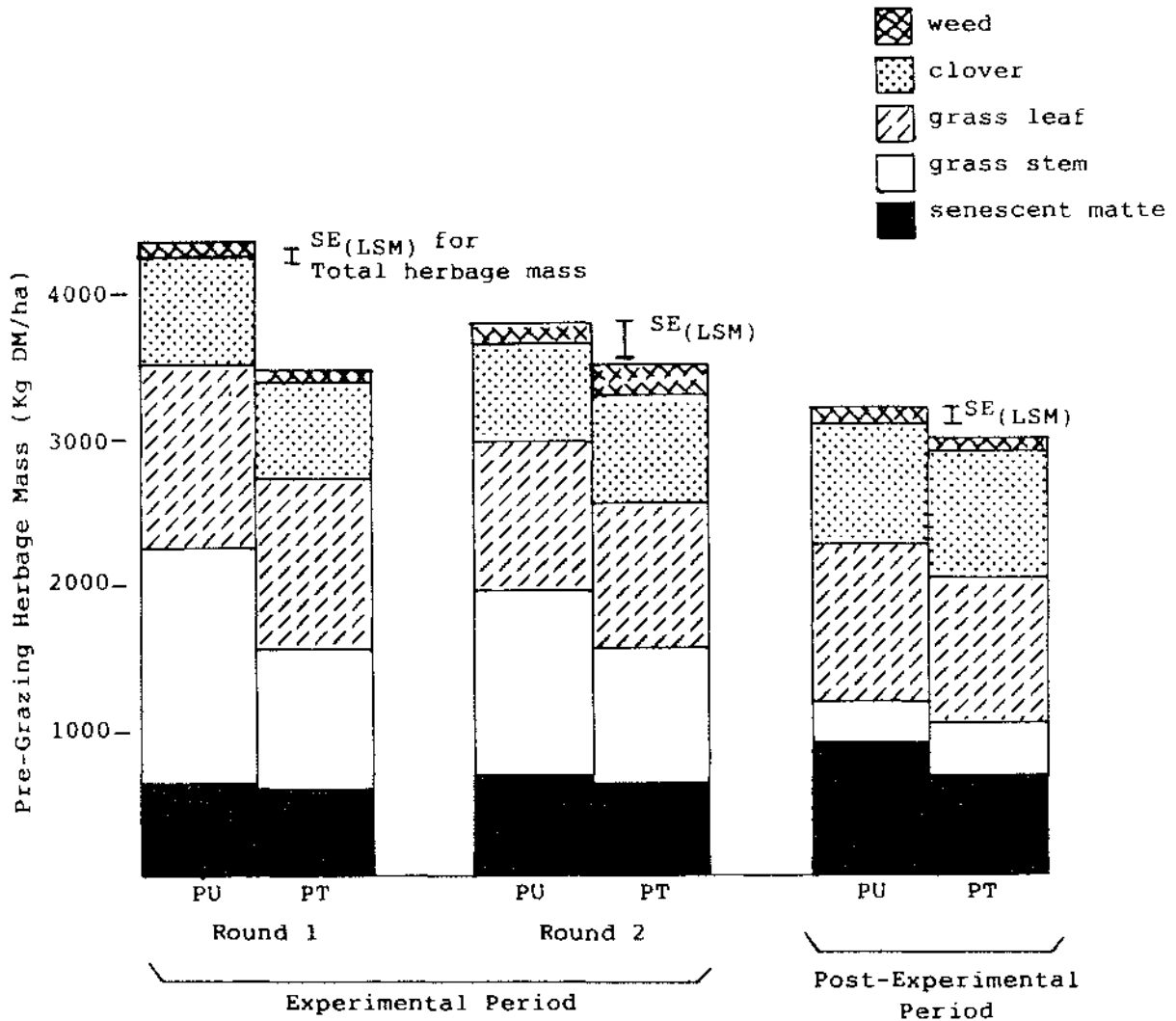


Figure 4.4.1 : THE EFFECT OF DEFOLIATION INTENSITY IN SPRING ON THE PRE-GRAZING MASS OF WEED, CLOVER, GRASS LEAF, GRASS STEM AND SENESCENT MATTER IN ROUNDS 1 AND 2 OF THE EXPERIMENTAL PERIOD (EARLY SUMMER) AND IN THE POST EXPERIMENTAL PERIOD (LATE SUMMER)

Where PU = cows grazing swards that had been leniently grazed in spring
 PT = cows grazing swards that had been topped in spring

Table 4.4.3 : THE EFFECT OF DEFOLIATION INTENSITY IN SPRING ON THE
 (a) IN VITRO DRY AND ORGANIC MATTER DIGESTIBILITY (DMD
 AND OMD RESPECTIVELY) (%) OF THE PRE-GRAZING TOTAL
 HERBAGE, GRASS STEM, GRASS LEAF, CLOVER, AND SENESCENT
 MATTER, AND (b) IN VIVO DRY AND ORGANIC MATTER
 DIGESTIBILITY (%) OF THE TOTAL PRE-GRAZING HERBAGE IN
 THE EXPERIMENTAL PERIOD - ROUND 1 (EARLY SUMMER)

		Sward Type		SE (LSM)	Sig. Level
		PU*	PT		
(a) <u>In vitro</u> DMD and OMD					
Total Herbage	DMD (%)	64.4	66.7	0.6	*
	OMD (%)	67.9	70.8	1.2	NS
Grass Stem	DMD	64.4	67.1	0.8	NS
	OMD	72.6	75.6	0.6	**
Grass Leaf	DMD	69.6	70.5	0.5	NS
	OMD	76.9	77.2	0.5	NS
Clover	DMD	71.9	73.1	0.5	NS
	OMD	80.5	81.2	0.6	NS
Senescent Matter	DMD	42.8	42.1	0.7	NS
	OMD	48.9	49.1	0.4	NS
(b) <u>In vivo</u> DMD and OMD (%)					
Total Herbage	DMD	\bar{x} (SD)	66.9** (2.5)	70.5 (2.2)	Not statistically analysed
Total Herbage	OMD	\bar{x} (SD)	73.2 (2.4)	74.4 (2.2)	Not statistically analysed

* For interpretation of abbreviations see Table 4.4.1

** In vivo DMD and OMD are raw means and their standard deviations

Table 4.4.4 : THE EFFECT OF DEFOLIATION INTENSITY IN SPRING ON
 (a) THE NITROGEN CONCENTRATION (N%) AND (b) THE
 IN VITRO DRY AND (c) ORGANIC MATTER DIGESTIBILITY (%)
 OF THE PRE-GRAZING TOTAL HERBAGE IN EACH OF FIVE
 VERTICAL STRATA, IN THE EXPERIMENTAL PERIOD - ROUND 1
 (EARLY SUMMER)

			Sward Type		SE (LSM)
			PU*	PT	
(a) Nitrogen (%)					
Stratum	1	0-4 cm	1.7	2.0	0.1
	2	4-12 cm	2.4	2.7	
	3	12-20 cm	2.9	3.2	
	4	20-28 cm	2.8	3.1	
	5	28+ cm	2.6	2.9	
Probability for stratum effects:			p < 0.05		
Probability for sward type effects:			p < 0.01		
N = 10					
(b) <u>In vitro</u> DMD (%)					
Stratum	1	0-4 cm	62.0	62.4	1.0
	2	4-12 cm	66.0	71.7	
	3	12-20 cm	71.3	73.1	
	4	20-28 cm	68.4	71.8	
	5	28+ cm	68.0	70.7	
Probability for stratum effects:			p < 0.05		
Probability for sward type effects:			p < 0.025		
N = 10					
(c) <u>In vitro</u> OMD (%)					
Stratum	1	0-4 cm	69.2	70.6	0.9
	2	4-12 cm	74.6	77.0	
	3	12-20 cm	77.8	80.2	
	4	20-28 cm	76.4	78.7	
	5	28+ cm	75.8	78.2	
Probability for stratum effects:			p < 0.05		
Probability for sward type effects:			p < 0.025		
N = 10					

* For interpretation of abbreviations see Table 4.4.1

Table 4.4.5 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE (DA) ON THE RESIDUAL HERBAGE MASS (KG DM/HA), RESIDUAL HERBAGE HEIGHT (CM) AND IN VITRO DRY AND ORGANIC MATTER DIGESTIBILITY (%) OF THE RESIDUAL HERBAGE IN THE EXPERIMENTAL PERIOD - ROUND 1 (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
Residual Herbage Mass (Kg DM/ha)	2420	2306	130	NS
Residual Herbage Height (cm)	14	10	1	**
Residual Herbage Dry Matter Digestibility (%)	58.5	59.9	0.6	NS
Organic Matter Digestibility (%)	61.9	63.1	1.2	NS

* For interpretation of abbreviations see Table 4.4.1

Table 4.4.6 : THE EFFECT OF DEFOLIATION INTENSITY IN SPRING ON THE TOTAL PRE-GRAZING HERBAGE MASS (KG DM/HA) AND COMPOSITION (% DRY WEIGHT), AND ON SWARD SURFACE HEIGHT (CM), HERBAGE BULK DENSITY (KG DM/HA PER CM OF SWARD SURFACE HEIGHT) AND TILLER DENSITY (NO. TILLERS/M²) IN THE EXPERIMENTAL PERIOD - ROUND 2 (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
Total Herbage Mass (Kg DM/ha)	3812	3502	236	NS
Grass Stem (%)	33.6	26.7	3.2	NS
Grass Leaf	26.0	28.1	0.9	NS
Clover	18.0	20.6	4.0	NS
Senescent Matter	18.3	18.5	1.2	NS
Weed	4.2	6.2	1.0	NS
Sward Surface Height (cm)	24	20	2	NS
Herbage Bulk Density (Kg DM/ha per cm of sward surface height)	162	161	18	NS
Tiller Density (no./m ²)	6175	6657	455	NS

* For interpretation of abbreviations see Table 4.4.1

Table 4.4.7 : THE EFFECT OF DEFOLIATION INTENSITY IN SPRING ON
(a) NET HERBAGE ACCUMULATION (KG DM/HA DAILY) BETWEEN
ROUNDS 1 AND 2 IN THE EXPERIMENTAL PERIOD IN EARLY
SUMMER, AND (b) THE PRE-GRAZING MASS OF TOTAL GREEN AND
LEAF MATTER (KG DM/HA) AND DIGESTIBLE DRY MATTER (DDM)
(KG DDM/HA) IN THE EXPERIMENTAL PERIOD - ROUND 2 (EARLY
SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
(a) Net Herbage Accumulation (Kg DM/ha daily)	66.0	62.0	11.1	NS
(b) Total Green Matter (Kg DM/ha)	3141	2865	220	NS
Total Leaf Matter (Kg DM/ha)	1820	1436	223	NS
Total Digestible Dry Matter (Kg DDM/ha)	2341	2218	134	NS

* For interpretation of abbreviations see Table 4.4.1

Table 4.4.8 : THE EFFECT OF DEFOLIATION INTENSITY IN SPRING ON THE
IN VITRO DRY AND ORGANIC MATTER DIGESTIBILITY (DMD AND
OMD RESPECTIVELY) (%) OF PRE-GRAZING TOTAL HERBAGE,
GRASS STEM, GRASS LEAF, CLOVER, AND SENESCENT MATTER
IN THE EXPERIMENTAL PERIOD - ROUND 2 (EARLY SUMMER)

		Sward Type		SE (LSM)	Sig. Level
		PU*	PT		
Total Herbage	DMD (%)	61.8	63.3	0.7	NS
	OMD (%)	65.9	66.5	1.8	NS
Grass Stem	DMD	61.8	64.6	0.8	NS
	OMD	69.8	73.5	1.3	NS
Grass Leaf	DMD	67.2	66.9	0.2	NS
	OMD	72.6	72.0	0.2	NS
Clover	DMD	70.3	69.8	0.2	NS
	OMD	79.7	78.4	0.4	NS
Senescent Matter	DMD	40.4	42.8	0.8	NS
	OMD	45.9	48.3	1.1	NS

* For interpretation of abbreviations see Table 4.4.1

Table 4.4.9 : THE EFFECT OF DEFOLIATION INTENSITY IN SPRING ON THE
 (a) NITROGEN CONCENTRATION (%) AND THE IN VITRO
 (b) DRY AND (c) ORGANIC MATTER DIGESTIBILITY (%) OF
 THE PRE-GRAZING TOTAL HERBAGE IN EACH OF FIVE VERTICAL
 STRATA IN THE EXPERIMENTAL PERIOD - ROUND 2 (EARLY
 SUMMER)

		Sward Type		SE (LSM)	
		PU*	PT		
(a) Nitrogen (%)					
Stratum	1	0-4 cm	2.1	2.0	0.1
	2	4-12 cm	3.0	3.1	
	3	12-20 cm	3.3	3.2	
	4	20-28 cm	3.1	3.0	
	5	28+ cm	3.0	2.8	
Probability for stratum effects:			p < 0.001		
Probability for sward type effects:			NS		
Probability for interaction effects:			NS		
N = 39					
(b) DMD (%)					
Stratum	1	0-4 cm	62.9	64.2	0.8
	2	4-12 cm	70.3	71.9	
	3	12-20 cm	72.2	73.1	
	4	20-28 cm	71.7	72.1	
	5	28+ cm	77.2	76.0	
Probability for stratum effects:			p < 0.001		
Probability for sward type effects:			NS		
Probability for interaction effects:			NS		
N = 39					
(c) OMD (%)					
Stratum	1	0-4 cm	70.4	71.4	0.8
	2	4-12 cm	76.5	78.0	
	3	12-20 cm	78.5	79.3	
	4	20-28 cm	78.3	78.9	
	5	28+ cm	77.2	76.0	
Probability for stratum effects:			p < 0.001		
Probability for sward type effects:			NS		
Probability for interaction effects:			NS		
N = 39					

* For interpretation of abbreviations see Table 4.4.1

Table 4.4.10 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE (DA) ON THE DAILY ALLOWANCE OF GREEN (GA) AND LEAF (LA) MATTER (KG DM/COW DAILY), DRY MATTER INTAKE (DMI) (KG DM/COW DAILY), AND ON THE COMPOSITION OF THE DIET (% DRY WEIGHT) IN THE EXPERIMENTAL PERIOD - ROUND 1 (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
Daily Allowance				
DA (Kg DM/cow daily)	39.2	44.2	1.0	***
GA (Kg DM/cow daily)	33.4	36.5	0.8	**
LA (Kg DM/cow daily)	14.7	18.4	0.4	***
Dry Matter Intake				
DMI : by difference (Kg DM/cow daily)	17.0	13.5	0.8	***
DMI : by Cr ₂ O ₃ dilution (Kg DM/cow daily)	13.5	15.0	1.0	NS
Composition of Diet (%)				
Grass Stem	30.5	22.3	5.5	NS
Grass Leaf	42.8	44.1	3.8	NS
Clover	22.7	28.4	4.4	NS
Senescent Matter	4.1	5.2	0.7	NS

* For interpretation of abbreviations see Table 4.4.1.

Table 4.4.11 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE (DA) ON THE DAILY ALLOWANCE OF GREEN (GA) AND LEAF (LA) MATTER (KG DM/COW DAILY) AND ON DRY MATTER INTAKE (DMI) (KG DM/COW DAILY) IN THE EXPERIMENTAL PERIOD - ROUND 2 (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
Daily Allowance				
DA (Kg DM/cow daily)	46.1	43.2	1.8	NS
GA (Kg DM/cow daily)	37.6	35.4	4.3	NS
LA (Kg DM/cow daily)	12.0	13.3	0.7	NS
Dry Matter Intake				
By difference (Kg DM/cow daily)	11.9	13.0	1.6	NS

* For interpretation of abbreviations see Table 4.4.1

Table 4.4.12 : THE EFFECT OF SWARD TYPE AND DAILY DRY MATTER ALLOWANCE (DA) ON THE RESIDUAL HERBAGE MASS (KG DM/HA), RESIDUAL HERBAGE HEIGHT (CM) AND IN VITRO DRY AND ORGANIC MATTER DIGESTIBILITY (%) OF THE RESIDUAL HERBAGE IN THE EXPERIMENTAL PERIOD - ROUND 2 (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
Residual Herbage Mass (Kg DM/ha)	2323	2263	270	NS
Residual Herbage Height (cm)	14	9	1	**
Residual Herbage Dry Matter Digestibility (%)	59.1	59.2	1.6	NS
Organic Matter Digestibility (%)	63.7	65.0	2.5	NS

Table 4.4.13 : THE EFFECT OF SWARD TYPE ON MILK, MILK FAT AND MILK PROTEIN YIELD (KG/COW DAILY) IN (a) WEEK 3 OF ROUND 1 AND (b) WEEK 2 OF ROUND 2 OF THE EXPERIMENTAL PERIOD (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
(a) Round 1				
Milk Yield (Kg/cow daily)	19.6	21.5	0.6	**
Milk Fat Yield (Kg/cow daily)	0.81	0.94	0.05	NS
Milk Protein Yield (Kg/cow daily)	0.70	0.78	0.01	***
(b) Round 2				
Milk Yield (Kg/cow daily)	17.1	19.7	0.5	***
Milk Fat Yield (Kg/cow daily)	0.80	0.88	0.04	NS
Milk Protein Yield (Kg/cow daily)	0.62	0.69	0.02	****

* For interpretation of abbreviations see Table 4.4.1

Table 4.4.14 : THE EFFECT OF SWARD TYPE ON THE COMPOSITION OF MILK FAT (% WEIGHT OF SHORT AND LONG CHAIN FATTY ACIDS) AT (a) THE END OF WEEK 3 OF ROUND 1 AND (b) THE END OF WEEK 2 OF ROUND 2 OF THE EXPERIMENTAL PERIOD (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
(a) Round 1				
Fatty Acids (% weight)				
Short Chain (C6:0 - C14:1)	28.93	29.50	0.41	NS
Long Chain (C18:0, C18:1)	29.20	27.46	0.85	NS
(b) Round 2				
Fatty Acids (% weight)				
Short Chain (C6:0 - C14:1)	27.11	27.56	0.65	NS
Long Chain (C18:1, C18:1)	30.08	29.03	0.45	NS

* For interpretation of abbreviations see Table 4.4.1

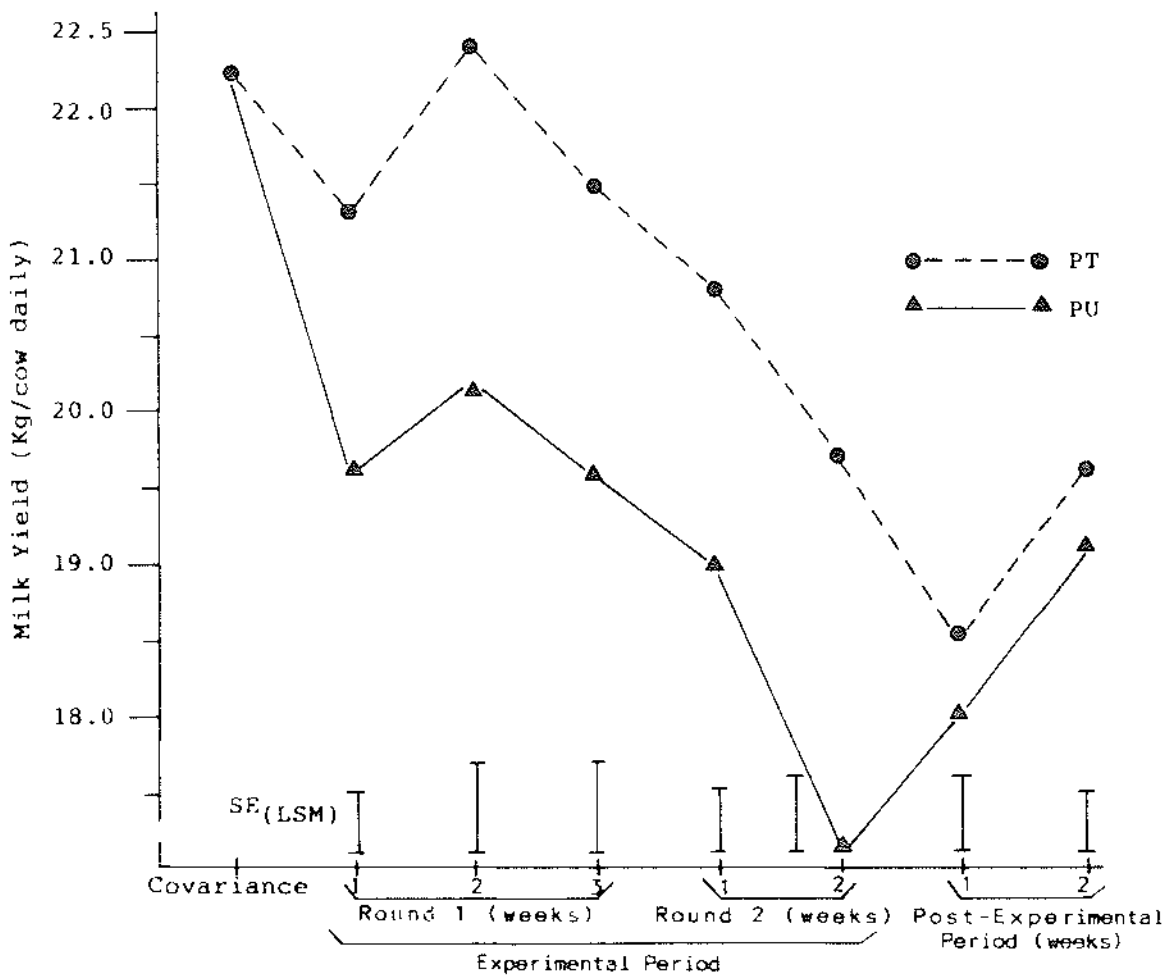


Figure 4.4.2 : THE EFFECT OF SWARD TYPE ON MILK YIELD IN THE EXPERIMENTAL AND POST EXPERIMENTAL PERIODS

Where PU = cow grazing swards that had been leniently grazed in spring
 PT = cows grazing swards that had been topped in spring

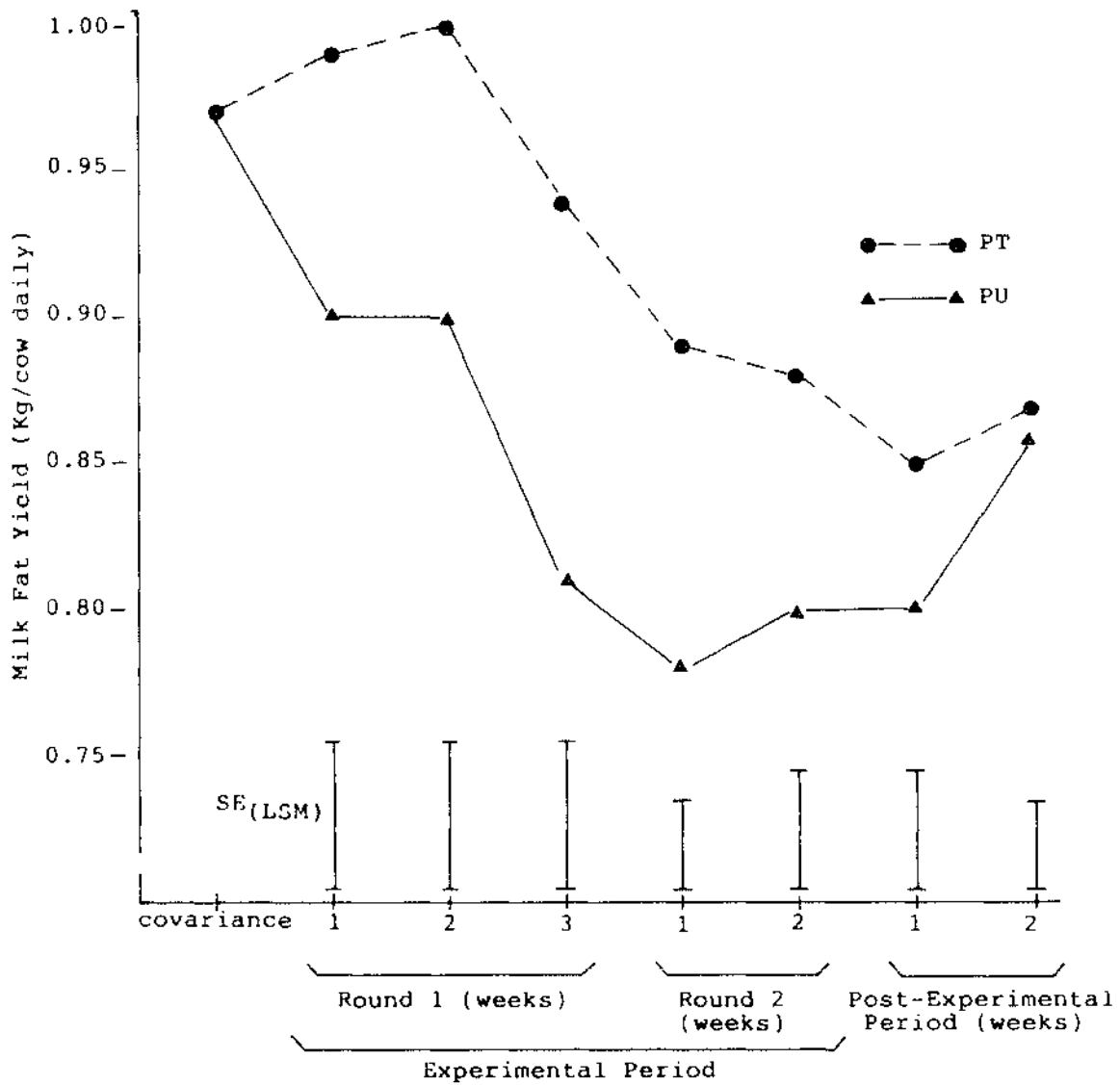


Figure 4.4.3 : THE EFFECT OF SWARD TYPE ON MILK FAT YIELD IN THE EXPERIMENTAL AND POST EXPERIMENTAL PERIODS

Where PU = cows grazing swards that had been leniently grazed in spring
 PT = cows grazing swards that had been topped in spring

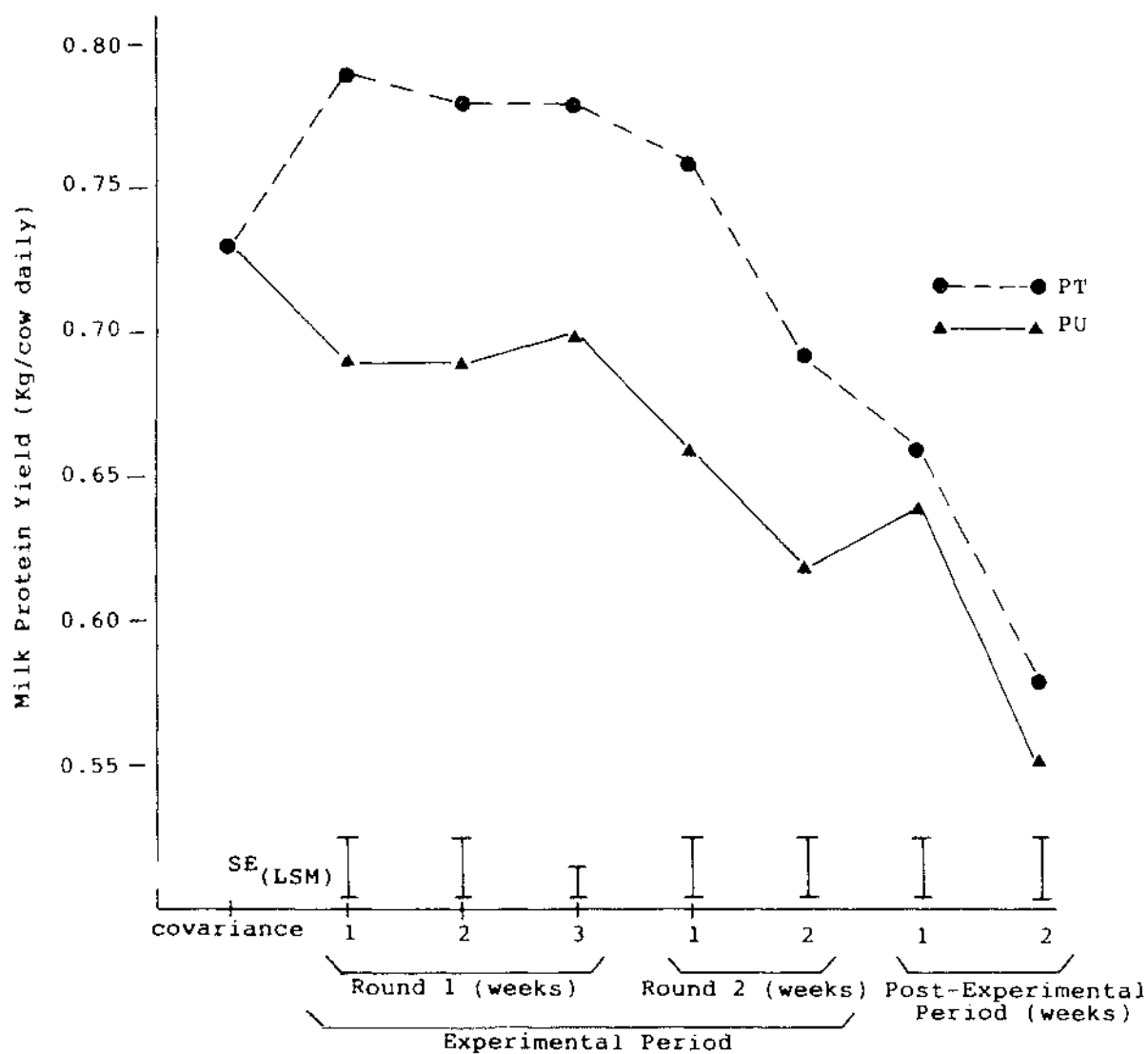


Figure 4.4.4 : THE EFFECT OF SWARD TYPE ON MILK PROTEIN YIELD IN THE EXPERIMENTAL AND POST EXPERIMENTAL PERIODS

Where PU = cows grazing swards that had been leniently grazed in spring
 PT = cows grazing swards that had been topped in spring

Table 4.4.15 : THE EFFECT OF SWARD TYPE ON UNFASTED LIVELWEIGHT (KG/COW) AND CONDITION SCORE AT THE END OF THE EXPERIMENTAL PERIOD, AND ON CHANGES IN UNFASTED LIVELWEIGHT (KG/COW OVER 35 DAYS) AND CONDITION SCORE OVER THE EXPERIMENTAL PERIOD (EARLY SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
Unfasted Liveweight (Kg/cow)	483	489	4	NS
Condition Score	4.7	4.7	0.1	NS
Change in Unfasted Liveweight (Kg/cow over 35 days)	12	17	4	NS
Change in Condition Score (over 35 days)	-0.2	-0.1	0.1	NS

* For interpretation of abbreviations see Table 4.4.1

Table 4.4.16 : THE EFFECT OF SWARD TYPE IN THE EXPERIMENTAL PERIOD ON MILK, MILK FAT, AND MILK PROTEIN YIELD (KG/COW DAILY) IN THE FIRST WEEK OF THE POST EXPERIMENTAL PERIOD (EARLY SUMMER)

Kg/cow Daily	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
Milk Yield	18.0	18.5	0.5	NS
Milk Fat Yield	0.80	0.85	0.04	NS
Milk Protein Yield	0.64	0.66	0.04	NS

* For interpretation of abbreviations see Table 4.4.1

Table 4.4.17 : THE EFFECT OF DEFOLIATION INTENSITY IN SPRING ON
PRE-GRAZING SWARD CHARACTERISTICS IN THE POST
EXPERIMENTAL PERIOD (LATE SUMMER)

	Sward Type		SE (LSM)	Sig. Level
	PU*	PT		
Herbage Mass (Kg DM/ha)				
Total Dry Matter	3196	2987	79	NS
Total Green Matter	2284	2277	81	NS
Total Leaf Matter	1481	1399	62	NS
Total Digestible Dry Matter (Kg DDM/ha)	2147	2002	49	NS
Net Herbage Accumulation (Kg DM/ha daily)	38	48	8	NS
Sward Surface Height (cm)	30	27	1	*
Herbage Bulk Density (Kg DM/ha per cm sward surface height)	106	111	4	NS
Composition (% dry weight)				
Grass Stem	9.1	11.8	2.9	NS
Grass Leaf	33.7	32.5	2.1	NS
Clover	25.4	28.8	4.7	NS
Senescent Matter	28.6	23.7	1.9	NS
Weed	3.3	3.4	1.0	NS
Total Herbage				
Dry Matter Digestibility (%)	67.2	67.1	0.5	NS
Organic Matter Digestibility (%)	71.5	72.3	0.5	NS
Tiller Density (no./m ²)	7390	7757	372	NS

4.5 TRIAL 3 THE EFFECT OF GRAZING INTENSITY IN SPRING ON
(1984/85) SWARD CHARACTERISTICS THROUGHOUT SPRING AND
EARLY SUMMER, AND ON THE PERFORMANCE OF COWS
GRAZING THOSE SWARDS WHEN OFFERED A COMMON
NOMINAL GREEN LEAF ALLOWANCE IN EARLY SUMMER

4.5.1 OBJECTIVES

The objectives of Trial 3 were to assess sward response throughout spring and summer to three target grazing intensities (2000 (L), 1500 (M), 800 (I) kg DM/ha residual respectively) imposed in spring.

Irrespective of daily dry matter allowance, in T1 and T2, cows consistently had a greater percentage of grass leaf and a smaller percentage of senescent matter in their diet than that which was present in the herbage on offer. In addition, those cows grazing the previously intensely grazed swards generally had a greater percentage of grass leaf and a smaller percentage of grass stem in their diet than cows grazing the previously leniently grazed swards. The cows grazing the previously intensely grazed swards produced more milk, milk fat, and milk protein than cows grazing the previously leniently grazed swards, although increased milk yields were not always associated with higher DMIs. Thus, the objective of T3 was to test the hypothesis that: when cows are given a common allowance of green leaf (Kg

DM/cow daily), over the range of sward types created in the present study (pre-grazing masses in early summer ranged from 2000 - 5000 kg DM/ha), the composition of intake and the production of milk and milk solids will be similar.

4.5.2 METHODS

SWARD PREPARATION PERIOD

For each of the two 21 day grazing rounds in spring, each of the eight experimental paddocks was grazed in the following manner:

- one third of each paddock was grazed by the milking herd until the target RHM of 2000 kg DM/ha had been reached (L swards)
- one third of each paddock was grazed by the milking herd until the target RHM of 1500 kg DM/ha had been reached (M swards)
- the remaining one third of each paddock was grazed by the milking herd for approximately 7 hrs, and then by dry stock until the target RHM of 800 kg DM/ha had been reached (I swards)

(see Appendix 4.2 for an illustration of treatment layout of experimental paddocks)

EXPERIMENTAL PERIOD

In early summer, 24 high breeding index cows (Appendix 4.5.1) were randomly assigned to the three sward types and given a common nominal LA of 15-16 kg DM/cow daily for two complete grazing rounds (35 days).

4.5.3 RESULTS

4.5.3.1 SWARD PREPARATION AND EXPERIMENTAL PERIODS

PRE-GRAZING SWARD CHARACTERISTICS

The pre-grazing sward characteristics of the herbage in the eight paddocks used in this trial prior to differential defoliation (early October) are presented in Table 4.5.1 and Figures 4.5.1 and 4.5.2 (commencing on page 188), and are typical of a vegetative sward in early spring (see chapters 3 and 5).

In October, the differential grazing of the herbage within each paddock to the three levels of RHM (Table 4.5.2) resulted in some marked differences in pre-grazing sward characteristics between the 3 sward types by the end of the 21 day period of

regrowth (Tables 4.5.3 - 4.5.9)(Figures 4.5.1 and 4.5.2). These differences were even more marked by the end of the second round of differential grazing (mid November), at which time grazing by the experimental cows commenced.

The influence of grazing intensity in spring on individual sward characteristics in spring and early summer is presented below.

NET HERBAGE ACCUMULATION

The effects of grazing intensity on NHA were evident over the first regrowth period after differential grazing had begun, with L swards having approximately twice the NHA compared with M and I swards (Tables 4.5.3a). However, between the first and second rounds of grazing by the experimental animals (mid November - December) there was a dramatic decrease in NHA compared to that in the sward preparation period, on the L swards (from 103 down to 18 kg DM/ha daily). While NHA on the M swards also decreased during this time (71 versus 32 kg DM/ ha daily for), that on the I swards remained essentially constant throughout the the entire sward preparation and experimental periods (55-60 kg DM/ha daily throughout). Thus, while the NHA on I swards was less than that on L and M swards from October through to early December, I swards had a greater NHA than L and M swards in December.

HERBAGE MASS

The pre-grazing mass of total dry matter, green dry matter, and digestible dry matter was greatest on the L swards throughout spring and early summer, followed by that on M swards, with I swards having approximately half the mass of total, green, and digestible dry matter present compared with the L swards (Table 4.5.4) The value for total leaf mass was, however, only 1.3 times greater on the L swards than on I swards throughout Oct/Nov, while in December the mass of leaf was similar on all sward types.

For both the L and M swards, the values for total dry matter, green matter, and digestible dry matter masses were greatest in Nov/Dec, and decreased again in December. On the I swards, however, the values for the total and component masses measured were relatively constant throughout the spring and early summer periods.

SWARD SURFACE HEIGHT AND HERBAGE BULK DENSITY

The surface height of the herbage on the L swards was always greater than that on the M swards, with I swards having the lowest sward surface heights (Table 4.5.3b). The surface height of the I swards remained relatively constant across measurement periods, while that on L and M swards increased during the spring periods and then decreased in early summer.

The bulk density of the total herbage was similar for the L, M, and I swards, at all periods, and tended to increase with time (Table 4.5.3c).

The percentage contribution of the total herbage in each of 5 horizontal strata to that of the total herbage mass, in all three sward types is presented in Figure 4.5.2. The relevant statistical analyses of between treatment differences in Rounds 1 and 2 of the experimental period are presented in Appendix 4.5.2. While the percentage of the total herbage mass that was present in the base of the swards (0-4 cm) and in the 4-12 cm stratum was generally greater for the I swards than the L and M swards, the total herbage mass in all three sward types became more concentrated towards the sward base with time.

HERBAGE COMPOSITION

Total Herbage

The percentages of grass stem and senescent matter in the total dry matter were generally greatest on L swards and lowest on I swards, while the percentage of grass leaf and both clover stem and leaf were greatest on I swards and lowest on L swards (Figure 4.5.1) (Appendix 4.5.3). The percentage of weed present in the total dry matter was similar for all sward types, and was low at all times (< 3.5 %).

The percentages of grass stem and senescent matter increased over the spring period, while the percentage of grass leaf decreased. In early summer the percentage of grass stem decreased while the percentage of senescent matter increased for the L and M swards. The composition of I swards remained relatively constant over the late spring and early summer period.

Horizontal Strata

The percentage of each component in the herbage of each of 5 horizontal strata within each sward type throughout the spring and early summer period is shown in Figure 4.5.2. The nature of the data prohibited statistical analysis of between treatment differences in composition of the herbage in each stratum since the between sample variation in composition was great, and so the figures presented are raw data means. Nevertheless, certain trends are evident.

In the first 2 strata (0-12 cm), the percentages of both senescent matter and clover tended to increase with time, while the percentages of grass leaf and stem decreased, for both the L and M swards. In the top three strata (12-28+ cm), the percentages of senescent matter and especially grass stem increased with time, while the percentage of grass leaf decreased. These changes were more marked in the L than the M swards. Clover was generally present in all strata for both L and M swards throughout the measurement period.

In the I swards, the composition of the first 2 strata changed little over the spring and early summer. In stratum 3 (12-20 cm), the percent grass stem increased while the percent grass leaf decreased with time, and this was especially noticeable between the late spring and early summer period. The percentage of senescent matter remained relatively constant throughout, and was actually absent in stratum 4 (20-28 cm) in late December. As in the L and M swards, clover was generally present throughout the sward profile.

TILLER MEASUREMENTS

Throughout the spring and summer period, individual reproductive tiller weights were highest for those tillers on L swards, followed by those on M swards, with the reproductive tillers on I swards having the lowest weights (Table 4.5.5a). Individual vegetative tiller weights were also greatest on L swards and least on I swards during the spring period, however, in early summer there was no difference between sward types in individual vegetative tiller weights (Table 4.5.5b).

Within each sward type individual reproductive tillers were heavier than vegetative tillers, with the difference being the greatest on L swards in early summer.

By the end of the first round of differential grazing in the sward preparation period (Oct/Nov), 63 % of tillers on L swards were reproductive, while on I swards only 33 % of tillers were reproductive (Table 4.5.5c). By the end of the second round, 77 % of the tillers on L swards were reproductive, while on the M and I swards the percentage of tillers that were reproductive had actually decreased compared to the first grazing round. In December, less than half the total tillers on the L swards were reproductive, while on M swards approximately one third were reproductive, and on I swards less than one quarter were reproductive.

There were no visible seed heads present in any of the swards in early October. However, after a three week period of regrowth following the first round of differential grazing, seed heads were visible in all three sward types, with L swards having greater numbers (per m^2) than M and I swards (Table 4.5.6). After the second round of differential grazing, the visible seed head density had increased by 11, 9 and 7 times that present in the previous round of grazing for the L, M, and I swards respectively.

In early summer, the density of seed heads was still greater on the L than the M and I swards, however, compared to the previous round the number of seed heads actually decreased on the L and M swards, and increased on the I swards.

IN VITRO DRY AND ORGANIC MATTER DIGESTIBILITYTotal Herbage

The in vitro DMD and OMD of the total herbage was unaffected by grazing regime after the first round of differential grazing in the sward preparation period (Table 4.5.7), and was essentially similar to that of the total herbage in early spring before differential grazing had commenced (Table 4.5.1). By late spring, however, values for both DMD and OMD were highest for I swards followed by that of the M swards, with L swards having the lowest values. A similar trend existed in early summer, with values for DMD and OMD changing very little over this time period within each sward type.

In Rounds 1 and 2 of the experimental period, when the herbage in each sward type was separated into horizontal strata, the DMD and OMD of the total herbage within each stratum was always greatest for the I swards, and lowest for the L swards (Tables 4.5.8a,b). In Round 1, across all sward types, the sward base (0-4 cm) had the lowest values for DMD and OMD, while values increased up to the third stratum, and then decreased again towards the top of the sward (Table 4.5.8a). In Round 2, the trends were essentially the same, except that the highest values for DMD and OMD occurred in the second stratum (4-12 cm) and then declined toward the sward surface.

Herbage Components

In both rounds of the experimental period, the grass stem and senescent matter in the M and I swards had higher values for DMD and OMD than that on L swards (Table 4.5.9). The DMD and OMD of the grass leaf was greatest on I swards and least on the L swards. The values for the DMD and OMD of grass stem increased for each sward type between the late spring and early summer periods while that of grass leaf remained similar over this time period.

ALLOWANCE AND DRY MATTER INTAKE -EXPERIMENTAL PERIOD

During the first and second round of grazing by the experimental cows, the difference in herbage composition between the three sward types was such that when each group of animals on these swards was given a common LA (15-16 kg leaf/cow daily), the GAs and DAs for cows grazing the L swards were twice that for cows grazing the I swards.

At a common LA, DMIs (by the difference method) were not significantly different for all three groups of cows in both grazing rounds (Table 4.5.10), with the average intake across all groups and grazing rounds being 13 kg DM/cow daily.

The apparent composition of the diet differed between cow groups, however. In both Rounds 1 and 2 the cows on the I swards had a greater percentage of grass leaf and a smaller percentage of

grass stem in their diets than cows on the L and M swards (Table 4.5.11). In Round 1 the percentage of clover leaf in the diet was also greater for cows grazing the I than M and L swards, whereas in Round 2 there was no significant difference between cow groups in the percentage of clover leaf in the diet. All three groups of cows had similar percentages of clover stem, senescent matter, and weed in their diets in both rounds.

During the first round of grazing the percentage of grass leaf in the diets of all cows was greater and the percentage of senescent matter smaller than that on offer in their respective sward types (Appendix 4.5.4). While the percentage of grass stem in the diet was less than that which was on offer for cows grazing the I swards, the cows on the L swards actually had a greater percentage of grass stem in their diet than that which was on offer. The percentage of clover leaf in the diet of cows grazing the I swards was also greater than that which was on offer in the I swards. Cows grazing both the L and M swards appeared to have a greater percentage of weed in their diets than that which was on offer, while the cows grazing the I swards appeared to have a similar percentage of weed in their diet to that which was on offer in the I swards.

In the second round of grazing all groups of cows again had a smaller percentage of senescent matter in their diet than that which was on offer in their respective sward types (Appendix 4.5.4). In addition, those cows grazing the M and I swards had a

smaller percentage of grass stem in their diets than that which was on offer. The percentage of grass leaf in the diet was greater than that which was on offer for cows grazing both the L and I swards, with that for the cows grazing the M swards being no different to that on offer. On both the L and M swards, the percentage of clover leaf in the diet was greater than that which was on offer, while cows on the M swards also had a greater percentage of clover stem in the diet than that which was on offer. In the second round there was no difference in the percentage of weed in the diet from that which was on offer for any of the cow groups.

The contribution of the total herbage in each horizontal stratum in the sward to the diet of cows grazing that sward is presented in Table 4.5.12. In the first round those animals grazing the I swards had a greater percentage of their diet coming from the sward base, and a smaller percentage of their diet coming from the 12-28+ strata than cows on the M and L swards. The percentage of the diet coming from the 4-12 cm stratum was greatest for cows on the M swards, while those on L and I swards had equal percentages coming from this stratum.

In round 2, similar trends were observed, with the exception that for cows on the M swards, the percentage contribution of each stratum to the diet was more similar to that of cows on the I swards than in the first rotation, when values for the percentage contribution of strata to the diet of M cows tended to fall

between that of the cows on the L and I swards.

The percentage contribution of a stratum to the diet was compared to the percentage contribution of that stratum to the total herbage mass on offer (Appendix 4.5.5). In general, for both Rounds 1 and 2, the contribution of stratum 1 (0-4 cm) to the diet was less than the contribution of that stratum to the total herbage mass. The percentage contribution of herbage in strata above the 4 cm mark to the diet was generally greater than that on offer.

POST-GRAZING SWARD CHARACTERISTICS

The RHMs achieved in the sward preparation period (October - mid November) were under the control of the experimenter, since the different RHMs were the criteria for sward treatment differences. The levels of RHM achieved during this period were, however, slightly higher than target RHMs for the L and M swards set in the objectives (Table 4.5.2) (target RHMs were 2500, 1500, and 900 for the L, M, and I swards respectively). During the experimental period (mid November - December), the RHMs achieved were a function the main treatment of a common daily LA for cows grazing on all three sward types. Nevertheless, as in the sward preparation period, the RHM was always greater on L than M swards, with I swards having the lowest values for RHM.

Within the L and M sward types, the RHM tended to increase with time up to the late spring period, and then decrease in early summer. The RHM on I swards remained more constant throughout the spring and early summer periods, increasing slightly in late spring and early summer.

The surface height of the residual herbage was always greatest in the L swards, and least on the I swards, exhibiting a within sward increase with time throughout spring and then decreasing in early summer (Table 4.5.2).

The values for DMD and OMD of the residual herbage were greatest for the I swards and least for the L and M swards (Table 4.5.2).

ANIMAL BEHAVIOUR

The behaviour of cows grazing each of the three sward types was assessed for one 24 hr period in each of the three weeks of the first grazing round of the experimental period (Table 4.5.13).

During the hours of daylight (0500-2130 hrs) the cows assigned to the I swards spent a longer time grazing than cows on the M and L swards (8.8 versus 8.3 and 8.1 hours for the cows on the I, M, and L swards respectively) (Table 4.5.13a). Conversely, ruminating times were shortest for those animals grazing the I swards (3.0 versus 3.9 and 4.5 hrs respectively for cows on the I,

M, and L swards). While the length of time the cows spent standing and walking was similar for all three groups, those cows on the I swards spent more time lying down than cows on the M and L swards.

Over the hours of darkness, as during daylight, the times spent walking and standing were similar for all groups of cows, while ruminating times were greatest for cows on the M and L swards, and time spent lying down was greatest for the cows on the I swards (Table 4.5.13b). The time spent grazing was, however, similar for all three groups of cows (1.4 hrs).

Thus, over a 24 hr period, the cows on the I swards spent, on average, 48 minutes longer grazing, and approximately 2 hr less time ruminating than cows on the L swards.

While there were significant differences between observation days in the average times cows spent at some of the activities (Table 4.5.14), there was no interaction between sward type and observation day. There did not appear to be any obvious connections between differences in grazing behaviour and differences in weather between any of the observation days (Appendix 4.5.6).

MILK, MILK FAT AND MILK PROTEIN YIELD

There was no significant difference between groups in milk and milk fat yield during both the first and second round of grazing (Tables 4.5.15) (Figures 4.5.3, and 4.5.4). Milk protein yield was, however, greater for cows grazing the M swards than those grazing the L and I swards in the first round of differential grazing (Table 4.5.15 and Figure 4.5.5). During the second round of grazing there was no significant difference between groups in milk protein yield.

Milk, milk fat, and milk protein yield decreased over the five week experimental period for all three groups of animals.

MILK FAT COMPOSITION

Analysis of milk fat samples taken at the end of the first round of grazing indicated no significant difference between groups in milk fat composition (Table 4.5.16). However, by the end of the second round of grazing, those cows grazing the I swards had a greater percentage of long chain fatty acids in the milk fat than cows on the L and M swards. The percentage of short chain fatty acids in the milk fat was not significantly different between the groups.

UNFASTED LIVWEIGHT

Unfasted liveweight was similar for all groups at the end of the experimental period (Table 4.5.17). Changes in unfasted liveweight over the 35 day experimental period were similar for all three groups of cows, with all animals apparently gaining weight over the five week period (Table 4.5.17).

4.5.3.2 POST EXPERIMENTAL PERIOD

MILK, MILK FAT AND MILK PROTEIN YIELD

Milk, milk fat, and milk protein yield were similar for all three groups of cows by the first week of the post experimental period (Table 4.3.18)(Figures 4.5.3, 4.5.4, and 4.5.5) and remained similar for the 8 week post experimental period. Milk, milk fat, and milk protein yield did, however, increase as soon as the cows were returned to the main herd, when compared to that in the latter weeks of the experimental period.

PRE-GRAZING SWARD CHARACTERISTICS - LATE SUMMER

At the end of the summer, after all swards had had equal opportunity to be grazed by the main milking herd for at least three grazing rounds after the experimental period, NHA was similar for all three sward types (an average of 32 kg DM/ha daily)(Table 4.5.3a). For the M and I swards, these rates were

lower than December, while for the L swards the NHA in late summer was almost twice that in early summer.

While total herbage mass was greater on the L than the I swards, there was no difference in the mass of total green, leaf, or digestible dry matter between the three sward types (Table 4.5.4).

The surface heights of the L swards were greater than the surface heights of the M and I swards, although there was no difference in the bulk density of the total herbage between the three sward types (Table 4.5.3b,c).

The percentages of grass stem, clover stem, and weed were similar for L, M, and I swards (Figure 4.5.1) (Appendix 4.5.3). The percentages of grass leaf and clover leaf were, however, greatest on the M and I swards. The percentages of senescent matter were greatest on the L swards, with over half the herbage present being in a senescent state.

Compared to the early summer period, the percentages of grass stem and grass leaf decreased on all sward types, while the percentages of senescent matter and clover stem increased. The decrease in the percentage of grass stem was especially noticeable on the L swards (31 - 9 % from early to late summer respectively) (Appendix 4.5.3).

The values for DMD and OMD of the total herbage were greatest for the herbage on the I swards and lowest on the L swards (Table 4.5.7). The values of both DMD and OMD of the total herbage were, however, considerably lower in the late summer, than in the early summer period for all sward types.

Table 4.5.1 : PRE-GRAZING SWARD CHARACTERISTICS AT THE
COMMENCEMENT OF THE FIRST ROUND OF
DIFFERENTIAL GRAZING IN SPRING (OCTOBER)

	Average of Eight Paddocks	SE (LSM)
Herbage Mass (Kg DM/ha)		
Total Dry Matter	2632	244
Total Green Matter	2348	124
Total Leaf Matter	1369	73
Total Digestible Dry Matter (Kg DDM/ha)	1984	105
Herbage Composition (% Dry Weight)		
Grass Stem	31.4	2.8
Grass Leaf	44.5	4.0
Clover Stem	3.5	0.3
Clover Leaf	7.0	0.6
Senescent Matter	11.4	1.0
Weed	1.3	0.1
Sward Surface Height (cm)	18	2
Herbage Bulk Density (Kg DM/ha per cm sward surface height)	144	13
Total Herbage		
<u>In vitro</u> Dry Matter Digestibility (%)	72.4	6.7
<u>In vitro</u> Organic Matter Digestibility (%)	81.8	7.6

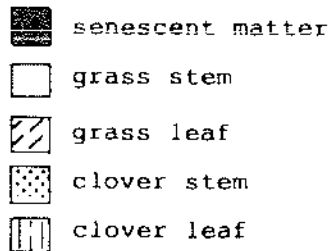
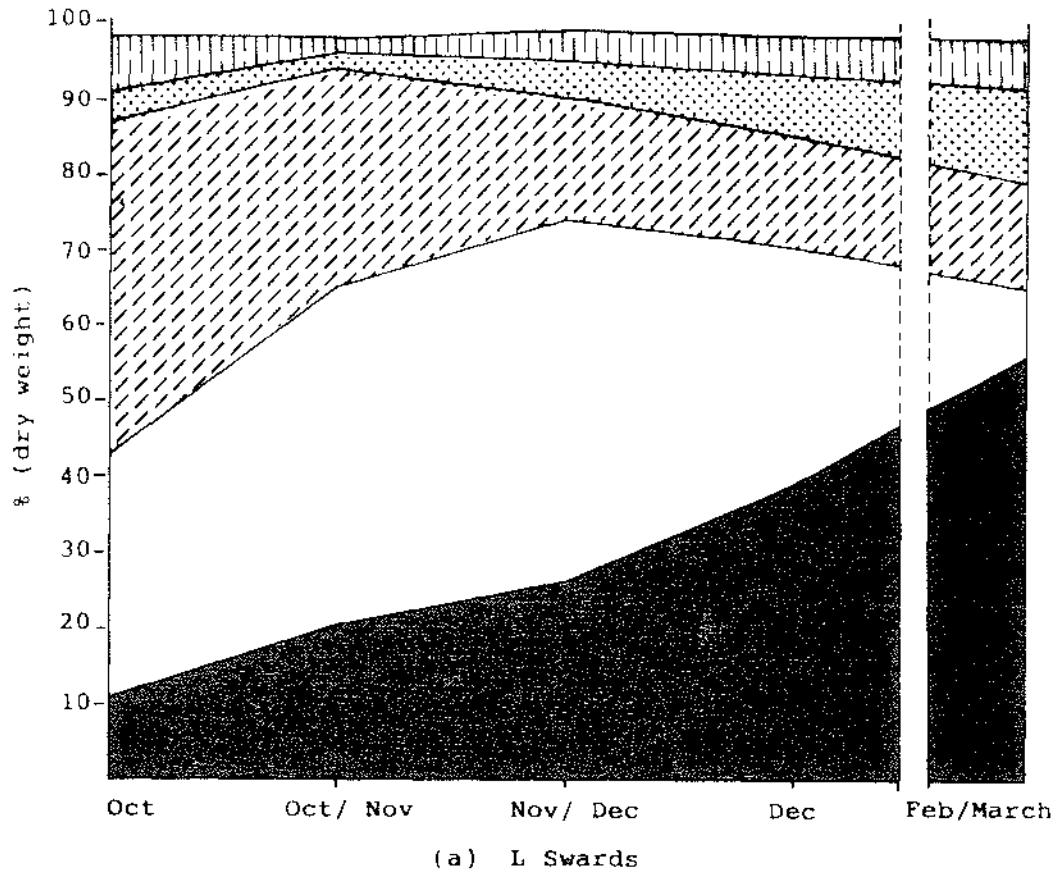
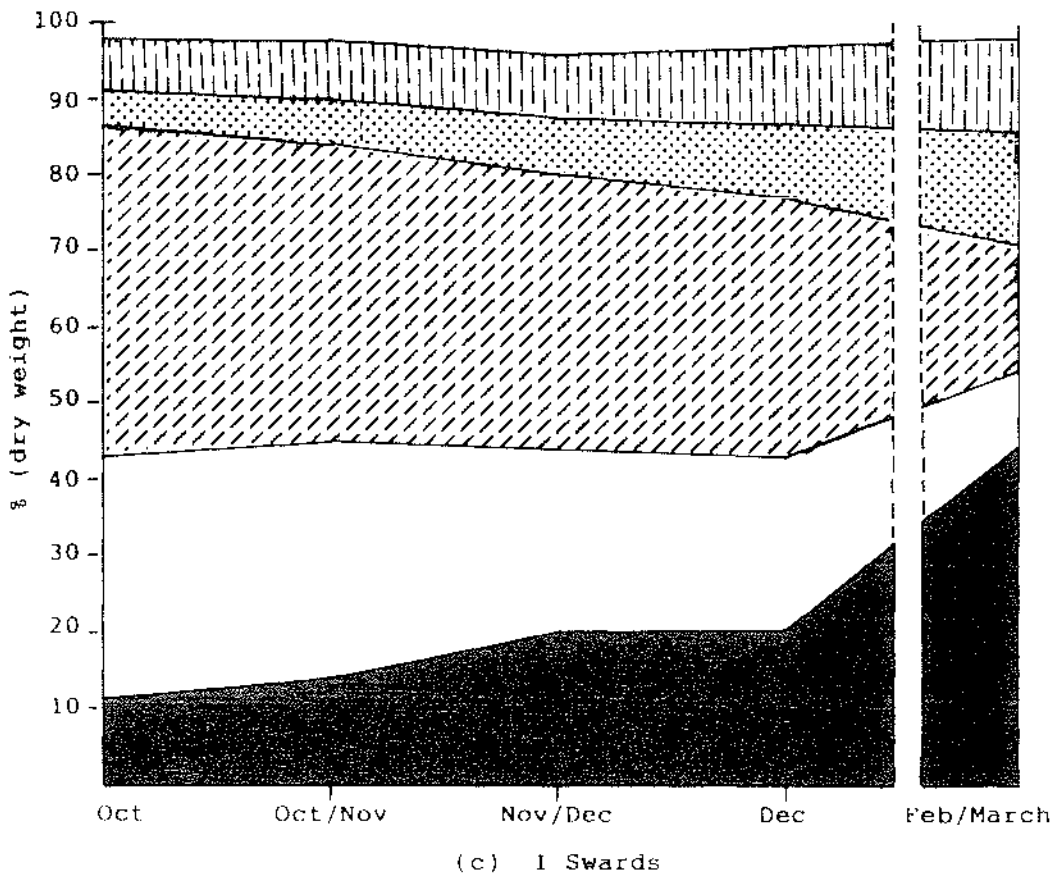
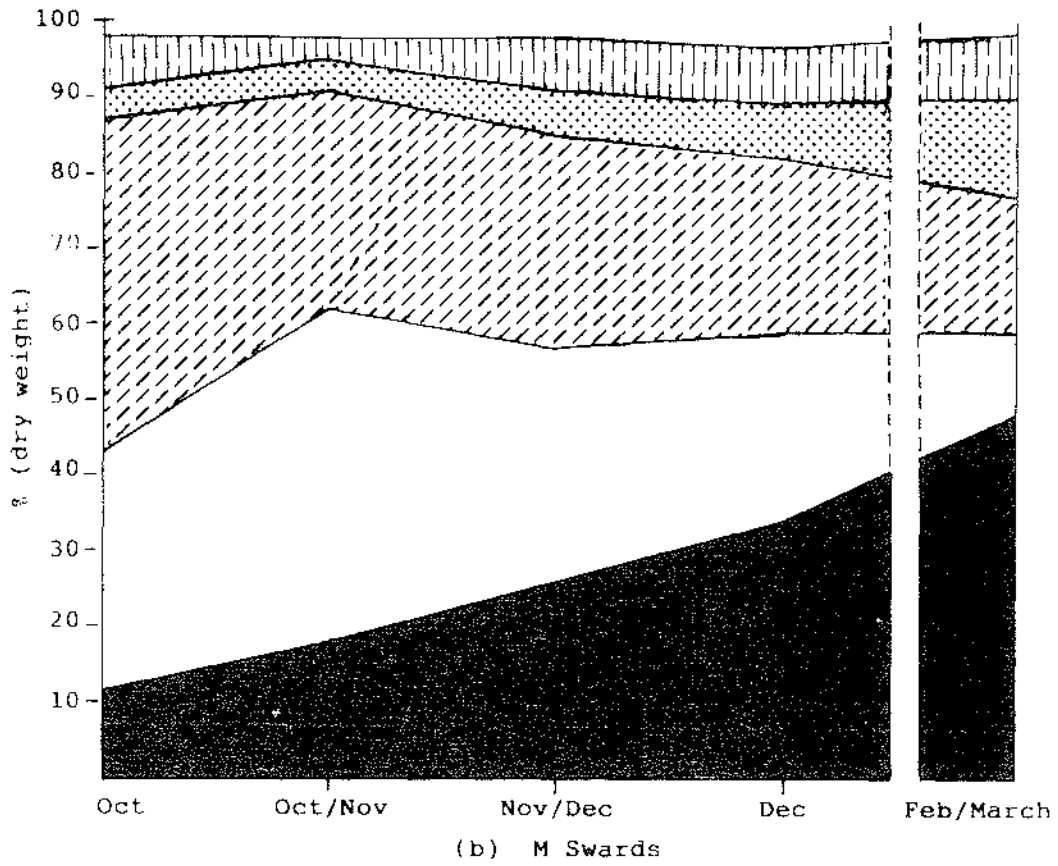


Figure 4.5.1 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON THE PERCENTAGE OF GRASS STEM, GRASS LEAF, CLOVER STEM, CLOVER LEAF AND SENESCENT MATTER IN THE TOTAL PRE-GRAZING HERBAGE IN SPRING AND SUMMER. SWARDS WERE GRAZED (a) LENIENTLY (L), (b) MODERATELY (M), AND (c) INTENSELY (I) IN SPRING (OCT-NOV)

Note: The difference between total component percentage and 100% is the weed fraction

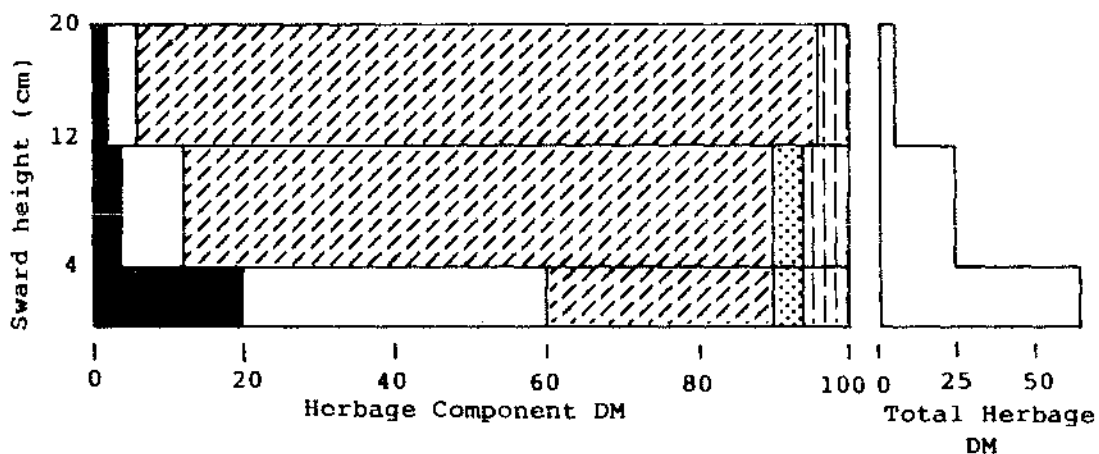


(b) M and (c) I Swards (see caption on preceding page)

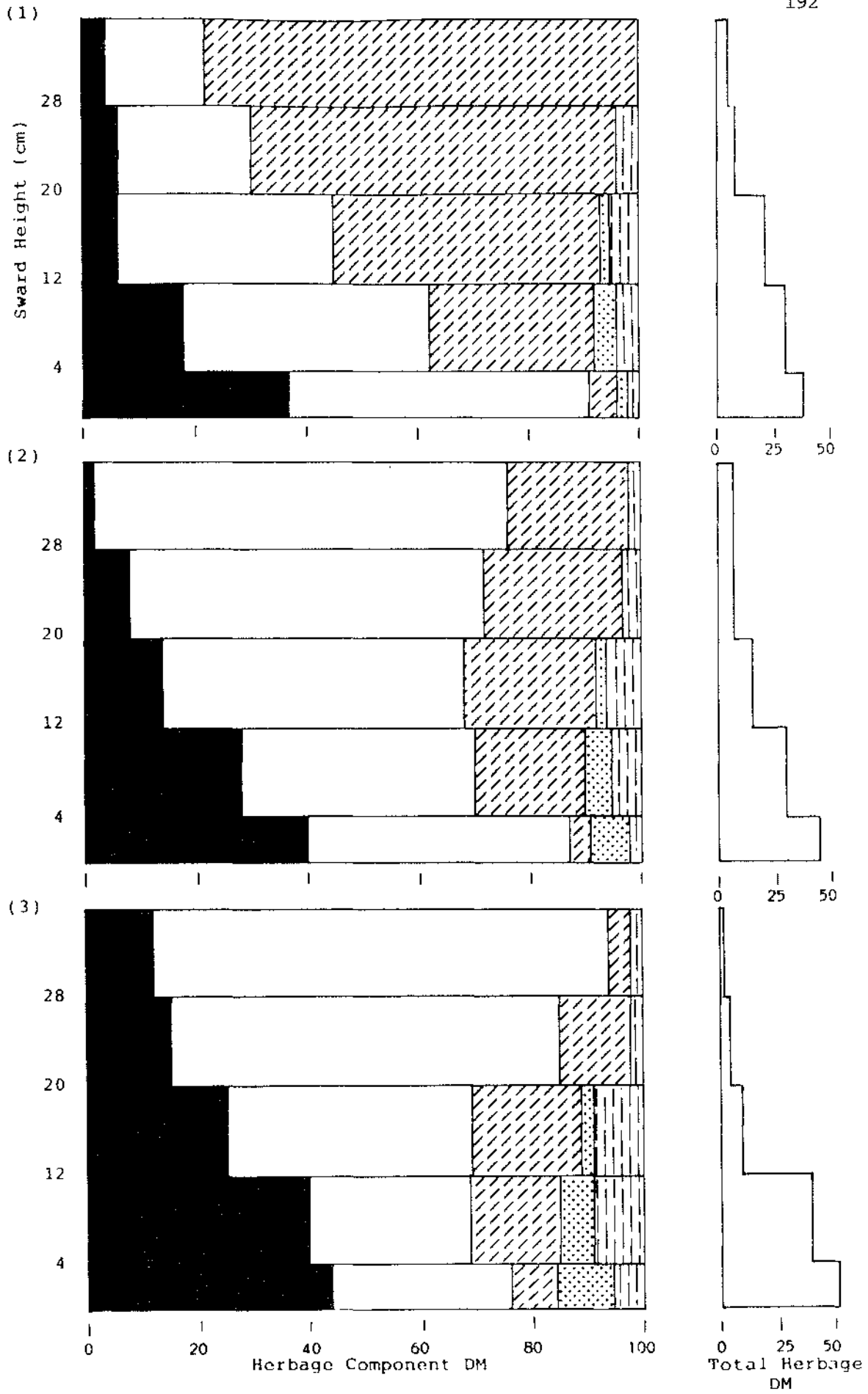
Figure 4.5.2 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON THE PERCENTAGE OF GRASS STEM, GRASS LEAF, CLOVER STEM, CLOVER LEAF AND SENESCENT MATTER IN THE TOTAL PRE-GRAZING HERBAGE IN EACH OF FIVE VERTICAL STRATA, AND OF THE PERCENTAGE CONTRIBUTION OF TOTAL HERBAGE IN EACH STRATUM TO THAT OF THE TOTAL HERBAGE MASS OVER ALL STRATA

- (a) Before Differential Grazing had Commenced (October)
- (b) Swards Grazed Leniently in Spring (L)
- (c) Swards Grazed Moderately in Spring (M)
- (d) Swards Grazed Intensely in Spring (I)

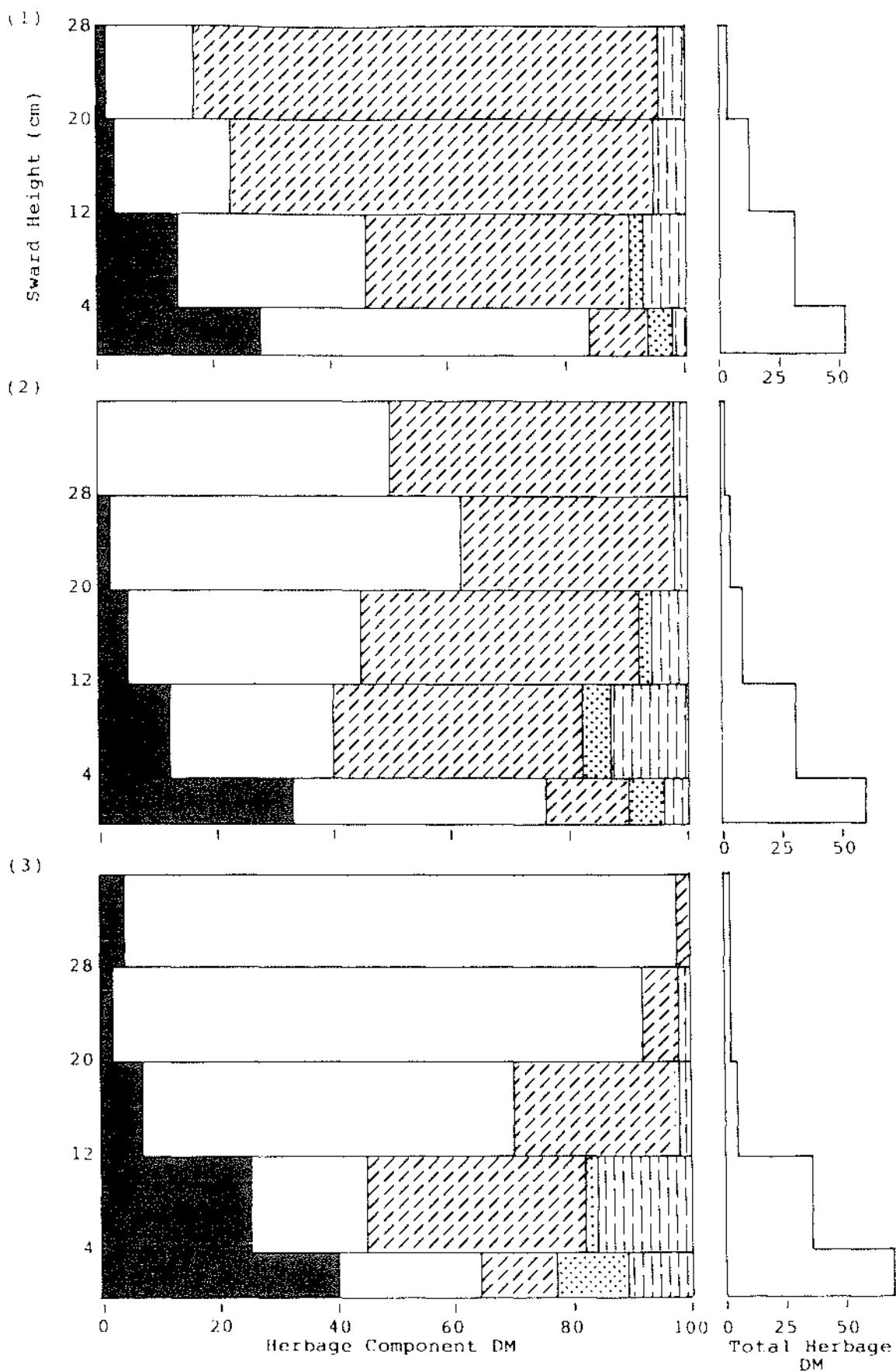
In (b), (c) and (d) Measurements were taken in 1 - October/November
 2 - November/December
 3 - December



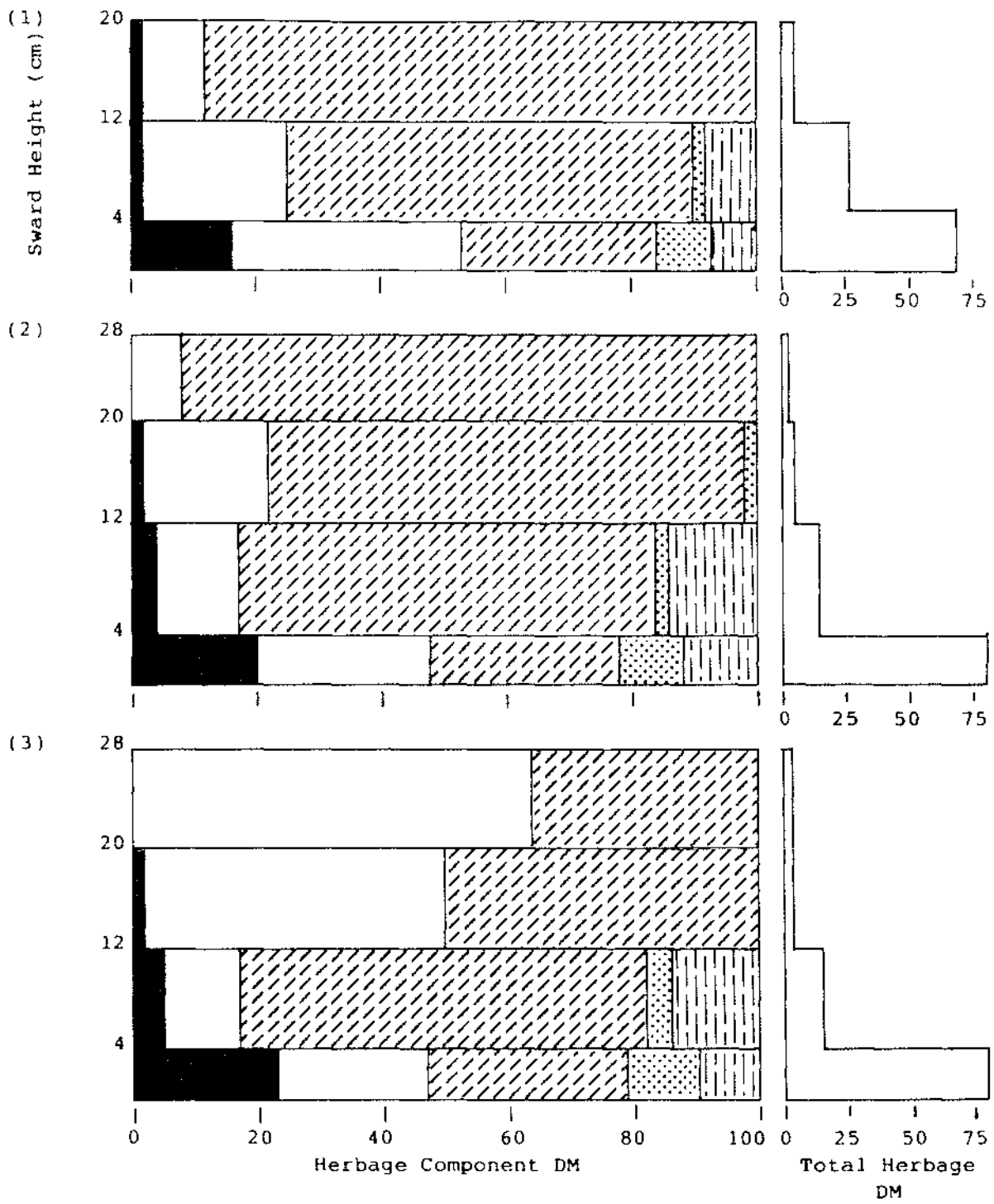
(a) Before differential grazing had commenced (October)



L Swards (see caption on page 191)



M Swards (see caption on page 191)



I Swards (see caption on page 191)

Table 4.5.2 : POST-GRAZING SWARD CHARACTERISTICS OF SWARDS THAT WERE GRAZED LAXLY (L), MODERATELY (M), OR INTENSELY (I) DURING THE SWARD PREPARATION (OCT-NOV) AND EXPERIMENTAL (NOV-DEC) PERIODS

	Sward Type			SE (LSM)	Sig. Level
	L*	M	I		
Residual Herbage Mass (Kg DM/ha)					
October	2177 c**	1583 b	820 a	165	****
October/November	2969 c	1880 b	957 a	202	****
November/December	3759 c	2391 b	1331 a	121	****
December	3172 c	2082 b	1372 a	84	****
Residual herbage Height (cm)					
October	14 c	9 b	5 a	1	****
October/November	18 c	11 b	5 a	1	****
November/December	26 c	18 b	10 a	1	****
December	21 c	17 b	8 a	1	****
Residual Herbage <u>in vitro</u>					
Dry Matter Digestibility (%)	52.5 a	55.5 a	60.5 b	0.9	*
Organic Matter Digestibility (%) (Nov/Dec only)	55.9 a	57.8 a	64.7 b	1.0	*

* In this table and in the remaining tables in this section the following abbreviations are used:

L = swards that were grazed laxly in spring (2600 Kg DM/ha RHM)
M = swards that were grazed moderately in spring (1700 Kg DM/ha RHM)
I = swards that were grazed intensely in spring (900 Kg DM/ha RHM)

** In this table and in the remaining tables in this section means within rows which are followed by different letters are different at $p < 0.05$ (LSD)

Table 4.5.3 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON (a) NET HERBAGE ACCUMULATION (KG DM/HA DAILY), (b) SWARD SURFACE HEIGHT (CM) AND (c) HERBAGE BULK DENSITY (KG DM/HA PER CM SWARD SURFACE HEIGHT) DURING THE SWARD PREPARATION (OCT-NOV), EXPERIMENTAL (NOV-DEC) AND POST EXPERIMENTAL (FEB-MARCH) PERIODS

	Sward Type			SE (LSM)	Sig. Level
	L*	M	I		
(a) Net Herbage Accumulation (Kg DM/ha daily)					
October-November	106 b	68 a	60 a	10	**
November-December	103 b	71 a	57 a	6	****
December	18 a	32 ab	55 b	6	***
February-March	32	22	42	10	NS
(b) Sward Surface Height (cm)					
October-November	37 c	25 b	15 a	3	****
November-December	38 c	27 b	16 a	1	****
December	29 c	20 b	14 a	1	****
February-March	21 b	17 a	16 a	1	***
(c) Herbage Bulk Density (Kg DM/ha per cm sward surface height)					
October-November	116	113	118	11	NS
November-December	130	124	126	7	NS
December	128	138	148	12	NS
February-March	204	214	194	9	NS

* For interpretation of abbreviations see Table 4.5.2

Table 4.5.4 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON THE PRE-GRAZING MASSES OF TOTAL (a) DRY, (b) GREEN (c) LEAF AND (d) DIGESTIBLE DRY MATTER DURING THE SWARD PREPARATION (OCT-NOV), EXPERIMENTAL (NOV-DEC) AND POST EXPERIMENTAL (FEB-MARCH) PERIODS (KG DM/HA)

	Sward Type			SE (LSM)	Sig. Level
	L*	M	I		
(a) Total Dry Matter					
October-November	4210 c	2875 b	1854 a	305	****
November-December	4945 c	3352 b	2019 a	97	****
December	3714 c	2749 b	2069 a	17	****
February-March	4185 b	3674 ab	3152 b	169	***
(b) Total Green Matter					
October-November	3458 c	2512 b	1737 a	113	****
November-December	3669 c	2471 b	1621 a	103	****
December	2280 b	1813 a	1656 a	91	****
February-March	1853	1908	1834	100	NS
(c) Total Leaf Matter					
October-November	1366 b	1027 a	959 a	73	**
November-December	1123 b	1157 b	878 a	65	**
December	751	836	922	45	NS
February-March	868	993	975	52	NS
(d) Total Digestible Dry Matter Kg DDM/ha)					
October-November	3164 c	2207 b	1457 a	98	****
November-December	3316 c	2317 b	1449 a	67	****
December	2489 c	1878 b	1490 a	84	****
February-March	2276	2094	1891	96	NS

* For interpretation of abbreviations see Table 4.5.2

Table 4.5.5 : THE EFFECT OF GRAZING REGIME IN SPRING ON THE WEIGHTS (MG DRY WEIGHT) OF INDIVIDUAL (a) REPRODUCTIVE AND (b) VEGETATIVE TILLERS AND ON THE (c) PERCENTAGE OF REPRODUCTIVE TILLERS IN THE SWARD (% BY NO. OF TOTAL TILLERS) BEFORE GRAZING DURING THE SWARD PREPARATION (OCT-NOV) AND EXPERIMENTAL PERIODS (NOV-DEC)

	Sward Type			SE (LSM)	Sig. Level
	L*	M	I		
(a) Individual Reproductive Tiller Weights (mg)					
October-November	98 c	77 b	56 a	6	***
November-December	94 c	63 b	36 a	6	****
December	73 c	48 b	32 a	4	****
(b) Individual Vegetative Tiller Weights (mg)					
October-November	50 b	38 a	30 a	3	***
November-December	27 b	26 b	20 a	1	****
December	20	18	20	2	NS
(c) Percentage of Reproductive Tillers (% by no. of total tillers)					
October-November	63.0 c	54.5 b	33.3 a	3.5	****
November-December	76.7 b	50.5 a	28.6 a	11.3	**
December	44.4 b	28.6 b	16.7 a	8.0	**

* For interpretation of abbreviations see Table 4.5.2

Table 4.5.6 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON THE NUMBER OF VISIBLE INFLORESCENCES (NO. PER M²) DURING THE SWARD PREPARATION (OCT-NOV) AND EXPERIMENTAL (NOV-DEC) PERIODS

Visible ₂ Inflorescences (no./m ²)	Sward Type			SE (LSM)	Sig. Level
	L*	M	I		
October-November	46 b	24 ab	7 a	7	***
November-December	515 c	232 b	52 a	26	****
December	334 a	161 b	70 b	46	***

* For interpretation of abbreviations see Table 4.5.2

Table 4.5.7 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON THE IN VITRO DRY (DMD) AND ORGANIC (OMD) MATTER DIGESTIBILITY (%) OF THE PRE-GRAZING TOTAL HERBAGE DURING THE SWARD PREPARATION (OCT-NOV) AND EXPERIMENTAL (NOV-DEC) PERIODS

	Sward Type			SE (LSM)	Sig. Level
	L*	M	I		
(a) <u>In vitro</u> DMD (%)					
October-November	70.2	70.7	70.8	0.5	NS
November-December	67.1 a	69.1 b	71.8 c	0.3	****
December	67.1 a	68.5 b	71.9 c	0.3	****
February-March	54.5 a	56.9 b	60.2 c	0.7	***
(b) <u>In vitro</u> OMD (%)					
October-November	79.4	80.9	80.0	0.7	NS
November-December	75.1 a	78.3 b	80.7 c	0.6	****
December	73.7 a	75.5 b	79.7 c	0.4	****
February-March	55.4 a	56.7 a	62.5 b	0.9	***

* For interpretation of abbreviations see Table 4.5.2

Table 4.5.8 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON THE IN VITRO DRY (DMD) AND ORGANIC (OMD) MATTER DIGESTIBILITY (%) OF THE TOTAL HERBAGE WITHIN EACH OF FIVE VERTICAL STRATA IN THE PRE-GRAZING HERBAGE DURING (a) ROUND 1 AND (b) ROUND 2 OF THE EXPERIMENTAL PERIOD (NOV-DEC)

		Sward Type					
		L*		M		I	
		DMD	OMD	DMD	OMD	DMD	OMD
(a) Round 1							
Stratum							
1.	0-4 cm	50.4	51.5	55.0	58.2	64.0	67.0
	SE (LSM)	(1.3)	(1.3)	(1.3)	(1.3)	(1.3)	(1.3)
2.	4-12 cm	62.0	63.4	70.5	73.1	75.4	79.7
	SE (LSM)	(1.4)	(1.4)	(1.3)	(1.3)	(1.3)	(1.3)
3.	12-20 cm	69.0	71.4	74.9	77.8	79.0	82.7
	SE (LSM)	(1.5)	(1.5)	(1.4)	(1.4)	(2.6)	(2.7)
4.	20-28 cm	70.1	73.8	69.1	73.8	Not enough Sample	
	SE (LSM)	(1.3)	(1.3)	(1.5)	(1.5)		
5.	28+ cm	66.0	69.9	69.8	73.5	Not enough Sample	
	SE (LSM)	(1.3)	(1.3)	(2.1)	(2.2)		
(b) Round 2							
Stratum							
1.	0-4 cm	50.4	51.5	55.0	58.2	64.0	67.0
	SE (LSM)	1.3	1.3	1.3	1.3	1.3	1.3
2.	4-12 cm	62.0	63.4	70.5	73.1	75.4	79.7
	SE (LSM)	1.4	1.4	1.3	1.4	1.3	1.3
3.	12-20 cm	69.0	71.4	74.9	77.8	79.0	82.7
	SE (LSM)	1.5	1.5	1.4	1.5	2.6	2.7
4.	20-28 cm	70.1	73.8	69.1	74.8	Not enough Sample	
	SE (LSM)	1.3	1.3	1.5	2.2		
5.	28+ cm	66.0	69.9	Not enough Sample		Not enough Sample	
	SE (LSM)	1.3	1.3				

For both (a) and (b):

Probability for sward type : $p < 0.001$ for both DMD and OMD

Probability for stratum : $p < 0.001$ for both DMD and OMD

Probability for interaction : NS for both DMD and OMD; tested for strata 1, 2 and 3 only

(a) N = 80

(b) N = 60

* For interpretation of abbreviations see Table 4.5.2.

Table 4.5.9 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON THE IN VITRO DRY (DMD) AND ORGANIC (OMD) MATTER DIGESTIBILITY (%) OF (a) GRASS STEM, (b) GRASS LEAF AND (c) SENESCENT MATTER IN THE PRE-GRAZING HERBAGE DURING THE EXPERIMENTAL PERIOD (NOV-DEC)

		Sward Type			SE (LSM)	Sig. Level
		L*	M	I		
(a) Grass Stem						
DMD	November-December	56.6 a	61.5 ab	63.4 b	1.4	**
(%)	December	62.0 a	66.1 b	65.9 b	0.7	**
OMD	November-December	60.8 a	65.7 b	67.7 b	1.4	****
(%)	December	63.8 a	68.9 b	69.0 b	0.9	**
(b) Grass Leaf						
DMD	November-December	67.1 a	70.3 ab	72.7 b	1.1	**
(%)	December	67.3 a	69.5 b	72.0 c	0.6	***
OMD	November-December	70.6 a	73.7 ab	76.8 b	1.1	****
(%)	December	70.0 a	73.0 b	76.6 c	0.7	****
(c) Senescent Matter						
DMD	November-December	40.3 a	43.0 b	42.6 b	0.2	**
(%)						
OMD	November-December	42.5 a	44.4 b	44.4 b	0.3	*
(%)						

* For interpretation of abbreviations see Table 4.5.2

Table 4.5.10 : THE EFFECT OF GRAZING INTENSITY IN SPRING AND DAILY LEAF ALLOWANCE (LA) (KG DM/COW DAILY) ON THE ALLOWANCE OF GREEN (GA) AND TOTAL DRY (DA) MATTER (KG DM/COW DAILY) AND ON DRY MATTER INTAKE (DMI) (KG DM/COW DAILY) DURING THE EXPERIMENTAL PERIOD (NOV-DEC) (a) ROUND 1 AND (b) ROUND 2

	Sward Type			SE (LSM)	Sig. Level
	L*	M	I		
(a) Round 1					
LA (Kg/cow daily)	15.1	15.2	15.1	0.3	NS
GA (Kg/cow daily)	47.0 c	32.1 b	26.2 a	1.8	****
DA (Kg/cow daily)	64.2 c	44.7 b	32.8 a	2.7	****
DMI (Kg/cow daily)	13.9	12.2	11.2	1.0	NS
(b) Round 2					
LA (Kg/cow daily)	16.0	16.0	16.2	0.2	NS
GA (Kg/cow daily)	49.6 c	37.0 b	28.3 a	2.2	****
DA (Kg/cow daily)	81.0 c	55.8 b	35.2 a	3.6	****
DMI (Kg/cow daily)	11.4	13.4	11.9	1.8	NS

* For interpretation of abbreviations see Table 4.5.2

Table 4.5.11 : THE EFFECT OF SWARD TYPE ON THE COMPOSITION OF THE DIET (% DRY WEIGHT) DURING THE EXPERIMENTAL PERIOD (NOV-DEC) (a) ROUND 1 AND (b) ROUND 2

	Sward Type			SE (LSM)	Sig. Level
	L*	M	I		
(a) Round 1 (% dry weight)					
Grass Stem	50.9 c	33.2 b	17.0 a	2.5	****
Grass Leaf	24.9 a	40.2 b	54.9 c	3.3	**
Clover Stem	6.3	5.4	6.6	1.6	NS
Clover Leaf	5.2 a	8.2 ab	11.8 b	1.8	*
Senescent Matter	8.8	8.6	8.7	2.7	NS
Weed	3.8	4.4	4.0	1.5	NS
(b) Round 2 (% dry weight)					
Grass Stem	30.9 b	19.5 a	15.4 a	3.1	***
Grass Leaf	18.3 a	26.0 a	46.4 b	4.0	****
Clover Stem	11.6	12.2	8.9	3.1	NS
Clover Leaf	14.3	16.8	11.8	2.9	NS
Senescent Matter	23.9	21.9	15.9	4.6	NS
Weed	0.9	3.5	1.6	0.9	NS

* For interpretation of abbreviations see Table 4.5.2

Table 4.5.12 : THE EFFECT OF SWARD TYPE ON THE CONTRIBUTION (% DRY WEIGHT) OF EACH OF FIVE VERTICAL STRATA TO THE DIET DURING THE EXPERIMENTAL PERIOD (NOV-DEC) IN (a) ROUND 1 AND (b) ROUND 2

		Sward Type			SE (LSM)	Sig. Level
		L*	M	I		
(a) Round 1 (% dry weight)						
Stratum 1	0-4 cm	13.2 a	31.8 b	62.5 c	4.2	****
2	4-12 cm	25.0 a	45.6 b	32.8 a	3.6	****
3	12-20 cm	28.8 c	16.6 b	4.6 a	1.7	****
4	20-28 cm	16.1 c	4.6 b	0.2 a	0.7	****
5	28+ cm	16.9	1.4	-	1.0	****
(b) Round 2 (% dry weight)						
Stratum 1	0-4 cm	19.8 a	50.7 b	65.5 c	5.9	****
2	4-12 cm	54.0 b	42.9 ab	31.6 a	5.1	**
3	12-20 cm	17.6 b	4.0 a	2.3 a	2.4	****
4	20-28 cm	4.7 b	1.4 a	0.7 a	0.6	****
5	28+ cm	4.0	1.1	-	0.6	****

* For interpretation of abbreviations see Table 4.5.2

Table 4.5.13 : THE EFFECT OF SWARD TYPE ON THE BEHAVIOUR OF COWS IN THE EXPERIMENTAL PERIOD (NOV-DEC) - ROUND 1

		Sward Type			SE (LSM)	Sig. Level
		L*	M	I		
(a) Activity During Daylight (hrs)						
	Grazing	8.1 a	8.3 a	8.8 b	0.2	**
	Ruminating	4.5 c	3.9 b	3.0 a	0.2	****
	Lying	0.5 a	0.9 b	1.3 c	0.1	***
	Walking	0.2	0.2	0.2	0.1	NS
	Standing	0.3	0.4	0.5	0.1	NS
(b) Activity During Darkness (hrs)						
	Grazing	1.3	1.4	1.4	0.2	NS
	Ruminating	4.0 b	4.3 b	3.3 a	0.2	***
	Lying	1.1 a	0.8 a	1.7 b	0.2	****
	Walking	0.1	0.1	0.1	0.1	NS
	Standing	0.2	0.1	0.2	0.1	NS

* For interpretation of abbreviations see Table 4.5.2

Table 4.5.14 : THE EFFECT OF OBSERVATION DAY ON THE BEHAVIOUR OF COWS IN THE EXPERIMENTAL PERIOD (NOV-DEC) - ROUND 1

	Observation Day			SE (LSM)	Sig. Level
	1	2	3		
(a) Activity During Daylight (hrs)					
Grazing	9.0 b	8.3 a	7.8 a	0.2	****
Ruminating	3.6	3.8	4.0	0.2	NS
Lying	1.0	0.8	0.9	0.1	NS
Walking	0.1	0.2	0.3	0.1	NS
Standing	0.1 a	0.4 a	0.8 b	0.1	****
(b) Activity During Darkness (hrs)					
Grazing	1.5	1.5	1.2	0.2	NS
Ruminating	3.8	4.0	3.8	0.2	NS
Lying	1.2 ab	0.9 a	1.6 b	0.1	****
Walking	0.1	0.1	0.1	0.2	NS
Standing	0.1	0.2	0.1	0.1	NS

Table 4.5.15 : THE EFFECT OF SWARD TYPE ON MILK, MILK FAT, AND MILK PROTEIN YIELD (KG/COW DAILY) IN (a) WEEK 3 OF ROUND 1 AND (b) WEEK 2 OF ROUND 2, OF THE EXPERIMENTAL PERIOD (NOV-DEC)

	Sward Type			SE (LSM)	Sig. Level
	L*	M	I		
(a) Round 1 (Kg/cow daily)					
Milk Yield	17.4	17.9	17.1	0.4	NS
Milk Fat Yield	0.74	0.79	0.81	0.03	NS
Milk Protein Yield	0.56 a	0.59 b	0.54 a	0.01	*
(b) Round 2 (Kg/cow daily)					
Milk Yield	14.2	15.7	14.4	0.5	NS
Milk Fat Yield	0.61	0.70	0.70	0.03	NS
Milk Protein Yield	0.45	0.52	0.48	0.02	NS

* For interpretation of abbreviations see Table 4.5.2

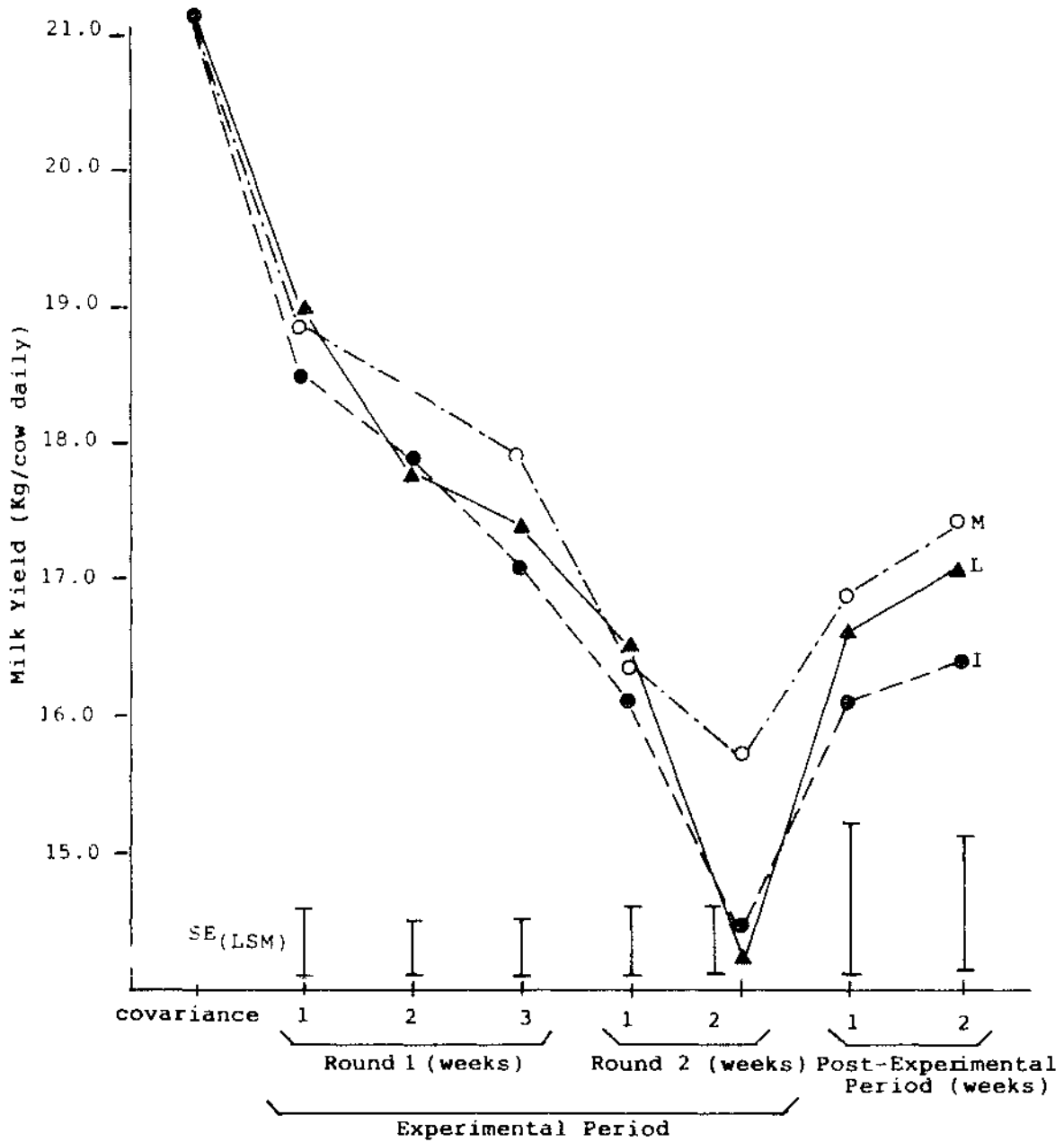


Figure 4.5.3 : THE EFFECT OF SWARD TYPE ON MILK YIELD IN THE EXPERIMENTAL AND POST EXPERIMENTAL PERIODS

Where L = cows grazing swards that had been grazed leniently in spring
 M = cows grazing swards that had been grazed moderately in spring
 I = cows grazing swards that had been grazed intensely in spring

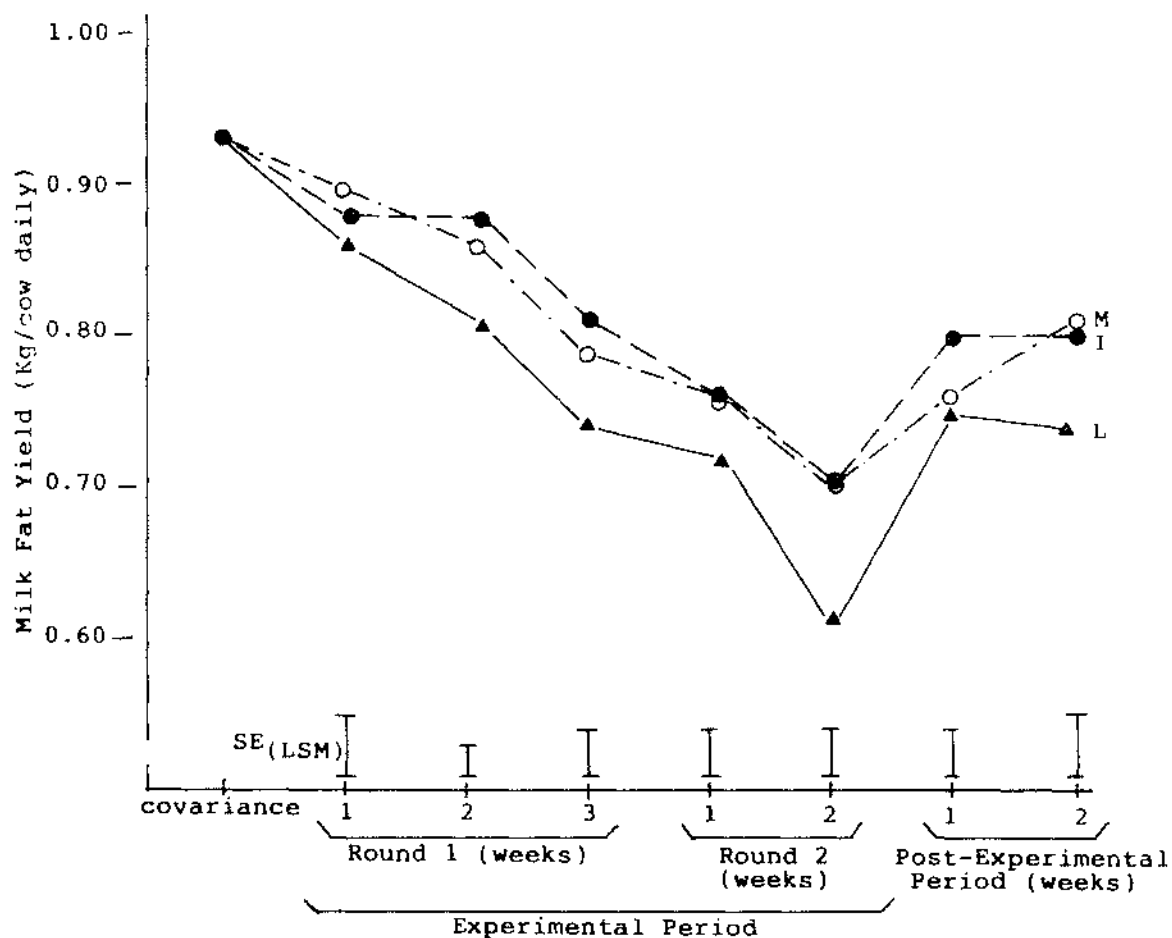


Figure 4.5.4 : THE EFFECT OF SWARD TYPE ON MILK FAT YIELD IN THE EXPERIMENTAL AND POST EXPERIMENTAL PERIODS

Where L = cows grazing swards that had been grazed leniently in spring
 M = cows grazing swards that had been grazed moderately in spring
 I = cows grazing swards that had been grazed intensely in spring

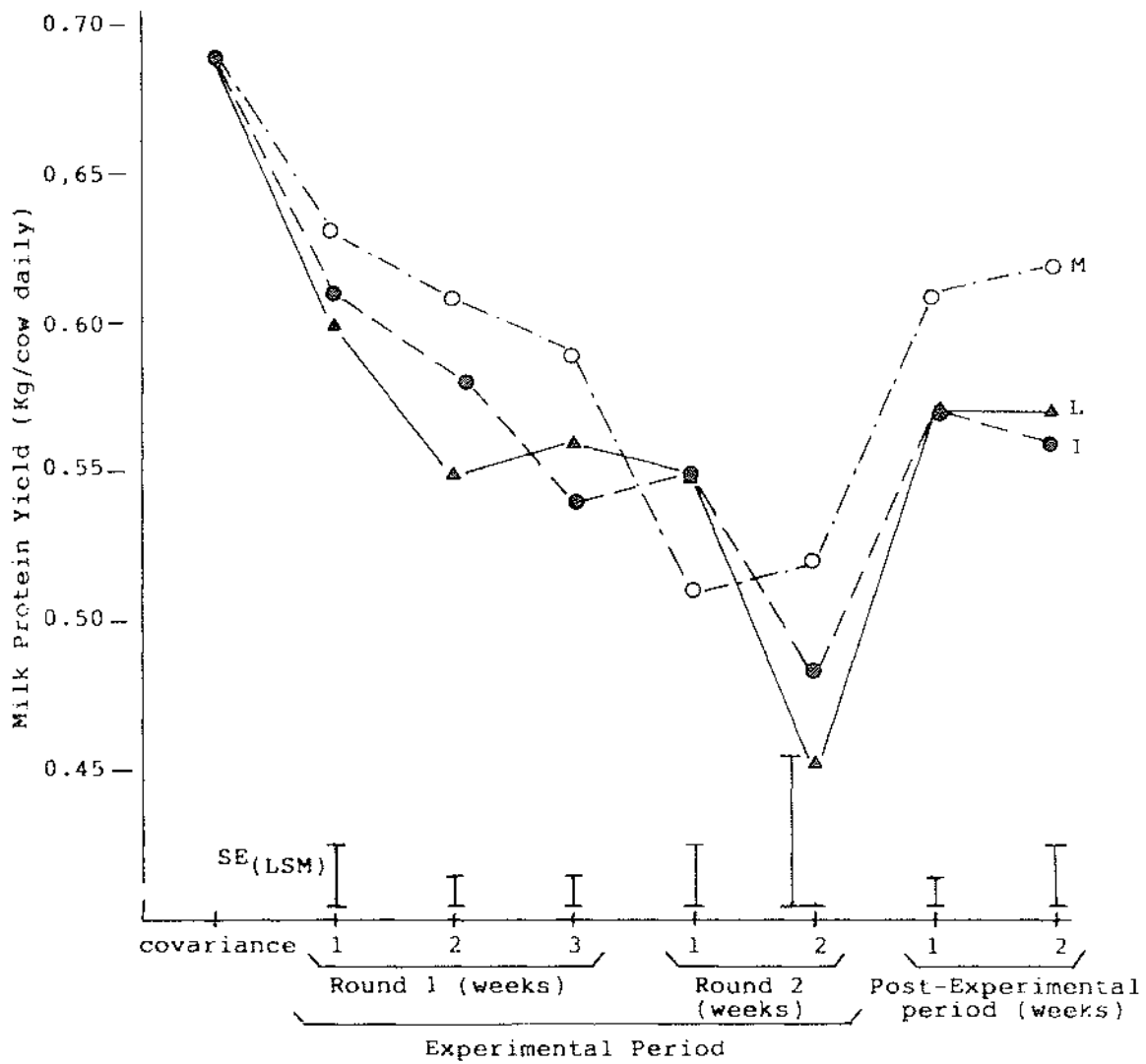


Figure 4.5.5 : THE EFFECT OF SWARD TYPE ON MILK PROTEIN YIELD IN THE EXPERIMENTAL AND POST EXPERIMENTAL PERIODS

Where L = cows grazing swards that had been grazed leniently in spring

M = cows grazing swards that had been grazed moderately in spring

I = cows grazing swards that had been grazed intensely in spring

Table 4.5.16 : THE EFFECT OF SWARD TYPE ON THE COMPOSITION OF MILK FAT (% WEIGHT OF SHORT AND LONG CHAIN FATTY ACIDS) AT (a) THE END OF WEEK 3 OF ROUND 1 AND (b) THE END OF WEEK 2 OF ROUND 2 OF THE EXPERIMENTAL PERIOD (NOV-DEC)

	Sward Type			SE (LSM)	Sig. Level
	L*	M	I		
(a) Round 1 (% weight)					
Fatty Acids					
Short chain (C6:0 - C14:1)	20.01	23.68	23.11	0.63	NS
Long chain (C18:0, C18:1)	33.17	30.68	33.90	1.18	NS
(b) Round 2 (% weight)					
Fatty Acids					
Short chain (C6:0 - C14:1)	22.56	24.46	22.36	0.74	NS
Long chain (C18:0, C18:1)	30.47 a	29.66 a	34.81 b	1.28	**

* For interpretation of abbreviations see Table 4.5.2

Table 4.5.17 : THE EFFECT OF SWARD TYPE ON UNFASTED LIVEWEIGHT (KG/COW) AT THE END OF THE EXPERIMENTAL PERIOD, AND ON CHANGES IN UNFASTED LIVEWEIGHT (KG/COW OVER 35 DAYS) OVER THE EXPERIMENTAL PERIOD (NOV-DEC)

	Sward Type			SE (LSM)	Sig. Level
	L*	M	I		
Unfasted Liveweight (Kg/cow)	459	459	454	9	NS
Change in Unfasted Liveweight (Kg/cow over 35 days)	5	6	3	4	NS

* For interpretation of abbreviations see Table 4.5.2

Table 4.5.18 : THE EFFECT OF SWARD TYPE IN THE EXPERIMENTAL PERIOD ON MILK, MILK FAT, AND MILK PROTEIN YIELD (KG/COW DAILY) IN THE FIRST WEEK OF THE POST EXPERIMENTAL PERIOD (DEC)

Kg/cow daily	Sward Type			SE (LSM)	Sig. Level
	L*	M	I		
Milk Yield	16.6	16.9	16.1	1.1	NS
Milk Fat Yield	0.75	0.76	0.80	0.03	NS
Milk Protein Yield	0.57	0.61	0.57	0.02	NS

* For interpretation of abbreviations see Table 4.5.2

4.6 DISCUSSION AND CONCLUSIONS OF TRIALS 1, 2 AND 3

Grazing swards intensely or topping (<1500 kg DM/ha RHM) from early October to mid November resulted in these swards maintaining the structure, composition, and quality of a vegetative sward into summer. More lenient grazing of swards (>2000 kg DM/ha RHM) at this time resulted in these swards having a greater percentage of reproductive tillers in spring, and thus a greater percentage of stem and consequently a greater percentage of senescent matter in the herbage in early summer. In late spring and especially in early summer, the DMD and N % of the total herbage and of some of the herbage components was lower on swards that had been leniently rather than intensely grazed. The positive effects of a more lenient grazing in spring on NHA were short term, since the more intensely grazed swards had a higher NHA by early summer. The sward responses to grazing intensity in spring reported in the present study are in general agreement with results reported by Korte (1981), Sheath and Boom (1985a), and Butler (1986) with pastures grazed by sheep, and by Thomson et al (1984) on dairy pastures; and with trends reported by Holmes and McClenaghan (1979), Bryant (1982b), Michell and Fulkerson (1985) and Bryant and L'Huillier (1986) on dairy pastures.

In early summer, those cows grazing the previously intensely defoliated swards produced more milk and milk protein, and sometimes more milk fat, than cows grazing the previously leniently grazed swards when common allowances of dry matter were

offered at either a restricted or a generous level. Similar results were reported by Thomson et al (1984), and similar trends were reported by Bryant (1982b), Michell and Fulkerson (1985), and Bryant and L'Huillier (1986).

In T1 and T2 the consistently greater percentages of grass leaf and the lower percentages of senescent matter in the diet, compared to that in the herbage on offer irrespective of DA and sward type, as well as the greater percentages of grass leaf and smaller percentages of grass stem in the diet, and the greater milk yields of cows grazing the previously leniently grazed swards led to the hypothesis that if given a common LA, composition of intake and milk yield would be similar over the range of sward types on offer. This hypothesis proved correct for milk and milk fat yield at the nominal LA chosen (15-16 kg leaf DM/cow daily), and within the range of sward types on offer (pre-grazing herbage masses ranged from 2019 - 4945 kg DM/ha). The composition of the diet did, however, differ between cows grazing the different sward types, although DMIs were not significantly different.

The following discussion will consider firstly the effects of grazing regime in spring on sward characteristics. This will be followed by a discussion on the effects of sward composition and structure on dry matter intake, the composition of intake and on cow behaviour. The effects of sward type and herbage allowance on dry matter intake and milk production and energy status will then be considered. Finally, the implications of the results in the

present study to the farming situation will be considered.

4.6.1 SWARD RESPONSE TO GRAZING REGIME IN SPRING

Under the conditions in the present study, a RHM of less than 1600 kg DM/ha in spring was necessary to minimize both the percentage of tillers that were reproductive and the number of mature reproductive tillers, in a sward (Tables 4.5.5c and 4.5.6). Parsons and Johnson (1986) reported that on set stocked swards a grazing height of 3-6 cm was necessary to minimize the percentage of reproductive tillers in spring. This agrees with results in the present study where swards grazed to a residual herbage height of 5 cm (Table 4.5.2) had the lowest percentages of reproductive tillers.

The major aim of grazing management in spring is to minimize reproductive growth, and thus a RHM of less than 1600 kg DM/ha in spring is recommended. This agrees with the target RHM of 1500 kg DM/ha reported necessary to maintain sward quality throughout spring and summer recommended by Bryant (1984) for a high stocked farm and with the 1600 kg DM/ha recommended by Sheath and Boom (1985a) for flat areas grazed by sheep. The target RHM of 2200 kg DM/ha recommended by Thomson (1985) seems rather high, considering the percentage of reproductive tillers present and the numbers reaching maturity on swards that were grazed to RHMs above 1600 kg DM/ha in the present study (Tables 4.5.5c and 4.5.6). Differences in environments as well as differences in methods of estimating

RHM between studies probably account for some of the differences noted.

The magnitude in difference between individual tiller weights on swards that had been leniently versus intensely grazed in spring (Table 4.5.5a,b) are similar to those reported by Tallowin et al (1986) for swards grazed by steers. Absolute tiller weights are difficult to compare, since Tallowin et al (1986) made no distinction between reproductive and vegetative tillers.

In T2, tiller densities on topped swards were transiently greater than on untopped swards (Tables 4.4.1 and 4.4.6) in early summer. Although tiller densities were not measured in T1 or T2, differences in tiller density between sward types in these years could be expected, since the difference in grazing intensities between treatments in the sward preparation period were greater than in T2. The tiller densities measured were much lower than those reported by Tallowin et al (1986) on swards continuously grazed by steers, and by O'Sullivan (1984b) on swards grazed both intermittently and continuously by steers at high and low stocking rates. However, they were slightly higher than that reported by Bryant and L'Huillier (1986) on swards grazed intermittently by dairy cows at a high stocking rate, but similar to that of the set stocked treatment. Tiller density is inversely proportional to tiller weight (Hodgson et al, 1981a). Thus, while a low tiller density is compensated for by a high tiller weight, very low tiller densities often measured on swards grazed by dairy cows may

be a limiting factor to herbage production from these swards. In addition, low tiller densities afford little buffering ability by the sward to drought and insect or weed ingress (Sheath and Boom, 1985b)

Net herbage accumulation

In spring, the swards grazed leniently had a greater pre-grazing mass due partly to the greater RHM after the previous grazing, and partly to a greater NHA, when compared with swards grazed intensely (Table 4.5.3). The greater NHA on swards with a greater percentage of reproductive tillers is to be expected, since the growth of reproductive tillers is more photosynthetically efficient than that of vegetative tillers (Parsons and Robson, 1981). The dramatic decrease in NHA on the previously leniently grazed swards in the subsequent grazing round can be partially attributed to the marked increase in senescent matter in these swards at this time (Figures 4.5.1 and 4.5.2). Senescent matter intercepts light yet has no photosynthetic capacity, and its shading effect on the sward base inhibits vegetative tiller development (Davies et al, 1983). In addition, during the period of reproductive growth vegetative tiller development and growth would have been inhibited (Ong et al, 1978), and thus subsequent growing point density would be low, accounting for some of the decrease in NHA noted.

In studies where the longer term production of swards differentially grazed in spring was monitored, the lower NHA on swards grazed intensely or topped in spring appears to be compensated for, or more than compensated for by the greater NHA on swards during the summer (Holmes and McClenaghan, 1979; Korte 1981; Thomson et al, 1984; Bryant and L'Huillier, 1986). The more even distribution of NHA over the season on swards grazed intensely in spring facilitates the matching of herbage supply with that of cow requirements.

Herbage composition and quality

Reproductive growth consists primarily of stem (Wilman et al, 1976d) and hence the greater proportion of grass stem on swards that were leniently grazed in spring. The percentage of clover was generally greater on swards that had been intensely defoliated in spring, although the difference was significant in T3 only (Appendix 4.5.3). The different grazing intensities may not have been imposed for long enough for marked differences in clover percentages to be manifest. While the death of reproductive growth per se was not measured in the present study, the marked decrease in the percentage of grass stem accompanied by an increase in the percentage of senescent matter on swards that contained a greater percentage of reproductive tillers in spring (Figures 4.5.1 and 4.5.2) implies the movement of reproductive tissue from the live to dead pool.

Grass stem has a lower digestibility than grass leaf and clover (Tables 4.3.3, 4.4.3, 4.4.8, and 4.5.9), and its higher concentration in the previously leniently grazed sward is partially responsible for the lower quality of the total herbage on these swards. Nevertheless, the presence of a higher percentage of senescent matter on these swards was the major contributor to the lower herbage quality, since the DMD of senescent matter was always low (42 - 44 %). The low digestibility of senescent matter noted in this study is in agreement with that quoted in the literature (Francis and Smetham, 1984).

The observed trends in the quality of the total herbage in each of five vertical strata in T2 (Tables 4.4.4 and 4.4.9) and T3 (Table 4.5.8) are similar to those reported by both Clark et al (1974a,b) and O'Sullivan (1984b), with herbage quality being lowest in the sward base, and increasing towards the sward surface. In comparatively tall swards, herbage quality tended to decrease again near the top of the sward, and this can be attributed to the presence of grass inflorescences in the top strata (Clark et al, 1974a). In T3 the differences in DMD between strata within a sward type and between sward types within any one stratum can be reconciled by differences in their composition (Figure 4.5.2). Those strata having a higher percentage of grass leaf and clover and a lower percentage of grass stem and senescent matter had a higher DMD and OMD than strata with a low percentage of grass leaf and clover and a high percentage of senescent matter

and grass stem.

4.6.2 SWARD TYPE, DRY MATTER INTAKE, AND COW BEHAVIOUR

The masses of green matter and leaf matter were usually greater on swards that had been grazed leniently in spring, despite the percentages of grass leaf and green matter being greater on the previously intensely grazed swards. However, a greater mass of green matter or leaf matter in a sward did not necessarily result in higher DMIs and milk yields.

When a common generous DA was offered, the effect of sward type on dry matter intake was variable (Table 4.3.4 and 4.4.10). At a common restricted DA, DMI was unaffected by sward type (Table 4.3.4), and at a common nominal leaf allowance, DMI was not significantly affected by sward type on offer (Table 4.5.10).

Grass leaf was always present to a greater, and senescent matter to a lesser, percent in the diet than to that in the herbage on offer irrespective of sward type and DA or LA offered (Appendices 4.3.2, 4.4.2, 4.5.4), and this is in agreement with reports in the literature on work done with goats, sheep and calves (Hughes et al, 1984; Guy et al, 1981; Milne et al, 1982; L'Huillier et al, 1986) and cattle (Langlands and Sanson, 1976).

It is tempting to conclude that cows actively select leaf and reject senescent matter at the biting site. However, it is unlikely that the cows on the restricted DA in T1 would have had the opportunity to actively select leaf and reject senescent matter. Furthermore, when grazing times were measured in T3, cows on the L swards spent a similar amount of time grazing compared with cows on the M swards (Table 4.5.13), despite having access to a much greater DA (Table 4.5.10) that consisted primarily of grass stem and senescent matter (Figures 4.5.1 and 4.5.2). The cows on the L swards would have had difficulty actively 'selecting' leaf and 'rejecting' senescent matter while still maintaining DMI levels and grazing times similar to those of cows on M swards.

There is another school of thought which considers that active selection at the biting site is not involved, but rather that indiscriminate grazing in the grazed horizon occurs. This is supported by data showing that the composition of the grazed horizon is similar to that of the diet (Milne et al, 1982). Others have noted selection for leaf in the grazed horizon (L'Huillier et al, 1986). The composition of the grazed horizon per se was not measured in the present study, and thus it is not possible to make direct comparisons with that in the literature.

Determination of the horizon grazed by dairy cows may be somewhat academic, however. In T3 each of the cow groups had at least 13 % of their diet coming from the sward base (0-4 cm) (Table 4.5.12) despite the average residual herbage height in the

experimental period always being greater than 8 cms (Table 4.5.2). It would be more valid then to define the entire sward as being the grazed horizon. It is safe to say that this would apply in most dairy cow grazing situations in New Zealand, since the range of pre-grazing herbage masses (2000 - 5000 kg DM/ha) (Table 4.5.4) and DAs (33 - 81 kg DM/cow daily) (Table 4.5.10) in T3 would encompass most situations experienced on dairy farms in spring and summer. While the average height of the RHM was never below 7 cm in the present study, areas of the sward were often grazed to within 1 or 2 cm of ground level, irrespective of sward type and allowance. Thus, it is likely that site selection was partially responsible for the intake compositions measured. The issue of site versus bite selection and/or indiscriminate versus discriminate grazing in the grazed horizon must be specifically addressed in grazing experiments with dairy cows before any conclusions can be made. It would seem likely, however, that a combination of these factors is operative in the daily grazing activities of the dairy cow (Hodgson, 1986).

Cows grazing the previously intensely grazed swards generally had a greater percentage of grass leaf and a lower percentage of grass stem in their diet than cows grazing previously leniently grazed swards, irrespective of DA or LA offered (Tables 4.3.4, 4.4.19 and 4.5.11). When the data of all three trials were combined, a simple regression of the percentage of a component in the diet on that in the sward on offer, indicated that the percentage of grass leaf in the sward accounted for 92.8 % of the

variation in the percentage of grass leaf in the diet (Appendix 4.6.1). The percentage of grass stem, clover, and senescent matter in the sward accounted for 91.0, 5.2 and 72.9 % respectively of the variation in the percentages of those components in the diet.

By combining data on diet composition and OMD of the various sward components (pre-grazing) in each trial in the present study it is possible to calculate a rough estimate of the probable concentration of metabolizable energy (ME) (MJ/kg DM) of the diet of each group of cows in each trial (Table 4.6.1, commencing on page 235). While calculations such as these are fraught with sources of error, they do serve to demonstrate that the ME concentration of the diets of cows grazing swards that were subject to lenient grazing in spring were likely to have been lower than that of cows grazing previously intensely grazed swards, over the range of DAs in the present study (12-80 kg DM/ha).

The probable differential concentrations of ME in the diets as calculated above were not reflected in greater ruminating times for cows on 'lower quality' diets when ruminating times were measured in T3. While total ruminating times were greater for cows on L than I swards (8.4 versus 6.3 hr respectively) (Table 4.5.13), the amount of time spent ruminating per unit of DMI was similar (36 versus 34 min/kg DM intake respectively). This is somewhat unexpected, since Hancock (1954) reported large

differences in ruminating times (per unit of DMI) between cows grazing herbages of two different crude fibre concentrations. In the case of Hancock, DMIs were low (10 kg/cow), and the differences in crude fibre content rather large (17.5 and 29 % crude fibre). The differences in the ME concentrations of the diet between the L and I cows in the present study may not have been large enough to result in differences in ruminating times (per kg DMI).

The salient point to be made here is that irrespective of DA offered, the greater the percentage of grass leaf and the lower the percentage of grass stem and senescent matter in a sward, the greater the percentages of leaf in the diet will be, and the greater the OMD or ME concentration of the diet is likely to be.

4.6.3 HERBAGE ALLOWANCE, DRY MATTER INTAKE AND MILK YIELD

Across the three trials, the effect of DA on DMI was variable and could not be related to sward type on offer. After the effects of year, cow type, and grazing round were taken into account using multiple regression techniques, simple regression was performed on the data to determine separately the ability of DA, GA, and LA to account for variations in DMI. DA could account for only 10 % of the variation in DMI (Appendix 4.6.2), while GA could account for 40 % of the variability in DMI, although this was not significant. However, LA accounted for 85 % of the variation in DMI.

Stepwise regression was also performed to test the effects of pre- and post-grazing total herbage mass, height, and DMD, and of DA, GA, and LA on DMI when the effects of year, cow type, and grazing round were forced into the equation (Table 4.6.2). LA was the only variable to enter the equation once the effects of the forced variables were taken into account. Caution must be used in interpreting these results, since the data set is small (N=14), and some of the variables which were free to enter into the equation were highly correlated (Table 4.6.3). Significant correlations between variables may artificially mask real relationships between the variables free to enter into the equation, and DMI. More sophisticated statistical analyses (ie principle components analysis) would be a more appropriate way of analysing data such as this. However, given the size of the data set and the objectives and design of the experiments in the present study, it was felt that further statistical analyses of the data would be inappropriate.

Stockdale (1985), using data collected over a range of sward types and years, concluded that DMI was positively related to DA and RHM, but that sward variables (pre- and post-grazing herbage mass, sward type, and DMD of the total herbage) influenced DMI less consistently. While Stockdale (1985) used DA instead of LA or GA, the conclusions made are in general agreement with that of the present study; namely, that allowance is more important in determining DMI than sward characteristics. The ability of the prediction equation presented by Stockdale to predict DMI in the

present study is examined in detail in Chapter 6 and will not be considered here.

Although DMIs were not significantly different between cow groups in T3 when a common LA of 15 to 16 kg leaf DM/cow daily was offered, this may not necessarily have been the case if either a higher or lower LA were offered. It is likely, for example, that the cows grazing the I swards were not able to realize their potential intake, since the incidental DA for these animals was only three times DMI (Table 4.5.10). In addition, the residual herbage height on the I swards was 8-10 cms, indicating that perhaps potential intakes on this sward type were being restricted (Le Du et al, 1979). The rate of intake of cows on these swards was also lower than that of cows grazing the L and M swards (1.1 versus 1.5 and 1.2 kg DM intake/hour of grazing respectively), which would most likely have been due to a lower IB than a lower RB, given the structure and composition of the I swards (Hodgson, 1986). Furthermore, milk fat fatty acid data indicate that by the end of the 35 day experimental period in T3, cows on the I swards were utilizing a greater percentage of body tissue energy to synthesize milk fat than cows on the L or M swards, indicating that I cows were more restricted in their ME intake than L and M cows. Since the calculated ME concentration of the DMI of cows on the I swards was greater than that of cows on the L and M swards, DMI would most certainly have been lower. Although DMIs were not significantly different in this trial, the measurement of DMI in a grazing situation is fraught with errors, and the possibility that

real differences did exist cannot be ruled out. The effects of LA on DMI need to be studied over a range of LAs and sward types before any conclusive statements on the relationship between LA, sward type, and DMI can be made.

Within the range of RHMs (800 - 2900 kg DM/ha) imposed in spring in the present study, the resultant sward types affected the yields of milk, milk fat, and milk protein when DA was both generous and restricted. The effect of sward type on cow performance was not significant when a common LA of 15-16 kg DM/ha was offered. Thus, although it is possible to prevent a decrease in animal performance in early summer on swards that were leniently grazed in spring provided that a high enough LA is given, the problem of subsequent sward quality is compounded. In T3 the DA allowance offered to cows on the L swards reached 80 kg DM/cow daily, in order to meet the LA specified (Table 4.5.10), and this resulted in large RHMs (3500 kg DM/ha) (Table 4.5.2) on these swards. This residual mass of predominantly stem and senescent matter would have to be mechanically removed if these swards would be expected to sustain production levels of lactating dairy cows.

The use of short periods of a restricted DA on previously leniently grazed swards in early summer (Table 4.3.4), while reducing DMI and milk production in the short term (Tables 4.3.4 and 4.3.5), did result in improved sward quality by late summer (Table 4.3.10) when summer rainfall was adequate (Appendix 2.1).

If a short term decrease in milk yield is acceptable, then intense grazing of previously leniently grazed swards in summer will result in improved herbage quality and composition.

Step-wise regression was performed on the effects of allowance and sward variables on milk, milk fat, and milk protein yield. As expected, the effects of year, cow type, and grazing round explained a large part of the variation in milk, milk fat, and milk protein yield (83, 66, and 67 % respectively) (Table 4.6.2). Once these three factors had been forced into the equation, LA explained an additional 11 % of the variation in milk yield, and an additional 26 % of the variation in milk protein yield, but did not contribute significantly to the variations in milk fat yield. The DMD of the RHM explained an additional 21 % of the variability in milk fat yield. Once the above factors were taken into account, none of the remaining variables (pre- and post-grazing herbage mass, height, and DMD; GA, and DA) contributed significantly to the variations in any of the production parameters. Again, these results must be interpreted with caution, since the data set is small, and some of the variables free to enter the equation were intercorrelated (Table 4.6.3).

The absence of any significant effect of DA and GA on cow performance under the conditions of the present study emphasizes the need for further research to challenge the hypothesis tested in the present experiment and to specifically examine the

relationships between LA, DMI and milk, milk fat, and milk protein production over a range of sward types, where LA is controlled, and does not vary incidentally as a result of sward type and DA.

DA is commonly used in New Zealand for the expression of feeding management of dairy cows (eg Holmes and Macmillan, 1982; Bryant and Trigg, 1982). However, the results presented here indicate that DA is not an adequate basis for prediction of DMI when sward characteristics vary. LA provided a better prediction of DMI under these circumstances. Nevertheless, in well managed swards containing a high percentage of leaf, DA and LA will be closely related, and feeding cows on a DA basis will result in closer agreement between predicted DMIs and milk yield.

When estimates of ME intake necessary to sustain the levels of production measured were calculated, there was little agreement both within and amongst years between the ME intakes calculated using intake quality and quantity measurements, and those calculated from production levels (Table 4.6.1). Difficulties in obtaining accurate estimates of both intake level and quality in a grazing situation probably account for most of the anomalies, since small differences in either would result in large over or under estimates of ME intake.

Fulkerson et al (1986) compared probable ME intakes (measured by difference and using a constant value for the ME concentration of herbage eaten) with calculated ME allowance (using the

equations of MAFF (1975)), over 2 years and found that probable ME intake was 95.7 ± 6 % of ME intake predicted from production levels. The greater agreement between probable and predicted ME intakes experienced by Fulkerson et al (1986) compared to that in the present study (Table 4.6.1) may be due to the longer term nature of measurements made by the latter. Short term changes in DMI and milk yield, and inaccurate estimates of short term liveweight changes probably also account for some of the discrepancy between probable and predicted ME intakes in the present study.

The lack of any significant response in unfasted liveweight and condition score to the treatment effects is not surprising since the experimental periods were short. Measurements of both unfasted liveweight and condition score are too variable for small differences to be significant, given the numbers of cows involved in the present study. It is especially difficult to explain the trends observed in T2, where an apparent gain of 17 kg/cow over the 35 day experimental period was associated with a loss of 0.2 of a condition score (Table 4.4.15). The practice of measuring unfasted liveweight and condition score over such short periods of time in grazing experiments in mid lactation must be questioned. Monitoring the fatty acid composition of milk fat is much more relevant since any differences in energy status between cow groups are first noted here (Stobbs and Brett, 1974,1976; Payne et al, 1979).

In the present study, there were only two occasions when differences in energy status between cows grazing different sward types were significant. In the first case, at a restricted DA, cows grazing previously leniently grazed swards were utilizing a greater percentage of tissue energy to synthesize milk fat than were cows grazing previously intensely grazed swards (Table 4.3.7). Since DMIs were similar (Table 4.3.4), those cows on the previously intensely grazed swards would have had a greater concentration of ME in their diets, and this agrees with the calculations of the probable ME intake concentrations for the cow groups in T1 (Table 4.6.1). At a generous DA, cows grazing the previously intensely grazed swards were utilizing a greater percentage of intake energy to synthesize milk fat than cows grazing the previously leniently grazed swards. On both sward types the effect of a restriction in DA was to decrease the percentage of milk fat being synthesized from intake energy, and to increase that being synthesized from body tissue energy. In the second case, when a common LA was offered, cows grazing the I swards were utilising a greater percentage of tissue energy to synthesize milk fat than cows on both L and M swards. The likely reasons for these differences have been discussed above.

4.6.4 IMPLICATIONS OF RESULTS TO DAIRY FARMING

In a farming situation the grazing of swards to less than 1600 kg DM/ha RHM (5-6 cm) for 6 weeks in mid spring would result in an immediate restriction of DM intake and a lower milk

production (Bryant and Trigg, 1979; Holmes et al, 1985). Nevertheless, the effects of a restriction of DM intake on cow performance at this stage in lactation appear to have very little effect on seasonal production (Bryant and L'Huillier, 1986)). Indeed, results reported in two farmlet studies indicate that the actual seasonal production of milk and milk fat were greater on farmlets that were intensely rather than leniently grazed/defoliated in spring (Thomson et al, 1984; Bryant and L'Huillier, 1986).

While most farmers would be reluctant to restrict their lactating cows for this length of time in mid spring, the use of dry stock and/or conservation to control reproductive growth are some alternatives. Topping swards proved successful in maintaining sward quality in the present study and in others reported in the literature (ie Bryant, 1982b and Holmes and McClenaghan, 1979). However, although nutrients contained in the topped herbage are partly recycled into the system, topping to control reproductive growth is generally wasteful.

Intense grazing/topping commenced in early October, and from the rapid increase in the presence of reproductive growth measured in this month, delaying the commencement of sward control measures till after early October would probably result in less successful control of reproductive growth.

The effects of spring grazing intensity on the performance of cows grazing these swards in early summer were only measured for a maximum of 35 days. Other studies have monitored the effects of defoliation intensity (or frequency in spring on cow performance over a longer time period (Bryant, 1982b; Thomson et al, 1984; and Bryant and L'Huillier, 1986). The effects of spring grazing intensity on longer term cow performance confirm the results of the present study that cows having access in summer to swards grazed intensely in spring produce more milk, milk fat, and milk protein than cows grazing previously leniently grazed swards. Minimizing reproductive growth in spring is therefore an important determinant of both sward and dairy cow productivity in New Zealand conditions.

4.6.5 CONCLUSIONS

The intensity with which a sward was grazed in spring had an immediate and marked effect on the structure, composition, quality, and net accumulation rate of herbage in that sward. The differences in sward characteristics between swards were greatest in the early summer period, and some of these differences persisted into late summer.

- lenient grazing (2500 - 3000 kg DM/ha RHM) from Oct - mid Nov resulted in a greater NHA in spring than on swards that were moderately grazed (1600 - 2000 kg DM/ha RHM) or intensely

grazed (< 1000 kg DM/ha RHM).

- by early summer (mid Nov - Dec), the previously leniently grazed swards had the lowest NHA, and contained a preponderance of grass stem and senescent matter, while previously intensely grazed swards retained their dense, leafy structure, and had higher values for DMD, OMD and N %.

- grass tiller densities were greater on swards that had been topped rather than leniently grazed in spring. Intense grazing in spring resulted in a minimal percentage of reproductive tillers and minimal numbers of reproductive tillers reaching maturity, compared to swards grazed moderately or leniently.

- differences in the percentages of grass leaf, clover, and senescent matter between the swards types persisted into the late summer period in two out of three years, although one intense grazing of previously leniently grazed swards in early summer was successful in achieving a sward similar to that which had been grazed intensely in spring.

In early summer, at both a restricted and unrestricted DA, milk and milk fat yield were affected by the intensity with which a sward had been defoliated in spring. The effect of sward type

on DMI was variable. However, when a common nominal LA was offered, DMI, milk and milk fat yield were not significantly affected by sward type on offer. Any differences in production between cows grazing the different sward types were immediate, and limited to the period of differential grazing.

- at a generous DA, cows grazing previously leniently grazed swards produced less milk, milk fat, and milk protein than those grazing the previously intensely grazed swards, while DMI was variable. At a restricted DA, intakes were similar but milk, milk fat, and milk protein yield was lower on previously leniently grazed swards.
- across all years, variations in both intake and milk and milk protein production were best explained by variations in LA.
- irrespective of DA, LA, or sward type, cows had a greater percentage of grass leaf, and a lower proportion of senescent matter in their diet than that which was in the sward on offer

The aim of grazing management in spring should be to maintain a leafy sward with minimal reproductive growth and hence senescent matter, in order to optimize both sward quality and metabolizable

energy intake and milk production over the entire season. Leaf allowance was a better determinant and/or predictor of dairy cow performance than either DA or GA, for the conditions in the present trials.

Table 4.6.1 : A COMPARISON OF ME INTAKE CALCULATED USING DIET COMPOSITION, COMPONENT ORGANIC MATTER DIGESTIBILITY, AND DRY MATTER INTAKES OBTAINED IN T1, T2, and T3, WITH THAT CALCULATED USING MILK YIELD AND UNFASTED LIVWEIGHT DATA

Year	Cow Group	Calculated ME Conc. of Diet* (MJ ME/Kg DM)	DM Intake (Kg DM/cow daily)	ME Intake (MJ ME/cow Daily)	Theoretical ME Intake** (MJ ME/cow daily)
1982/83	PLUR	9.4	16.1	151.3	133.1
	PLR	9.1	7.9	71.9	112.3
	PIUR	10.6	21.3	225.8	152.0
	PIR	10.7	7.1	76.0	123.0
1983/84 (round 1)	PUT	9.8	17.0	166.6	175.3
	PT	10.8	13.5	145.8	193.6
1984/85 (round 1)	L	8.5	14.0	119.0	158.2
	M	9.3	12.0	111.6	162.5
	S	10.4	11.0	114.4	141.6

* where ME (MJ ME/Kg DM) = 0.181 ± 0.01 OMD - 2.68 ± 0.66
(Bryant and Trigg, 1982)

** where ME intake (MJ ME/cow daily) = Mm + Ml + Mg
(Bryant and Trigg, 1982 (adapted from MAFF, 1975))

where Mm = allowance for maintenance including an activity allowance and a safety margin

Ml = allowance for milk production

Mg = allowance for change in liveweight

Table 4.6.2 : RESULTS OF STEPWISE REGRESSION OF SWARD CHARACTERISTICS AND HERBAGE ALLOWANCE ON DRY MATTER INTAKE (KG DM/COW DAILY) AND MILK YIELD (KG/COW DAILY) (KG/COW DAILY) (where N = 14)

Dependent Variable	Regression Equation	Total R ²	R ² due to LA
Dry Matter Intake (Kg DM/cow daily)	= 12.0-2.0(Y)-0.4(R)-2.5(C)+0.6(LA)	90.1	84.9
Milk Yield (Kg/cow daily)	= 34.3-2.8(Y)-1.4(R)-9.7(C)+1.9(LA)	93.4	10.5
Milk Protein Yield (Kg/cow daily)	= 1.22-0.15(Y)-0.02(R)-0.33(C)+0.094(LA)	92.3	25.8

Dependent Variable	Regression Equation	Total R ²	R ² due to RD
Milk Fat Yield (Kg/cow daily)	= 0.40-0.06(Y)-0.05(R)-0.32(C)+0.017 RD	66.0	21.2

where Y = year (1-3)
 R = grazing round (1, 2)
 C = cow type (1 = high breeding index cows,
 2 = monozygous twins)

LA = Leaf Allowance (Kg DM/cow daily)
 RD = DMD % of the residual herbage

Other variables which were free to enter into the equations were:

pre- and post-grazing herbage mass, height, DMD %; dry matter allowance (Kg DM/cow daily) and green matter allowance (Kg DM/cow daily)

Table 4.6.3 : CORRELATION MATRIX FOR PRE- AND POST-GRAZING (BG AND AG RESPECTIVELY) TOTAL HERBAGE MASS, HEIGHT, AND DRY MATTER DIGESTIBILITY (DMD), DRY, GREEN, AND LEAF MATTER ALLOWANCE (DA, GA, AND LA RESPECTIVELY), DRY MATTER INTAKE (DMI) AND MILK, MILK FAT, AND MILK PROTEIN YIELD (N = 14)

	BG Mass	BG Height	AG Mass	AG Height	BG DMD	AG DMD	DA	GA	LA	DMI	Milk Yield	Fat Yield
BG Height	0.89											
AG Mass	0.74	0.63										
AG Height	0.51	0.53	0.87									
BG DMD	-0.61	-0.36	-0.50	-0.14								
AG DMD	-0.34	-0.29	-0.35	-0.24	0.39							
DA	0.12	0.02	0.68	0.71	-0.30	-0.40						
GA	-0.30	-0.23	0.22	0.43	0.23	0.41	0.57					
LA	0.13	0.01	0.69	0.70	-0.31	-0.14	0.94	0.73				
DMI	0.03	0.06	0.37	0.49	-0.12	0.47	0.45	0.89	0.69			
Milk Yield	-0.13	-0.15	0.10	-0.10	-0.41	-0.03	0.29	0.37	0.41	0.38		
Fat Yield	-0.29	-0.31	-0.78	-0.23	-0.24	0.26	0.12	0.44	0.31	0.45	0.94	
Protein Yield	-0.12	-0.20	0.09	-0.12	-0.35	0.24	0.26	0.50	0.44	0.55	0.89	0.89

Where critical value for correlation coefficients : $K_{.05 [1,12]} = 0.53$

$K_{.01 [1,12]} = 0.66$

CHAPTER 5 THE INFLUENCE OF SWARD REGROWTH INTERVAL IN
AUTUMN/WINTER ON SWARD CHARACTERISTICS AND
DAIRY COW PERFORMANCE IN EARLY SPRING

5.1 INTRODUCTION AND OBJECTIVES

The influence of post calving nutrition on both immediate and subsequent cow production has been discussed by Bryant and Trigg (1982). In New Zealand the prevalence of late winter calving necessitates the provision of adequate feed at a time when pasture growth is normally low. To ensure adequate feed at calving, areas of a farm are closed for varying lengths of time in the autumn-winter period. There are conflicting reports regarding the influence of a long versus short period of regrowth in autumn/winter on sward characteristics and on the the performance of dairy cows grazing those swards, in early spring (Santamaria et al, 1979; Bryant and Cook, 1980; Holmes and McClenaghan, 1980; Santamaria and McGowan, 1982; Gray and Matthews, 1982; Bryant and L'Huillier, 1986). Conflicting results are due partly to environmental differences between studies (Bryant, 1982a). However, it is difficult to reconcile some of the conflicting results since most studies report either minimal sward measurements (Holmes and McClenaghan, 1980; Santamaria and McGowan, 1982; Bryant and L'Huillier, 1986) and/or predominantly animal measurements (Santamaria et al, 1979; Bryant and Cook, 1980; Gray and Matthews, 1982; Bryant and L'Huillier, 1986);

with cow condition and herbage allowance often being confounded with sward type.

The purpose of this trial was to assess the influence of a 60 day versus a 120 day period of regrowth in autumn/winter, on sward characteristics and on dairy cow performance when grazing these swards, in early spring.

5.2 MATERIALS AND METHODS

The trial was conducted between May and October 1984. The three 0.8 ha swards used in this trial were predominantly ryegrass/white clover with small proportions of prairie grass, cocksfoot, and *Poa annua*. These swards had been sown 10 years previous to the trial.

The trial was divided into three time periods. The first or 'sward preparation' period (May 21 - September 12) comprised the differential grazing of the experimental swards. The second or 'experimental' period (September 13 - October 4) involved the grazing of experimental swards by the experimental animals, and the collection of both sward and animal performance data. The third period or 'post experimental' period consisted of collecting milk and milk fat yield data from the experimental cows after their removal from the experimental swards.

5.2.1 PREPARATION PERIOD

The three experimental paddocks were grazed intensely (727 ± 75 kg DM/ha RHM) by dry cows in late May. In mid July two thirds of each paddock was fenced off and the fenced off area grazed intensely (733 ± 114 kg DM/ha RHM) by dry cows to produce the SR swards. The remaining third was left ungrazed (LR swards). A diagram of the experimental area is given in Figure 5.1 (page 265).

Net herbage accumulation rates (NHA) on each sward type were measured throughout the preparation period. The average period of regrowth was 60 days for SR swards (range of 56 - 67 days) , and 120 days (range of 115 - 123 days) for the LR swards. Details of the grazing dates and RHMs for each paddock during the preparation period are presented in Appendix 5.2.

During August and early September the cows to be used in the experimental period were grazed with the main milking herd which was fed at a generous herbage allowance. The milk , milk fat and milk protein yield of the experimental animals was measured on two consecutive days per week for the two weeks preceeding the experimental period. Unfasted liveweight was taken on two consecutive mornings immediately preceeding the experimental period. The milk yield and unfasted liveweight data collected in the preparation period were used as covariates in the analyses of effects of sward type on cow performance in the experimental

period.

5.2.2 EXPERIMENTAL PERIOD

The cows were grazed on their appropriate sward types at a common nominal DA (26 kg DM/cow daily) for a period of 21 days. Management of the cows was similar to that described in Chapter 4 with the exception that, a) the daily herbage break was given after the morning milking, and b) any signs of estrous were noted but the animals were not mated.

5.2.3 POST EXPERIMENTAL PERIOD

After the experimental period the cows were returned to the main milking herd, and fed at a generous herbage allowance. Milk and milk fat yield of the experimental cows was measured on two consecutive days in the week immediately following the experimental period, and again on one day in the fifth week following the experimental period.

5.2.4 MEASUREMENTS TAKEN DURING THE EXPERIMENTAL PERIOD

Unless otherwise indicated, the methods of measurement are those described in Appendix 2.2.

SWARD MEASUREMENTS

The following sward characteristics were measured throughout the experimental period:

- (i) pre-grazing herbage mass and composition - 5 days/week
- (ii) RHM (residual herbage mass) - 5 days/week
- (iii) pre-grazing sward surface height and herbage bulk density - 4 days/week
- (iv) pre- and post-grazing herbage mass and composition of five vertical strata within the sward canopy - 3 days/week
- (v) DMD and OMD in vitro and N % of the total herbage, grass leaf, grass stem, and of the total herbage within each vertical stratum (all on pre-grazing herbage) - 2 bulked samples per paddock

- (vi) DMD and OMD in vivo of the total pre-grazing herbage, measured using three sheep per sward type - 2 consecutive five day periods during weeks 2 and 3

COW MEASUREMENTS

The following cow measurements were taken during the three week experimental period (on a per cow basis unless otherwise indicated):

- (i) milk, milk fat and milk protein yield - 3 days/week
- (ii) fatty acid composition of milk fat - 1 day only at the end of week 3
- (iii) dry matter intake using the Cr_2O_3 dilution method - 2 consecutive five day periods during weeks 2 and 3 on four twin pairs only
- (iv) unfasted liveweight - 2 consecutive days 48-76 hours after cows were returned to the main milking herd

- (v) cow behaviour - over four 24-hr periods
in weeks 2 and 3 on six
twin pairs only

5.2.5 STATISTICAL ANALYSES

All pasture data were analysed according to a completely randomized model (Chapter 2). Animal production data were analysed according to a repeated measurements analysis of covariance (Chapter 2), and the milk fat composition, unfasted liveweight and changes in unfasted liveweight, and animal behaviour data were subject to univariate analysis of variance according to a randomized block design.

5.3 RESULTS

5.3.1 SWARD PREPARATION PERIOD

Following a wet early autumn, the remainder of the autumn/winter period was warmer and drier than the 55 year average for the area (Appendix 2.1). The net accumulation rate of herbage over the May/July period was similar for both the LR and SR swards (Table 5.1 (commencing on page 266)). From July to September there was a difference in NHA between the sward types at $p < 0.10$, with LR swards having a higher NHA than SR swards (42 and 35 kg DM/ha daily respectively) (Table 5.1). The use of a probability of less

than 10 % is justified here due to the small number of observations in this analysis (N = 6).

5.3.2 EXPERIMENTAL PERIOD

5.3.2.1 PRE-GRAZING SWARD CHARACTERISTICS

In early spring, swards grazed twice (SR swards) over the mid May - mid September period showed marked contrasts in pre-grazing sward characteristics compared with swards grazed once between May and September (LR swards).

The pre-grazing total DM mass and sward surface height on LR swards were greater than that on SR swards, while the bulk densities of the two sward types were similar (Table 5.2). Although the pre-grazing herbage in each sward type contained similar percentages of grass leaf and weed, LR swards had greater percentages of grass stem and senescent material, and lower percentages of clover stem and clover leaf than SR swards (Table 5.3). Nevertheless, LR swards contained greater masses (kg DM/ha) of total green matter and total leaf matter (Table 5.4). The total mass of clover present was greater on SR swards, which was due to the presence of a greater mass of clover leaf, since both sward types had equal masses of clover stem (Table 5.4).

Despite the total herbage on LR swards having lower values for DMD and OMD (Table 5.3), the total masses of digestible dry matter and digestible organic matter (DDM and DOM respectively) were greater on the LR compared to SR swards (Table 5.4). The DMD and OMD of grass leaf in the SR swards was greater than that in the LR swards (Table 5.3). The OMD of the grass stem in the SR swards was also greater than that in LR swards, and while the DMD of the grass stem followed similar trends, the difference in DMD between the two sward types was not significant (Table 5.3). The N % in the total herbage was greatest on SR swards (Table 5.3).

Values for the DMD and OMD of total herbage measured in vivo are presented in Table 5.5. As with in vitro estimates, the values for both DMD and OMD were greater for the SR than the LR herbage. The absolute values were, however, lower when the DMD and OMD were estimated in vitro than when measured in vivo. In addition, the differences in herbage quality between the two sward types were more marked for the in vitro than the in vivo measurements.

Analyses of data obtained from vertical distribution measurements indicated that on a per stratum basis (stratum 1 = 0-4 cm, stratum 2 = 4-12 cm, stratum 3 = 12-20 cm, stratum 4 = 20-28 cm, stratum 5 = 28+ cm), there was no difference between sward types in the mass of total herbage present in stratum 1, while in strata 2-5 the LR swards had consistently greater masses of total herbage present than SR swards (Figure 5.2). The

proportional contribution of each vertical stratum to the total mass differed between sward types (Table 5.6). Approximately 50 % of the total herbage mass in SR swards was concentrated in the lower 4 cm of the sward, while in LR swards approximately one third of the total herbage mass was present in the lower 4 cm of the sward.

The masses of each herbage component in each vertical stratum are presented in Figure 5.2 and Appendix 5.3. In Figure 5.2 the masses of clover stem and leaf are combined, since their values were rather small in some of the strata (Appendix 5.3). The mass of weed present in any stratum of both of the sward types was small (Appendix 5.3), and thus the illustration of weed mass is omitted from the figure.

In strata 1 and 2, the masses of grass stem and senescent matter present were greatest in LR swards, while the masses of clover leaf present were greatest in SR swards. In stratum 1 the masses of grass leaf and clover stem were greater in the SR than LR swards, while in stratum 2 the masses of grass leaf and clover stem were similar in both sward types.

In stratum 3 similar masses of grass stem and clover leaf and stem were present in both sward types, with the masses of grass leaf and senescent matter being greater in LR swards.

The effect of treatment on the component masses in strata 4 and 5 were not statistically analysed because of high standard deviations surrounding the means. However, the following trends were evident. In stratum 4 the LR swards had greater masses of grass leaf and stem, senescent matter and clover leaf present, and in stratum 5, the mass of grass leaf present was greatest in LR swards. Senescent matter was present in stratum 5 for the LR swards only.

The DMD and OMD of total herbage within each stratum was greater for SR than LR swards (Table 5.7). There was also an overall effect of stratum on the DMD and OMD of the total herbage. The lowest values of DMD and OMD were measured in stratum 1, followed by that in stratum 2, with herbage in strata 3, 4, and 5 (LR swards only for stratum 5) having the highest values for both the SR and LR swards.

5.3.2.2 HERBAGE ALLOWANCE AND INTAKE

The target herbage DA of 26 kg DM/cow daily was realized for cows grazing both sward types (Table 5.8). Offering cows a common DA resulted in animals on the SR swards being offered a greater GA and LA (allowances of green matter and leaf matter respectively) than those animals grazing LR swards.

Herbage DMI estimated by the difference method was similar for both groups (12.8 and 12.5 kg DM/cow daily on the SR and LR swards respectively)(Table 5.8). When estimated by the Cr_2O_3 dilution method, DMIs were again similar for both groups of cows (Table 5.8). However, the average value for DMI estimated by the Cr_2O_3 method was greater than that estimated by the difference method (16.0 and 12.7 kg DM/cow daily respectively).

The cows grazing the LR swards left a greater RHM than those grazing the SR swards (2610 and 1520 kg DM/ha respectively)(Table 5.8).

Of the total herbage which disappeared between pre- and post-grazing sward sampling, those cows grazing the LR swards appeared to derive a greater percentage of their diet from strata 4 and 5 than the cows grazing the SR swards (Table 5.9). There was no significant difference between sward types in the percentage contribution of herbage in strata 1, 2, and 3 to the total herbage consumed. The percentage contribution of herbage which disappeared from each vertical stratum to that of the total herbage disappearing in each sward type (Table 5.9) was compared to the percentage contribution of the herbage in each stratum to that of the total pre-grazing herbage mass (Table 5.6) using a $t_{(s)}$ test (Appendix 5.4). For cows grazing the SR swards, the percentage contribution of herbage mass in each stratum to that of the total herbage disappearing was not significantly different from the percentage contribution of each stratum to the

pre-grazing herbage mass. For those animals grazing the LR swards, the percentage contribution of herbage mass in strata 1, 2, 3, and 5 to that of the total herbage which disappeared was not significantly different from the percentage contribution of these strata to the pre-grazing herbage mass. The percentage contribution of the herbage mass in stratum 4 to the diet was greater than that to the pre-grazing herbage mass.

Of the total herbage that disappeared over the grazing period, and was therefore presumed to have been eaten, that disappearing from the LR swards contained a greater percentage of senescent matter, and a lower percentage of clover leaf than that disappearing from the SR swards (Table 5.10). The percentages of grass stem, grass leaf, and clover stem in the herbage presumed to have been eaten was similar for both sward types.

Cows grazing both the LR and SR swards had a lower percentage of grass stem in the diet than that which was in the respective herbage on offer (Appendix 5.5). In addition, cows on the LR swards had a smaller percentage of senescent matter present in their diet than that which was on offer in the LR swards. Those animals grazing the SR swards had a greater percentage of clover leaf in their diet than that which was on offer in the SR swards. The percentage of grass leaf and clover stem in the diet was similar to that on offer for cows grazing both the LR and SR swards.

5.3.2.3 COW MEASUREMENTS

MILK, MILK FAT, AND MILK PROTEIN YIELD

After adjustment for production levels during the preparation period, the quantities of milk, milk fat, and milk protein produced per day were greatest for cows grazing the SR swards, across all three weeks of the experimental period (Table 5.11)(Figures 5.3, 5.4, and 5.5 for milk, milk fat, and milk protein yield respectively).

COMPOSITION OF MILK FAT

The fatty acid composition (% by weight of short ($C_{6:0}$ - $C_{14:1}$) and long ($C_{18:0}$ - $C_{18:1}$) chain fatty acids) of milk fat samples taken on one occasion at the end of week three were similar between the 2 groups (Table 5.11).

UNFASTED LIVWEIGHT

Between 48 and 72 hrs after the experimental period ended, unfasted liveweights, adjusted for liveweights at the start of the experimental period, were similar for both groups of animals (Table 5.11). In addition, unfasted liveweight changes over the three week experimental period were similar and positive for both groups of animals (Table 5.11).

ANIMAL BEHAVIOUR

Due to the different error structures inherent in animal behaviour observations made during daylight versus darkness, results obtained for the two time periods were analysed separately.

During daylight hours (approximately 0600-1830 hours) those animals on the SR swards spent less time grazing and more time lying down and standing than cows on the LR swards (Table 5.12a). Time spent walking within the paddock, and time spent ruminating was similar for both groups.

During the hours of darkness, the cows on the SR swards spent more time grazing and less time ruminating than those grazing the LR swards (Table 5.12b). Both groups spent equal time lying down, standing, and walking.

There was an overall effect of observation day during both light and dark hours (Table 5.13a). In day 4, during daylight, all cows spent less time grazing, standing, and walking, and more time lying down than in the other days. Day 4 was exceptionally warm, with very little wind (Appendix 5.6). During darkness, time spent lying down was less, while standing times were greater in day 3 than in any of the other periods (Table 5.13b). Day 3 was unusually wet and windy (Appendix 5.6).

5.3.3 POST EXPERIMENTAL PERIOD

Milk and milk fat yield data collected in week 1 were analysed separately to that in week 5. When milk fat yield data were subject to analysis of covariance, the covariate, pre-experiment milk fat yield, was not significant. Thus, milk fat yield in the post experimental period was subject to analysis of variance.

There was no difference in either milk or milk fat yield between the animals previously grazed on the SR or LR swards, in both the first and fifth week following the experimental period (Table 5.14)(Figures 5.3 and 5.4 for milk and milk fat yield respectively).

5.4 DISCUSSION

A 60 day period of regrowth (SR swards) in autumn/winter resulted in 40 % less herbage being present on those swards in early spring than on swards which had had 120 (LR) day regrowth interval (Table 5.2). However, the herbage present on the LR swards contained only half the percentage of clover, over twice the percentage of dead matter, and had 8 % and 18 % lower values for total herbage OMD and N % respectively, than herbage on the SR swards (Table 5.3.). At a common DA, cows grazing the SR swards had similar DMIs to cows grazing LR swards (Table 5.8), yet

produced approximately 10 % more milk, milk fat, and milk protein (Table 5.11 and Figures 5.3 - 5.5).

The effects of autumn/winter grazing management on various aspects of immediate and subsequent pasture and/or dairy cow production have been the subject of a number of studies in Australasia in recent years (section 5.1). In the experiments conducted, detailed concurrent sward and animal measurements are the exception (Ryan, 1986) and thus comparisons between these studies and the present trial are necessarily restricted.

5.4.1 NET HERBAGE ACCUMULATION OVER THE AUTUMN/WINTER PERIOD

The absence of an effect of regrowth interval in autumn/winter on NHA over May 25-July 20 is to be expected, as swards had yet to be differentially grazed. The higher NHA on LR swards during the latter part of the late winter/early spring (July 20 - September 13) (Table 5.1) is in agreement with work reported by Ryan (1986) and Santamaria and McGowan (1982).

A greater NBA on the LR swards in late winter/early spring is not unexpected. LAI on LR swards would have been above the winter critical LAI of 3 (Brougham, 1960) over the July - September period, whereas at an initial post-grazing herbage mass of approximately 750 kg DM/ha (Appendix 5.2) the SR swards would probably have been below this critical LAI for some time (Bircham and Hodgson, 1983). Thus, the photosynthetic rate per unit area

would probably have been greater on the LR swards until the critical LAI on the SR swards had been reached. Although the rate of herbage decomposition is reported to increase linearly with increasing herbage mass (ibid), the loss of herbage through death and decay has been reported to be minimal during the cooler winter months (Brougham, 1960). The higher photosynthetic rates, coupled with minimal sward death were probably responsible for the greater NHA measured on the LR swards.

5.4.2 SWARD STRUCTURE AND COMPOSITION

The observed differences between the LR and SR swards in sward structure, composition, and quality were as expected, given the information available in the literature on the effects of regrowth interval on the sward characteristics of vegetative temperate swards (Santamaria and McGowan, 1982; Curll, 1982; Ryan, 1986).

It is interesting to note that while senescent herbage was confined to the lower twelve cm in the SR swards, senescent herbage was present in relatively substantial amounts in all strata of the LR swards (Figure 5.2) (Appendix 5.3). Dead herbage is generally assumed to be in the base of the sward, although evidence in the literature is limited to reproductive swards.

The relative presence of the various sward components in both the total herbage mass (Table 5.3) and in each stratum (Figure 5.2 and Appendix 5.3) was reflected in the digestibility and N values of that herbage (Tables 5.3 and 5.7), emphasizing the importance of the presence of young grass leaf and clover in maintaining herbage quality in a sward.

The mass of herbage remaining after grazing (Table 5.8) was proportional to that present before grazing (Table 5.2) for the two sward types, with an average degree of defoliation of 46 % measured for both. Both Meijs (1983), working with a range of herbage masses on perennial ryegrass swards (1400 - 4800 kg OM/ha), and Ryan (1986), working with mixed swards similar to those in the present trial, reported a directly proportional relationship between pre-grazing herbage mass and RHM, when DA was constant.

Despite the DA being only twice that of DMI (Table 5.8), the cows on the LR swards left a rather high RHM. A mean residual herbage mass of 2610 kg DM/ha on the LR swards in early spring would be expected to lead to rapid sward deterioration in mid-late spring (Chapter 4). Maintaining levels of herbage intake on swards with a low pre-grazing herbage mass, and thus achieving a low RHM is desirable for both optimal pasture and animal husbandry. While there is obviously a limit to which a low pre-grazing herbage mass will sustain DMI (Hodgson, 1977), the concept is of practical importance to the maintenance of sward

quality throughout the year.

5.4.3 ALLOWANCE AND INTAKE

A common DA of 26 kg DM/cow daily resulted in a common DMI despite animals on the SR swards being offered greater amounts of green matter and leaf matter than those grazing LR swards (Table 5.8). This was somewhat unexpected since DMI has been reported to increase with increasing GA or LA (Langlands and Sanson, 1976; Hodgson, 1982; Chapter 4 in the present study). It may be that the difference in mass of leaf on offer between the two sward types (14 and 17 kg leaf DM/cow daily for the LR and SR swards respectively) was not great enough to promote differences in DMI within the range of sward types in the present trial.

Ryan (1986) also reported common DMIs for cows grazing swards similar to those in the present trial when DA was controlled at 22 kg DM/cow daily. The DAs in both this study and in that of Ryan's were only twice the quantity of DM eaten, and so may have been restricting potential DMIs (Bryant and Trigg, 1982). The DA may therefore have been too low for sward characteristics of the LR and SR swards to have had a differential effect on DMI. Results of milk fat composition measurements indicate that if a DA of 26 kg DM/cow daily was restricting intake, it was doing so to a similar extent for both sward types (Table 5.11).

Total grazing times were longer for cows on the LR swards (by 38 min \pm 11 min) (Table 4.12). Since DMIs were similar, the rate of intake would have been lower for these animals compared to cows on the SR swards (1.6 versus 1.7 kg DM/hr for cows grazing the LR and SR swards respectively). A lower rate of intake would probably manifest itself through a slower RB and/or a smaller IB (Hodgson, 1982). The presence of a large percentage of senescent matter throughout the sward profile in LR swards may have been a reason for a lower intake rate (Hughes, 1983). The fact that cows grazing the LR swards had a smaller percentage of senescent matter in their diet than that which was present in the sward on offer (Appendix 5.5) suggests that there may have been some form of discriminatory grazing (on a site and/or bite basis) by these animals, which may account for the decreased rate of intake. Grazing times over 24 hrs (Tables 5.12 and 5.13) were well within the range of values quoted for dairy cows grazing temperate swards (Arnold, 1981; Stockdale and King, 1983), so it is unlikely that either group of cows limited grazing time due to fatigue or the need for social interaction.

There did not appear to be any preferential grazing by the cows within any of the designated 5 vertical strata within the sward canopy of both the SR and LR swards (Appendix 5.4). However, this result must be interpreted with caution, since the errors surrounding the means for the diets are high (Table 5.9). It is therefore difficult to demonstrate significant differences between the percentage contribution of a particular stratum to the

diet and that to the total pre-grazing herbage mass.

Intakes estimated by the Cr_2O_3 dilution method were greater than those estimated by the difference method, and were also more variable as reflected in the greater standard errors reported with this method (Table 5.8). Mitchell (1985), in a grazing trial conducted at the same site as the present study and at the same time of year, also found marked variation between intake measurements when estimated by the difference method and by the Cr_2O_3 dilution method. In Mitchell's case, DMIs measured using the Cr_2O_3 dilution method were over 50 % greater than those measured using the difference method. Carruthers and Bryant (1983) reported a 14 % overestimation of intake compared to total collection measurements when using the Cr_2O_3 dilution method to estimate intake in an indoor feeding experiment. In the present study, compared to the difference method, intakes were 21 % and 30 % greater with the Cr_2O_3 dilution method for cows grazing the LR and SR swards respectively.

5.4.4 MILK PRODUCTION

Despite the two groups of cows having similar DMIs, the cows on the SR swards produced more milk, milk fat, and milk protein (Table 5.11 and Figures 5.3 - 5.5). Ryan (1986), working with high breeding index cows, reported similar differences in yield between animals grazing SR and LR swards at a common DA of 22 kg DM/cow daily. However, Santamaria et al (1979) found no effect of

sward type on milk and milk solids yield when DAs of either 10 or 20 kg DM/cow daily were given, but that at a DA of 40 kg DM/cow daily cows on the SR swards did have greater milk and milk fat yields than those grazing LR swards, despite the latter having greater DMIs.

By taking the data on the proportional contribution of the various strata to the diet (Table 5.9), and the OMD of each stratum (Table 5.7), it is possible to calculate the probable ME concentration of the diet and therefore the probable total ME intake of both groups of animals (Appendix 5.7). These calculations indicate that the diet of the cows on the LR swards had a probable ME concentration of 11.2 MJ/kg DM compared to 12.4 MJ/kg DM for cows on the SR swards. These figures translate into a probable total daily intake of 140 and 159 MJ ME/cow daily for cows on the LR and SR swards respectively.

Using the equations of MAFF (1975)(and substituting fat corrected milk (FCM) for solids corrected milk (SCM) for the sake of simplicity (Bryant and Trigg, 1982)), with the milk and milk fat yields and liveweight gains recorded in this trial, the theoretical intake of ME needed to support the levels of production measured is calculated to be 144 and 161 MJ ME/cow daily for cows on the LR and SR swards respectively (Appendix 5.8). These figures are very similar to those calculated for probable ME intakes. These calculations support the view that when DMIs were similar for both groups, the extra milk and milk

fat yield of the cows on the SR swards can be accounted for by the greater probable concentration of ME in the diet of these animals.

Rumination times over a 24 hour period were approximately 1 hour longer for cows on LR than SR swards (6.6 versus 5.45 ± 0.23 hours/24 period respectively) (Table 5.12). When expressed as the time spent ruminating per kg DMI, cows on the LR swards spent approximately 6 min ± 2 min longer ruminating per kg DMI than cows on the SR swards. This may indicate that the size of herbage particles ingested was greater on the LR swards, and that intake was probably of lower a quality (Lee and Pearce, 1984; Ulyatt et al, 1986). Hancock (1954) reported increases in the ruminating times of grazing dairy cows when herbage quality decreased. Furthermore, the apparent greater proportion of clover in the diet of cows on the SR swards (Table 5.10) would result in a faster rate of disappearance of digesta from the rumen, reducing the need for rumination (Thornton and Minson, 1973). The total rumination times monitored over a 24 hour period (Tables 5.12 and 5.13) are similar to those reported elsewhere for dairy cows (Arnold, 1981).

The effects of sward type on milk and milk fat production were limited to the experimental period (Table 5.14 and Figures 5.3 and 5.4). One week after the cows were returned to the main herd, milk and milk fat yield were similar for both groups, and were higher than during the experimental period. The cows previously grazed on the LR swards appeared to increase their production of both milk and milk fat to a greater extent than the

cows previously grazing the SR swards. The cows in the main herd were being fed at a more generous allowance than that received by the experimental animals, as evidenced by the greater RHM (by eye estimation) on paddocks grazed by the main herd when the experimental period was in progress. This may account for the increase in milk yield and milk fat production of experimental animals on return to the main herd, and supports the suggestion that the DA of 26 kg DM/cow daily in the present trial was limiting DMI.

In the present trial, when DA was set at 26 kg DM/cow daily, the LR swards were theoretically supporting 184 cows/ha for a 24 hr period, compared to 111 cows/ha for a 24 hr period being supported by the SR swards. Thus, although individual cow production was greater on the SR swards, production per ha over this period was greater on the LR swards (3054 and 2031 kg/ha of milk, and 144 and 96 kg/ha of milk fat for the LR and SR swards respectively). The relevance of the above with regards to seasonal milk fat production and/or the feed supply situation in the early spring needs to be assessed.

In 1982 Bryant stated that 'the lack of information about amounts of feed that should be on the farm in spring and how best to achieve it is the greatest gap in our knowledge of autumn/winter management'. The objectives of the present study were to examine in detail a small but crucial part of that gap. While these objectives were essentially met, a number questions

remain unanswered. There is a need for more longer term studies (ie Bryant and L'Huillier, 1986), which include detailed sward and animal measurements, on the effects of grazing regime in the autumn/winter on both sward and cow performance throughout the autumn/winter period and in the following spring.

5.5 CONCLUSIONS

- (i) Swards that had been allowed to regrow for 60 versus 120 days in autumn/winter had a lower NHA over the late winter period. In early spring the SR swards had a lower mass of total pre-grazing herbage, however, the percentage of clover was higher and the percentage of senescent matter lower, than that on LR swards.
- The quality of the total herbage as well as that of some of the herbage components was greater on the SR swards than that on LR swards.
- (ii) At a common DA of 26 kg DM/cow daily, cows grazing SR swards produced more milk, milk fat and milk protein than cows grazing swards that had been allowed to regrow for 120 days over autumn/winter, despite DMIs being similar. The greater production of milk and milk solids was attributed to the greater quality of herbage available and likely to have been eaten by the cows grazing the SR swards.

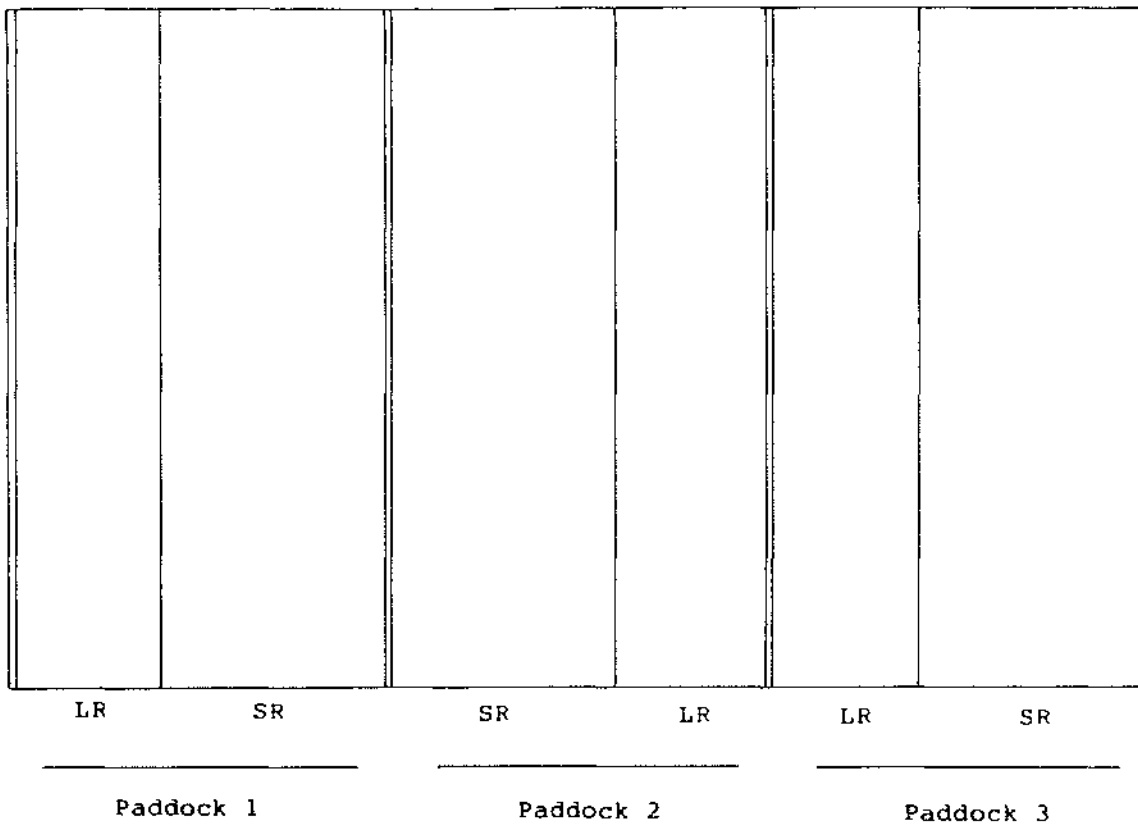


Figure 5.1 : DIAGRAM OF EXPERIMENTAL AREA

Table 5.1 : THE EFFECT OF REGROWTH INTERVAL IN AUTUMN/WINTER ON NET HERBAGE ACCUMULATION OVER MAY TO SEPTEMBER (KG DM/HA DAILY)

Net Herbage Accumulation (Kg DM/ha daily)	Sward Type		SE (LSM)	Sig. Level
	LR*	SR		
May - July	22.9	20.7	0.7	NS
July - September	41.8	35.3	1.2	0.10

* LR = Long Regrowth Interval in Autumn/Winter (120 days)

SR = Short Regrowth Interval in Autumn/Winter (60 days)

Table 5.2 : THE EFFECT OF REGROWTH INTERVAL IN AUTUMN/WINTER ON PRE-GRAZING HERBAGE MASS (KG DM/HA), SWARD SURFACE HEIGHT (CM) AND HERBAGE BULK DENSITY (KG DM/HA PER CM SWARD SURFACE HEIGHT) IN EARLY SPRING

	Sward Type		SE (LSM)	Sig. Level
	LR*	SR		
Pre-grazing Herbage Mass (Kg DM/ha)	4788	2894	113	****
Sward Surface Height (cm)	32	20	1	****
Herbage Bulk Density (Kg DM/ha per cm Sward Surface Height)	146	140	5	NS

* For interpretation of abbreviations see Table 5.1

Table 5.3 : THE EFFECT OF REGROWTH INTERVAL IN AUTUMN/WINTER ON THE COMPOSITION (% DRY WEIGHT), IN VITRO DRY (DMD) AND ORGANIC (OMD) MATTER DIGESTIBILITY (%), AND NITROGEN CONCENTRATION (N%) IN EARLY SPRING

		Sward Type		SE (LSM)	Sig. Level
		LR*	SR		
Composition (% Dry Weight)					
Grass Stem		22.2	17.1	1.1	***
Grass Leaf		50.6	53.8	1.3	NS
Clover Stem		3.7	7.3	0.5	****
Clover Leaf		4.0	13.2	0.8	****
Senescent Matter		18.3	8.3	1.3	****
Weed		1.3	1.0	1.6	NS
DMD (%)	Total Herbage	69.1	75.1	0.6	****
	Grass Leaf	77.0	79.0	0.2	**
	Grass Stem	72.6	76.2	1.7	NS
OMD (%)	Total Herbage	73.1	79.7	0.5	****
	Grass Leaf	80.1	82.1	0.2	**
	Grass Stem	76.1	79.5	0.5	*
N%	Total Herbage	2.64	3.22	0.07	*

* For interpretation of abbreviations see Table 5.1

Table 5.4 : THE EFFECT OF REGROWTH INTERVAL IN AUTUMN/WINTER ON THE PRE-GRAZING MASS OF HERBAGE COMPONENTS IN EARLY SPRING (KG DM/HA)

Component (Kg DM/ha)	Sward Type		SE (LSM)	Sig. Level
	LR*	SR		
Total Green Mass	3823	2661	90	****
Total Leaf Mass	2632	1997	87	****
Total Clover Mass	366	586	47	***
(Clover Stem Mass)	175	208	22	NS
(Clover Leaf Mass)	191	378	32	****
Total Digestible DM Mass	3308	2169	67	****
Total Digestible OM Mass	3136	2101	150	***

* For interpretation of abbreviations see Table 5.1

Table 5.5 : THE EFFECT OF REGROWTH INTERVAL IN AUTUMN/WINTER ON PRE-GRAZING HERBAGE IN VIVO DRY (DMD) AND ORGANIC (OMD) MATTER DIGESTIBILITY (%) IN EARLY SPRING (ALL NUMBERS ARE RAW DATA MEANS AND THEIR SD'S)

	Sward Type					
	\bar{x}	LR*	SD	\bar{x}	SR	SD
DMD (%)						
Days 1 - 5	77.5		(0.7)	79.5		(0.9)
6 - 10	72.3		(0.6)	75.9		(0.6)
OMD (%)						
Days 1 - 5	79.7		(0.6)	83.4		(0.5)
6 - 10	76.0		(0.6)	79.0		(0.6)

* For interpretation of abbreviations see Table 5.1

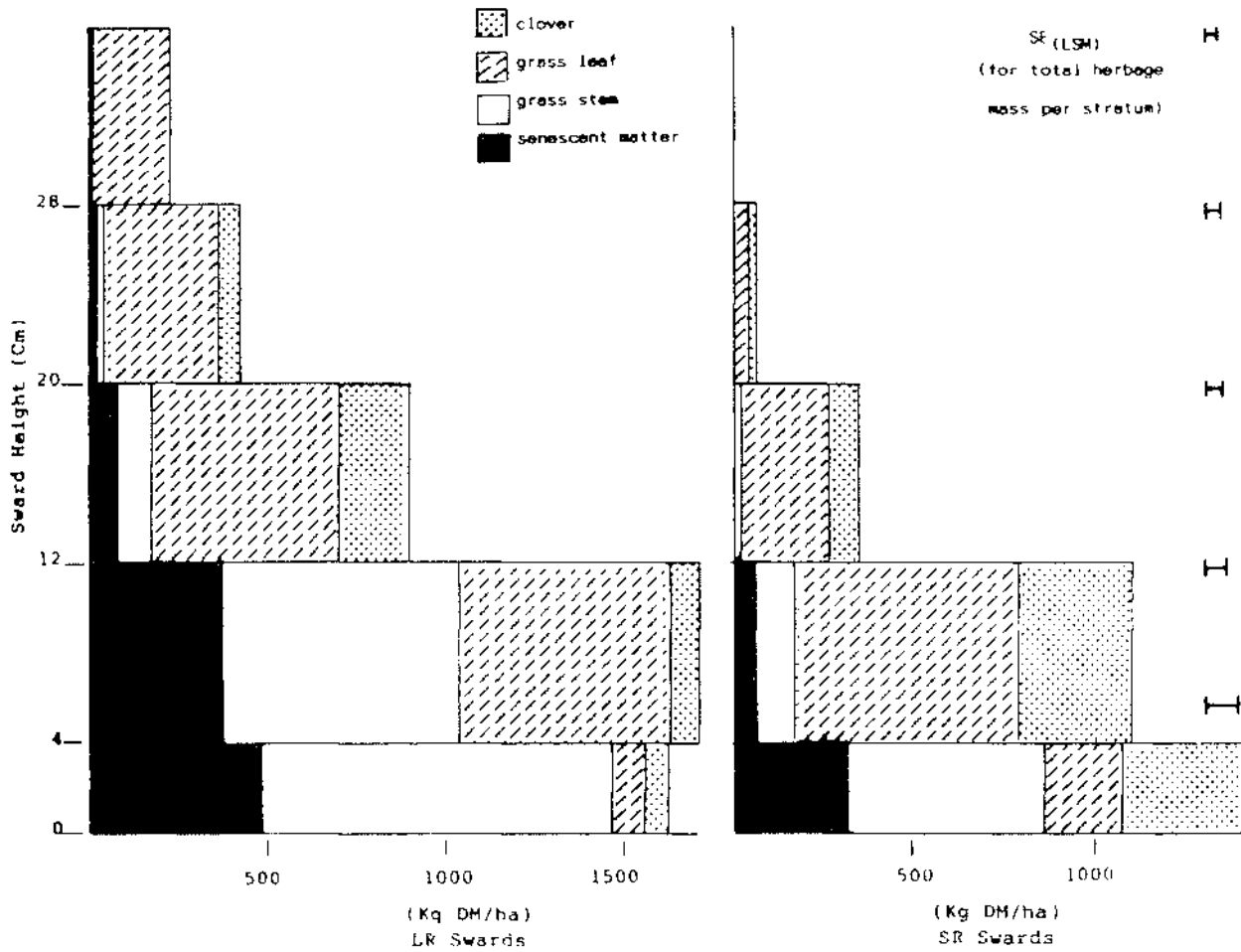


Figure 5.2 : THE EFFECT OF REGROWTH INTERVAL IN AUTUMN/WINTER ON THE PRE-GRAZING MASS OF CLOVER, GRASS LEAF, GRASS STEM AND SENESCENT MATTER IN EACH OF FIVE VERTICAL STRATA IN THE SWARD IN EARLY SPRING

Where LR = Long Regrowth Interval in Autumn/Winter (120 days)

SR = Short Regrowth Interval in Autumn/Winter (60 days)

Table 5.6 : THE EFFECT OF REGROWTH INTERVAL IN AUTUMN/WINTER ON THE PERCENTAGE CONTRIBUTION OF EACH VERTICAL STRATUM TO THE TOTAL PRE-GRAZING HERBAGE MASS IN EARLY SPRING (% DRY WEIGHT)

Stratum	Sward Type		SE (LSM)	Sig. Level
	LR*	SR		
1. 0 - 4 cm	33.5	48.1	2.2	****
2. 4 - 12 cm	35.6	38.3	2.0	NS
3. 12 - 20 cm	18.1	11.6	1.2	***
4. 20 - 28 cm	8.5	1.9	0.7	****
5. 28+ cm	4.3	0.3	0.6	****

* For interpretation of abbreviations see Table 5.1

Table 5.7 : THE EFFECT OF REGROWTH INTERVAL IN AUTUMN/WINTER ON THE
IN VITRO DRY (DMD) AND ORGANIC (OMD) MATTER
 DIGESTIBILITY OF THE TOTAL HERBAGE WITHIN EACH VERTICAL
 STRATUM OF PRE-GRAZING HERBAGE PRESENT IN EARLY SPRING
 (%)

Stratum	Sward Type			
	DMD	LR*	OMD	SR
1. 0 - 4 cm	64.7	70.0	71.3	76.1
SE (LSM)	1.0	0.9	1.3	1.1
2. 4 - 12 cm	71.2	75.7	73.8	80.1
SE (LSM)	1.0	0.9	1.8	1.5
3. 12 - 20 cm	74.8	78.8	78.1	82.1
SE (LSM)	1.0	0.9	1.3	1.1
4. 20 - 28 cm	75.1	79.0	76.5	80.4
SE (LSM)	1.3	1.1	1.8	1.5
5. 28+ cm	76.4	80.4	Not enough Sample	
SE (LSM)	0.8	0.7		

Probability for regrowth interval = $p < 0.001$ W/SR > LR

Probability for stratum = $p < 0.05$ W/Stratum 5,4,3>2>1

Probability for interaction = NS
 (using data from strata 1-4 only)

N = 32

* For interpretation of abbreviations see Table 5.1

Table 5.8 : THE EFFECT OF SWARD TYPE ON THE ALLOWANCE (KG DM/COW DAILY) OF TOTAL GREEN AND LEAF MATTER WHEN DRY MATTER ALLOWANCE WAS KEPT CONSTANT; ON THE DRY MATTER INTAKE (KG DM/COW DAILY) OF COWS GRAZING THOSE SWARDS; AND ON THE RESIDUAL HERBAGE MASS (KG DM/HA)

	Sward Type		SE (LSM)	Sig. Level
	LR*	SR		
Allowance (Kg DM/cow daily)				
Dry Matter	26.3	25.9	0.2	NS
Green Matter	21.5	23.8	0.3	****
Leaf Matter	14.4	17.3	0.3	****
Dry Matter Intake (Kg DM/cow daily)				
Difference Method	12.5	12.8	0.2	NS
Cr ₂ O ₃ Dilution Method	15.1	16.8	1.7	NS
Residual Herbage Mass (Kg DM/ha)	2610	1520	54	****

* For interpretation of abbreviations see Table 5.1

Table 5.9 : THE EFFECT OF SWARD TYPE ON THE PERCENTAGE CONTRIBUTION OF EACH VERTICAL STRATUM TO THE TOTAL DIET OF COWS GRAZING THOSE SWARDS IN EARLY SPRING (%)

Stratum	Sward Type		SE (LSM)	Sig. Level
	LR*	SR		
1. 0 - 4 cm	11.5	13.6	5.5	NS
2. 4 - 12 cm	35.0	59.2	7.3	NS (p<0.1)
3. 12 - 20 cm	32.3	21.9	3.6	NS (p<0.1)
4. 20 - 28 cm	14.3	4.2	1.6	***
5. 28+ cm	6.9	1.1	1.6	*

* For interpretation of abbreviations see Table 5.1

Table 5.10 : THE EFFECT OF SWARD TYPE ON THE COMPOSITION OF THE DIET OF COWS GRAZING THOSE SWARDS IN EARLY SPRING (% DRY WEIGHT)

Component	Sward Type		SE (LSM)	Sig. Level
	LR*	SR		
Grass Stem	2.5	1.7	1.1	NS
Grass Leaf	83.6	72.9	5.0	NS
Clover Stem	2.5	5.3	1.7	NS
Clover Leaf	4.0	18.9	0.3	***
Senescent Matter	7.4	1.3	1.8	*

* For interpretation of abbreviations see Table 5.1

Table 5.11 : THE EFFECT OF SWARD TYPE ON MILK, MILK FAT, AND MILK PROTEIN YIELD (KG/COW DAILY), AND ON THE FATTY ACID COMPOSITION OF MILK FAT (% BY WEIGHT) IN WEEK 3 OF THE EXPERIMENTAL PERIOD, AND ON UNFASTED LIVELWEIGHT AND CHANGES IN UNFASTED LIVELWEIGHT OVER THE EXPERIMENTAL PERIOD (KG)

	Sward Type		SE (LSM)	Sig. Level
	LR*	SR		
Milk Yield - Week 3 (Kg/cow daily)	17.0	17.8	0.5	***
Milk Fat Yield - Week 3 (Kg/cow daily)	0.81	0.87	0.04	**
Milk Protein Yield - Week 3 (Kg/cow daily)	0.57	0.62	0.02	**
Milk Fat Composition				
Short Chain Fatty Acids (% wt.)	25.11	26.98	1.38	NS
Long Chain Fatty Acids (% wt.)	35.58	34.31	1.39	NS
Unfasted Liveweight (Kg)	366	370	3	NS
Change in Unfasted Liveweight Over the Experimental Period (Kg)	3	7	3	NS

* For interpretation of abbreviations see Table 5.1

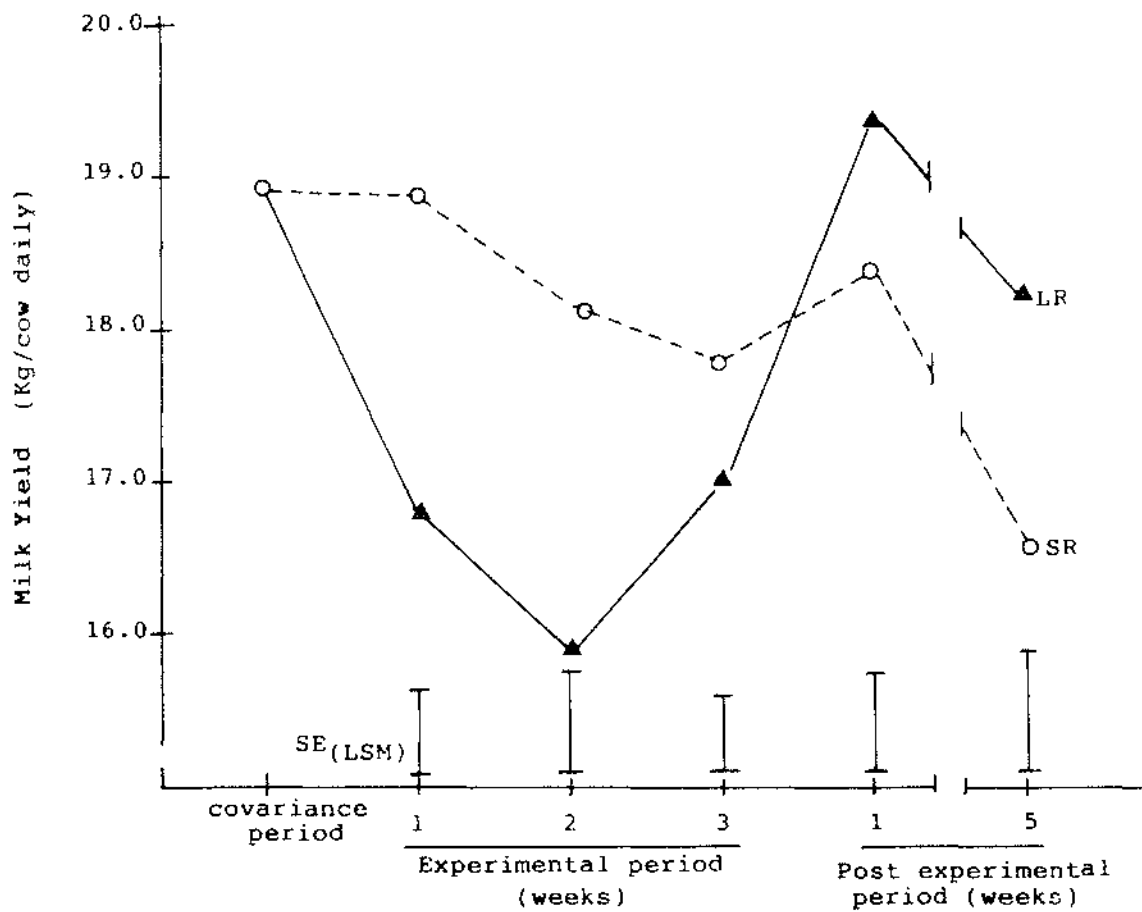


Figure 5.3 : THE EFFECT OF SWARD TYPE ON MILK YIELD IN THE EXPERIMENTAL AND POST EXPERIMENTAL PERIODS

Where LR = cows grazing long regrowth interval swards
 SR = cows grazing short regrowth interval swards

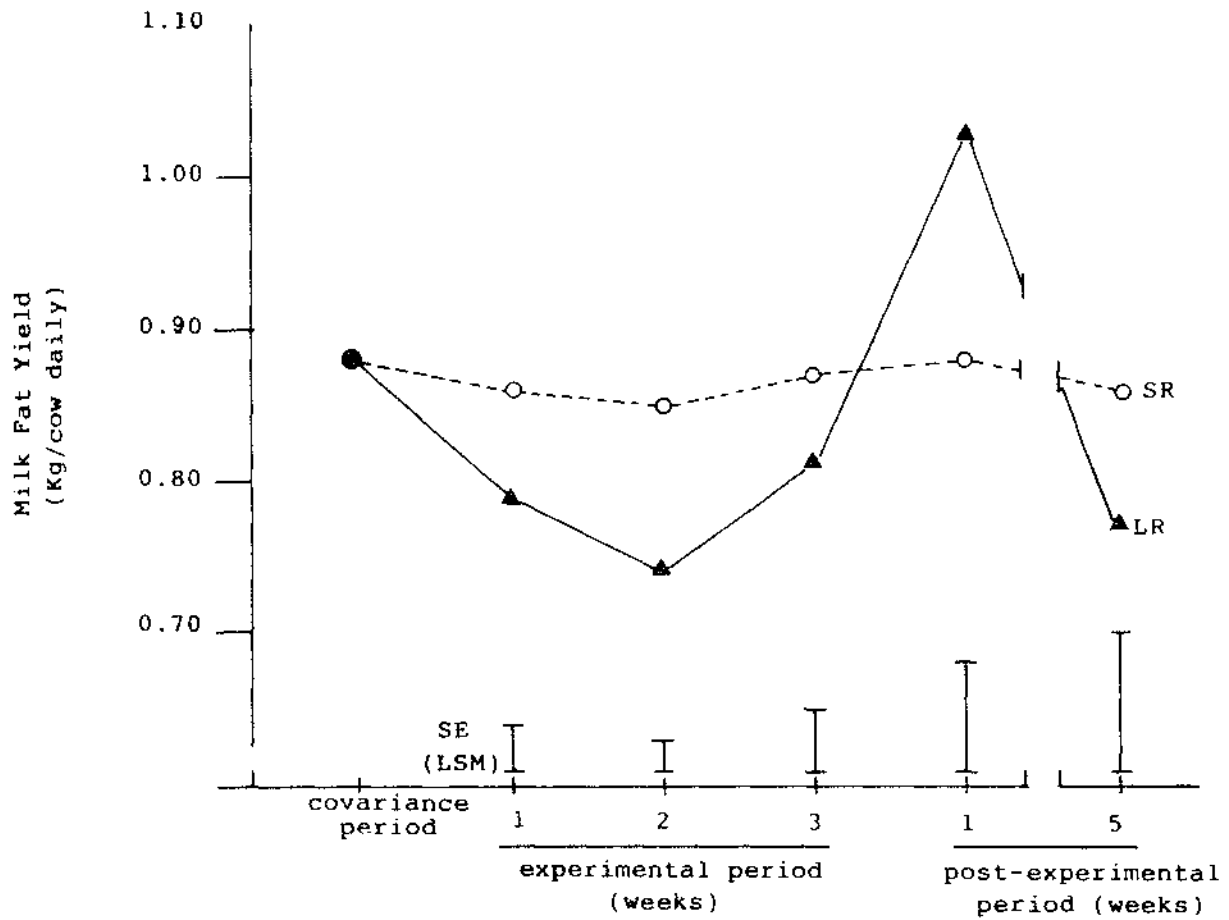


Figure 5.4 : THE EFFECT OF SWARD TYPE ON MILK FAT YIELD IN THE EXPERIMENTAL AND POST EXPERIMENTAL PERIOD

Where LR = cows grazing long regrowth interval swards
 SR = cows grazing short regrowth interval swards

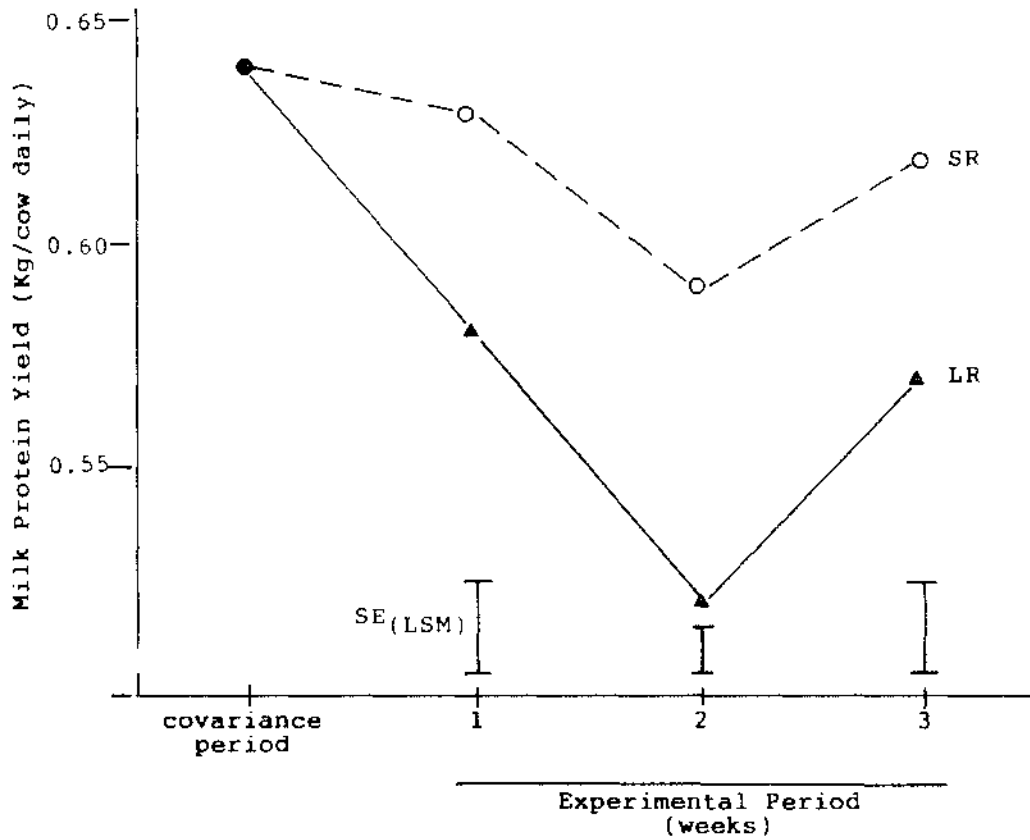


Figure 5.5 : THE EFFECT OF SWARD TYPE ON MILK PROTEIN YIELD IN THE EXPERIMENTAL PERIOD

Where LR = cows grazing long regrowth interval swards
 SR = cows grazing short regrowth interval swards

Table 5.12 : THE EFFECT OF SWARD TYPE ON THE AMOUNT OF TIME COWS SPENT AT EACH ACTIVITY DURING (a) DAYLIGHT AND (b) DARKNESS (IN HOURS)

Activity	Sward Type		SE (LSM)	Sig. Level
	LR*	SR		
(a) Daylight				
Grazing	6.35	5.12	0.07	****
Ruminating	1.46	1.64	0.09	NS
Lying	0.60	1.40	0.07	****
Standing	0.73	0.94	0.05	**
Walking	0.11	0.15	0.03	NS
(b) Darkness				
Grazing	1.43	2.02	0.11	***
Ruminating	5.11	4.05	0.14	****
Lying	3.20	3.22	0.12	NS
Standing	1.52	1.80	0.15	NS
Walking	0.02	0.19	0.08	NS

* For interpretation of abbreviations see Table 5.1

Table 5.13 : THE EFFECT OF OBSERVATION DAY ON THE AMOUNT OF TIME COWS SPENT AT EACH ACTIVITY DURING (a) DAYLIGHT AND (b) DARKNESS (IN HOURS)

Activity	Observation Day				SE (LSM)	Sig. Level
	1	2	3	4		
(a) Daylight						
Grazing	6.07 b*	6.36 b	6.07 b	5.51 a	0.10	****
Ruminating	1.67 b	1.26 a	1.72 b	1.14 a	0.12	***
Lying	0.38 a	0.86 b	0.43 a	1.76 c	0.10	****
Standing	0.76 b	1.17 c	1.03 c	0.39 a	0.08	**
Walking	0.13 ab	0.22 b	0.15 b	0.03 a	0.04	***
(b) Darkness						
Grazing	1.52	1.56	2.10	1.71	0.16	NS
Ruminating	4.94	4.50	4.21	4.69	0.20	NS
Lying	4.21 b	4.00 b	1.00 a	3.73 b	0.17	****
Standing	1.00 a	1.13 a	3.60 b	0.92 a	0.21	****
Walking	0.02	0.06	0.33	-	0.21	NS

* Means followed by different letters within rows are different at $p < 0.05$ (LSD)

Table 5.14 : THE EFFECT OF SWARD TYPE IN THE EXPERIMENTAL PERIOD ON MILK AND MILK FAT YIELD IN WEEK 1 OF THE POST EXPERIMENTAL PERIOD (KG/COW DAILY)

	Sward Type		SE (LSM)	Sig. Level
	LR*	SR		
Milk Yield - Week 1 (Kg/cow daily)	19.4	18.4	0.6	NS
Milk Fat Yield - Week 1 (Kg/cow daily)	1.03	0.88	0.06	NS

* For interpretation of abbreviations see Table 5.1

CHAPTER 6 GENERAL DISCUSSION AND CONCLUSIONS

The objectives of the present study were to: - monitor sward response to different grazing regimes throughout the year, and more specifically in the autumn/winter and spring periods, and - to measure dairy cow performance on the sward types created by the different grazing regimes, in early spring and early summer.

The aim of this chapter is to briefly review results and conclusions obtained, make brief comparisons with the most relevant published work, consider some of the problems associated with conducting grazing experiments, suggest areas for further research, and finally, relate the relevance of results obtained in this study to dairy farming.

6.1 RESUME OF RESULTS AND CONCLUSIONS

In chapter 3, season was shown to exert large effects on the characteristics measured. The effects of season on sward characteristics often interacted with grazing regime and sometimes with pasture mixture sown. The greatest changes in sward characteristics on all swards generally occurred between the late spring and early summer periods. Unfortunately, the effect of prairie grass swards could not be properly assessed because of

poor establishment of this species. However, there did not appear to be many significant differences between currently recommended versus out-dated cultivar mixtures of ryegrass/clover. In general, an intense and frequent grazing regime was the most satisfactory in terms of having the greatest overall NHA, minimal senescent matter, maximum values for DMD and N %, and the most constant mass of herbage present (total, green and digestible dry matter).

In the second set of experiments, intense defoliation in spring resulted in minimal reproductive growth and consequently a minimal percentage of senescent matter in the sward in early summer and a higher percentage of grass leaf and clover, and thus a higher herbage quality than swards that had been more leniently grazed. At both restricted and generous DAs, cows grazing the previously intensely grazed swards in early summer produced more milk and milk protein, and sometimes more milk fat, and this was attributed to a greater probable ME concentration of intake. However, at a common LA both DMI and milk and milk fat yield were not significantly affected by the type of sward on offer, although the botanic composition of DMI was affected by sward type on offer.. Variations in both DMI and milk yield were best explained by variations in LA, rather than by variations in DA and GA.

In chapter 5, swards that were subjected to a 60 day period of regrowth (SR) in the autumn/winter had a greater percentage of clover and grass leaf and a lower percentage of grass stem and

senescent matter in early spring than swards that were subjected to an 120 day period of regrowth (LR). At a common nominal DA of 26 kg DM/cow daily, cows grazing the SR swards produced more milk than cows grazing the LR swards, even though DMIs were similar. The greater milk yield of cows grazing the SR swards was attributed to a greater nutritive value of intake.

Conclusions to be drawn from the 5 trials in the present study are:

- the grazing regime which resulted in the highest values for total herbage digestibility and N %, the greatest percentages of leaf and clover, and the lowest percentage of senescent matter in a sward was an intense and frequent grazing regime. This grazing regime also resulted in the greatest overall NHA.
- milk yield was greatest on swards with a high percentage of grass leaf and clover and a low percentage of senescent matter, and this is attributed to the greater percentage of grass leaf and a lower percentage of grass stem and senescent matter in the diets of cows grazing these swards, as opposed to swards with a high percentage of grass stem and senescent matter
- leaf allowance played a major role in determining intake and production over a range of sward types.

- the herbage consumed by cows contained a greater percentage of leaf and a lower percentage of senescent matter than was contained in the sward, over a wide range of sward types and dry matter allowances.

6.2 COMPARISON OF RESULTS WITH RELEVANT PUBLISHED WORK

Bryant and L'Huillier (1986) have recently stated that wide variations in grazing management have negligible effects on the production (per cow and per hectare) of milk solids over the whole season. This conclusion was based on three seasons of farmlet studies, and is thus of considerable strength. Nevertheless, the same article states that grazing management in spring is likely to have an impact on both the seasonal production of milk solids, and on the subsequent performance of ryegrass and white clover in the sward. Conversely, autumn/winter grazing policies were reported to have very little longterm effect on milk solids production and pasture performance. It is difficult to critically appraise this report, since no estimates of the errors surrounding means quoted are given.

In more short term studies conducted by Thomson et al (1984), and Michell and Fulkerson (1985), the benefit of intense versus lenient grazing on both short and longterm milk production are stated, and this agrees with results of short term work reported

in the present study.

It is difficult to extrapolate results obtained in short term grazing experiments to that of a long term, on farm situation. The effects of grazing regime on sward performance may interact with year and environment, and so results from one study or area should not be extrapolated unreservedly to another situation. There is clearly a need for more work involving farmlet studies where both animal and sward performance are monitored.

The lack of ability to accurately predict DMI by grazing cows is a major hindrance to the development of more precise and effective feed budgeting programs for dairy cows. The prediction equation published by MAFF (1975) uses milk yield and liveweight to predict DMI, and while simplicity is its virtue, it takes no account of management or sward factors which affect DMI in grazing animals. However, Caird and Holmes (1986) reported that the equation of MAFF was reasonably accurate at predicting DMIs of dairy cows grazing ryegrass swards and receiving concentrates, in the northern hemisphere. Caird and Holmes developed a prediction equation, based on data collected over a range of trials in England, which considered in addition, the effect of herbage allowance (DA) and pre-grazing herbage mass, and level of concentrate eaten on DMI. Stockdale (1985) presented a prediction equation which considered the effects of DA and pre-grazing herbage mass and DMD on DMI. The data collected in the present study were used to test the ability of the equations proposed by

MAFF (1975), Caird and Holmes (1986) and Stockdale (1985) to predict DMI (Tables 6.1, 6.2 and 6.3 respectively, commencing on page 291).

All three equations generally underestimated DMI in the present study. Stockdale's equation had the lowest MSPE (mean square prediction error = $\Sigma(\text{actual} - \text{predicted DMI})^2/n$) (15.3), while the equation of MAFF had an MSPE of 33.4. The ability of Caird and Holmes' equation to predict DMI was intermediate to that of the others (MSPE = 22.7). None of the three equations predict DMI very satisfactorily.

Between environment differences in methods of measuring sward characteristics and DMI in a grazing situation account for some of the discrepancies noted. Given the present state of knowledge of the effects of, and interactions between, sward variables and herbage allowance on DMI, it is not surprising that most DMI prediction equations are only useful in the environment and under the conditions in which they were generated. Clearly, more work in this area is needed.

6.3 SOME PROBLEMS ASSOCIATED WITH MEASUREMENT TECHNIQUES USED

The purpose of this section is not to provide an exhaustive critique of problems associated with animal and sward measurements in grazing studies, for these have been expertly reviewed elsewhere (eg Hodgson et al, 1981b and Leaver, 1982). Rather, a

brief discussion of the measurement techniques that were surrounded by the greatest errors will be given, and where possible, alternative methods suggested.

The major problem associated with any grazing research is the lack of an effective method of estimating herbage intake. In the present study, intake was always estimated using the difference method, and in two of the five trials the Cr_2O_3 dilution method was simultaneously used. In both trials there was little agreement between the two methods in terms of absolute intakes, however, the relative trends evident were usually similar. In general, the Cr_2O_3 dilution method gave higher values for DMI than the difference method.

One of the major problems associated with the Cr_2O_3 dilution method is diurnal variation in the excretion of Cr_2O_3 in the faeces, and this has been attributed to the method of once or twice daily dosing with Cr_2O_3 . The development of a slow release device which releases a constant amount of Cr_2O_3 in the rumen over time shows great promise in rectifying this problem when evaluated on sheep (Parker, pers. comm.), although the appropriate work with cows has yet to be done.

One problem associated with estimating intake by the difference method is the high standard errors associated with this method. This was true even when pre- and post-grazing cuts were taken daily throughout the experiment, and the number of cuts

taken was the maximum physically possible in any one day. Although most of the absolute values of intake estimated by the difference method were realistic, there were several occasions when the figures were particularly high (ie, in chapter 4: Table 4.3.4, where cows on the PI-G treatment apparently ate 21 kg DM/cow daily).

The development of simple and inexpensive methods of estimating intake are necessary before any real progress can be made in determining relationships between sward structure, herbage allowance and DMI, and between DMI and milk yield.

Measurement of the composition of herbage consumed was also problematic. The method used in the present study is very tedious and time consuming. Nevertheless, this method was chosen in preference to the hand plucking method as the hand plucking technique was thought too subjective to be applied to the present sward types, given the grazing habits of the cows. The use of exclusion cages was also thought undesirable, since the swards were always heterogenous, and cows tended to graze in the entire sward horizon irrespective of sward type and DA.

The use of esophageal fistulates appeared to be a solution to the problem of estimating intake composition, and thus in the second year of the study two cows were fistulated at the esophagus. Unfortunately, the fistulae were placed in an unsatisfactory position which made the retrieval of ingested

material extremely difficult. After much patience and perseverance this method was abandoned. The entire exercise proved very costly and time consuming, and the wisdom of attempting to fistulate adult lactating cows is questioned.

The in vitro and in vivo estimates of whole sward DMD and OMD were usually quite different. In general, the in vivo measurements estimates were higher than the in vitro measurements for a particular sward type. This can be related to the different methods used to harvest the herbage. The in vivo measurements were taken on herbage cut 2 cm above ground level, while the in vitro measurements were taken on herbage cut to ground level. In the present study the absolute values of DMD and OMD were not as important as the relative ranking of the herbage of each of the sward types within any one year, and these rankings were similar for both methods. The use of wether sheep to estimate the in vivo digestibility of herbage grazed by lactating dairy cows must be questioned, since digestibility is affected by animal species and the physiological state of the animal. However, using lactating cows to estimate the in vivo digestibility of herbage being grazed by experimental animals necessitates a large input of resources which are usually stretched to the limit in any case. The important point to note here is that the absolute values of digestibility of the sward types were not of utmost importance in the present study. Rather, the relative differences in digestibility between sward types were of interest, and thus digestibility data collected using sheep were adequate for this

purpose.

One of the major problems in the conduct of grazing studies with dairy cows is the rapid escalation of workload when attempting to make simultaneous cow and sward measurements. Indeed, the replication of treatment groups, an elementary rule in experimentation, is often not possible. The major weakness in the present study is the lack of replication of animal treatment groups. Replication, apart from increasing workload, would have demanded cow numbers and land area that were beyond the scope of the facilities available. Nevertheless, the subject of replication of animal treatment groups in dairy cow grazing studies is one which needs addressing.

6.4 FUTURE WORK

One of the major needs of grassland based dairy farming is the development and/or refinement of more efficient ways to produce a given unit of milk solids. The results obtained in this study emphasize the importance of maintaining swards in a vegetative state, where grass leaf and clover are the main herbage components. This is important not only from the view of maintaining a pasture with a high photosynthetic capacity and growing point density but also from the view of maximizing metabolizable energy intake and milk production by the grazing cow.

In order to facilitate the development of more effective feeding systems, the relationships between LA, and DMI and milk production over a range of sward types and seasons need to be investigated, as it appears that both DA and GA are inadequate in predicting DMI and milk production.

There is a need for more work on the effects of grazing management on 'non traditional' dairy pasture species when grazed by dairy cows. This is especially important if these species continue to be recommended to dairy farmers; and if sown, are to be exploited to their full advantage and integrated effectively into grazing management policies on the farm.

The research that is most likely to make significant contributions to improving the efficiency of harvesting and converting herbage grown into animal products is that where cooperation of animal scientists and agronomist result in simultaneous measurements of animal and sward performance. There is much lost opportunity in conducting grazing research where only one or two components of a complex system are monitored. A number of more recent grazing studies with dairy cows which have included measurements of a greater range of sward variables (eg Thomson et al, 1984; Michell and Fulkerson, 1985; and Bryant and L'Huillier, 1986) is encouraging, and this trend must be continued.

6.5 RELEVANCE OF RESULTS TO DAIRY FARMING

While the results of the present ^{study} must not be extrapolated unreservedly to all dairy farm situations in New Zealand, the following recommendations can be made with confidence.

In the present study, yields of milk, milk fat, and milk protein were greatest on swards that had high values for digestibility and N %, a high percentage of leaf and clover, and a low percentage of grass stem (in early summer) and senescent matter. The management needed to maintain swards in this state throughout the year is an intense and frequent grazing regime. In order to ensure that swards are grazed intensely and frequently throughout, stocking rates must be high and/or conservation policies adequate. At a given stocking rate, the conservation of excess herbage will ensure the most efficient (in terms of output of milk solids/ha) use of herbage grown.

Table 6.1 : A COMPARISON OF DRY MATTER INTAKES (KG DM/COW DAILY)
MEASURED (BY DIFFERENCE) IN CHAPTER 4 AND 5 AND
PREDICTED USING THE EQUATION OF MAFF (1975)*

Trial	Dry Matter Allowance (Kg DM/cow daily)	Dry Matter Intake (Kg DM/cow daily)			
		Measured	Predicted	Deviation	
Chapter 4					
T1	PL-G	48	16.1	7.0	-9.1
	PL-R	12	7.9	6.6	-1.3
	PI-G	48	21.3	7.2	-14.1
	PI-R	12	7.1	6.9	-0.2
T2	PU Rnd 1	39	17.0	9.2	-7.8
	PT	44	13.5	9.5	-4.0
	PU Rnd 2	46	11.9	9.0	-2.9
	PT	44	13.0	9.3	-3.7
T3	L Rnd 1	64	13.9	8.6	-5.3
	M	45	12.2	8.7	-3.5
	I	33	11.2	8.5	-2.7
	L Rnd 2	81	11.4	8.3	-3.1
	M	56	13.4	8.5	-4.9
	I	35	11.9	8.3	-3.6
Chapter 5					
	LR	26	12.5	7.2	-5.3
	SR	26	12.8	7.3	-5.5

* Where Dry Matter Intake = $0.10 \text{ (Milk Yield)} + 0.015 \text{ (Liveweight)}$
(Kg DM/cow daily) (Kg/cow daily) (Kg/cow)

Table 6.2 : A COMPARISON OF ORGANIC MATTER INTAKES (KG OM/COW DAILY) MEASURED (BY DIFFERENCE) IN CHAPTERS 4 AND 5, AND PREDICTED USING THE EQUATION OF CAIRD AND HOLMES (1986)*

Trial	Organic Matter Allowance (Kg OM/cow daily)	Organic Matter Intake (Kg OM/cow daily)			
		Measured	Predicted	Deviation	
Chapter 4					
T1	PL-G	42	14.1	14.2	+ 0.1
	PL-R	11	7.0	6.2	+ 0.8
	PI-G	42	16.7	18.7	- 2.0
	PI-R	11	9.4	6.2	+ 3.2
T2	PU Rd 1	41	16.6	15.0	+ 1.6
	PT	38	17.3	11.9	+ 5.4
	PU Rd 2	35	19.1	10.5	+ 8.6
	PT	39	20.3	11.4	+ 8.9
T3	L Rd 1	56	14.6	12.2	+ 2.4
	M	40	17.0	10.7	+ 6.3
	I	29	16.6	9.9	+ 6.7
	L Rd 2	71	11.6	10.0	+ 1.6
	M	49	17.1	11.8	+ 5.3
	I	31	16.5	10.5	+ 6.0
Chapter 5					
	LR	23	12.0	11.0	+ 1.0
	SR	23	13.7	11.3	+ 2.4

* where: Organic Matter Intake = $0.323 + 0.177 (MY) + 0.010 (LW) - 1.008 HM + 0.54 (HA) - 0.006 (HA)^2$
(Kg OM/cow daily)

MY = Milk yield (Kg/cow daily)
LW = Liveweight (Kg/cow)
HM = Herbage mass (tonnes OM/ha)
HA = Herbage allowance (Kg OM/cow daily)

Table 6.3 : A COMPARISON OF DRY MATTER INTAKES (KG DM/COW DAILY) MEASURED BY DIFFERENCE) IN CHAPTERS 4 AND 5 AND PREDICTED USING THE EQUATION OF STOCKDALE (1985)*

Trial	Dry Matter Allowance (Kg DM/cow daily)	Dry Matter Intake (Kg DM/cow daily)			
		Measured	Predicted*	Deviation	
Chapter 4					
T1	PL-G	48	16.1	8.2	- 7.9
	PL-R	12	7.9	8.0	+ 0.1
	PI-G	48	21.3	11.2	-10.1
	PI-R	12	7.1	5.3	- 1.8
T2	PU	39	17.0	12.8	- 4.2
	PT	44	13.5	12.7	- 0.8
	PU	46	11.9	12.9	+ 1.0
	PT	44	13.0	12.5	- 0.5
T3	L	64	13.9	15.5	+ 1.6
	M	45	12.2	8.2	- 4.0
	I	33	11.2	9.6	- 1.6
	L	81	11.4	14.2	+ 2.8
	M	56	13.4	12.7	- 0.7
	I	35	11.9	10.0	- 1.9
Chapter 5					
	LR	26	12.5	10.6	- 1.9
	SR	26	12.8	8.6	- 4.2

* Where $DMI = -6.99 + 0.270 DA - 0.0018 DA^2 + 1.108 (HM) + 6.2 (DMD) - 0.633 (PT) + 0.011 (LW) - 1.46 (DE)$

DMI = Dry matter intake (Kg/cow daily)
 DA = Dry matter allowance (Kg/cow daily)
 HM = Pre-grazing herbage mass (tonnes DM/ha)
 DMD = Dry matter digestibility
 PT = Pasture type (always = 1)
 DE = Duration of experiment (always = 1)

Appendix 2.1 : METEOROLOGICAL DATA FOR EACH MONTH FROM APRIL 1982
TO MARCH 1985

(a) Air Temperature (°C) - Average Maximum and Minimum

	1982/83		1983/84		1984/85		52 year mean	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
April	17.2	8.5	17.5	9.8	18.4	9.7	18.2	9.6
May	15.4	6.5	14.5	7.3	14.6	7.5	15.0	6.8
June	12.1	4.3	12.7	5.2	14.0	7.2	12.6	4.7
July	12.0	4.0	11.4	3.9	13.1	5.6	11.9	4.0
August	13.0	4.9	13.3	6.1	14.3	6.4	13.1	5.0
September	14.5	6.2	15.1	7.7	15.1	6.9	14.7	6.6
October	14.6	7.6	17.1	9.8	16.3	8.2	16.6	8.3
November	18.3	11.8	18.5	9.0	20.1	11.6	18.5	9.8
December	18.4	10.3	19.7	11.3	22.6	13.6	20.6	11.6
January	19.4	11.7	20.9	11.4	23.5	14.3	21.9	12.8
February	21.5	12.1	21.9	12.2	23.2	12.9	22.3	12.8
March	20.1	12.1	22.0	13.0	21.0	11.6	20.9	11.7

(b) Total Rainfall (mm) and Hours of Sunshine (hrs)

	1982/83		1983/84		1984/85		52 year mean	
	Rain	Sun	Rain	Sun	Rain	Sun	Rain	Sun
April	10	183	88	114	39	157	81	136
May	81	126	82	84	96	115	89	112
June	65	83	93	84	87	60	97	94
July	63	125	35	79	97	95	89	104
August	53	121	64	90	46	126	89	122
September	49	123	117	104	57	115	54	133
October	80	143	57	86	42	142	88	158
November	61	132	54	149	80	161	78	177
December	161	N/A	68	184	103	210	124	193
January	60	211	35	210	124	210	81	209
February	30	187	91	195	37	211	67	186
March	49	145	114	147	39	197	69	170

APPENDIX 2.2 MEASUREMENT TECHNIQUES

2.2.1 ANIMAL MEASUREMENTS

2.2.1.1 MILK YIELD AND COMPOSITION

Daily milk yield was measured on three consecutive days per week during the experimental period and on two consecutive days per week during the preparation and post experimental periods. Milk sampling meters (Tru-test Distributors Ltd.), which sample a proportion of the milk flow of each cow, were used to measure milk yield. Daily milk yield was taken as the sum of the yield at the evening milking and the yield at the following morning's milking. Aliquots of milk from both milkings were combined and analyzed for fat and protein concentration using a Milko Scan 104 A/B (A/S N. Foss Electric, Denmark).

Milk, milk fat and milk protein yields were calculated for each cow and the figures averaged for the two or three days to give a mean value for daily yield per cow for each week. These data were subject to repeated measurements analysis of covariance (Chapter 2).

2.2.1.2 MILK FAT COMPOSITION

Samples of milk fat were obtained from each cow on two consecutive days in the final week of each experimental period, and analyzed for fatty acid content (% by weight). The $C_{6:0}$ - $C_{14:1}$ fatty acids were designated as the short chain, and $C_{18:0}$ and $C_{18:1}$ the long chain fatty acids (Mackenzie, pers. comm.).

The proportions of long and short chain fatty acids in the milk fat for each cow for each experimental period were taken as the average value of the two consecutive days. In Chapter 4 (T3) only, milk fat samples were taken on two consecutive days during the preparation period and analyzed for their fatty acid composition. The values obtained were averaged over the two days and the resultant value used as a covariate in the analysis of the effects of treatment on milk fat composition.

Analysis of Milk Fat

The content and concentration of fatty acids in milkfat were analyzed as their methyl esters using a Aerograph Varian 1200 Gas Chromatograph. The basis for the separation of the components being analyzed is the difference in the partition coefficients of the volatilized compounds between the liquid and gas phases as they are carried through the column by the gas.

Preparation of Fatty Acid Methyl Esters

Approximately 2.5 mgm of fat was weighed into a 0.3 ml reaction vial (Kontes Glass Co., USA) and the vial closed with a vapor-tight rubber seal. Approximately 25 μ l of transesterifying reagent was injected into the vial and the vial gently rotated for 5 minutes. Approximately 25 μ l of petroleum ether was then injected into the vial, with a further two minute mixing.

Analysis of Methyl Esters of Fatty Acids

Approximately 2.5 μ l of the prepared sample was injected on to the column at an initial column temperature of 50°C. The mobile gas phase was nitrogen flowing at 30 ml per minute. The temperature of the oven surrounding the column was programmed to increase at a rate of 6°C per minute to a final temperature of 200°C. The oven temperature was held at 200°C until the last of the sample had passed through the column. The hydrogen flame ionisation detector operated at 240°C using hydrogen and air flows of 30 and 300 ml per minute respectively.

Proportions of the individual fatty acids in the milk fat were obtained using a Varian Aerograph Digital Integrator 480.

2.2.1.3 UNFASTED LIVWEIGHT AND CONDITION SCORE

Cows were weighed after the morning milking (between 0700 and 0800 hours) on two consecutive days immediately prior to the commencement of the experimental period, and on two days commencing 48 hrs after the experimental period had terminated. The 48 hour interval between termination of the experimental period and first weighing of the animals was to minimize bias due to possible differential gut fill between the treatment groups.

The unfasted liveweight of each animal before and after the experimental period was taken as the mean of the two consecutive weights.

In Chapter 4 (T1 and T2) three independent observers condition scored the animals (Earle, 1976)) as they were being weighed both before and after the experimental period. The average of the three condition scores on any one day was taken as that cow's condition score for that day. Daily condition scores were then averaged across the two consecutive days.

Both unfasted liveweight and condition score data were subject to analysis of covariance to test for treatment effects at the end of the experimental period. In addition, changes in liveweight and condition score over the experimental period were subject to analysis of variance to test for treatment effects.

2.2.1.4 DRY MATTER INTAKE (DMI) -CHROMIUM DILUTION METHOD

In Chapter 4 (T2) and Chapter 5 individual cow DM intakes were estimated using chromium sesquioxide (Cr_2O_3) as an indigestible marker (Le Du and Penning, 1982). Dry matter intakes (DMI) of 4 cows per treatment in each of the trials were estimated using estimates of faecal output and in vivo DMD according to the following equation:

$$\text{DMI (kg DM/day)} = \frac{\text{Faecal Output (kg DM/day)}}{1 - \text{DMD (in vivo)}}$$

Faecal Output

In Chapter 4 (T2) four cows per treatment were selected at random, and in Chapter 5 four sets of identical twins were selected at random from the experimental animals, for the estimation of faecal output. Commencing at the start of the second week of the experimental period these cows were dosed twice daily for 17 days with a gelatin capsule containing 10 gm Cr_2O_3 in an oil suspension (R.P.Scherer Pty Ltd.Australia). The first 7 days of dosing were to allow for the stabilizing of Cr_2O_3 levels throughout the digestive system. From days 8 - 17 twice daily (at 0500-0600 and 1400-1500 hrs) samples of faeces were collected from each cow as it defecated in the paddock. At each collection time, samples of faeces from any one of the cows in each treatment not receiving the Cr_2O_3 capsules were taken in order that any Cr_2O_3

occurring naturally in the faeces could be accounted for. Faecal samples for each cow were bulked for 5 day periods and stored at -4°C .

Faecal samples were thawed, thoroughly mixed, subsampled, and oven dried at 80°C for 7 days. Dried samples were ground to pass a 2mm sieve and analyzed for Cr_2O_3 by spectrophotometry according to method A of Fenton and Fenton (1979). Faecal output was calculated as follows:

$$\text{Faecal Output (kg DM/day)} = \frac{\text{daily intake of } \text{Cr}_2\text{O}_3 \text{ (gm/day)}}{\text{Cr}_2\text{O}_3 \text{ in faeces (gm/gm DM faeces)}} * 0.001$$

The recovery rate of Cr_2O_3 in the faeces was assumed to be 100 % (Le Du and Penning, 1982). The average recovery rate of Cr_2O_3 calculated from 55 trials conducted over a range of feeds and methods of Cr_2O_3 administration, with both sheep and cattle was 96.5 % (SD = 5.6 %) (ibid). In an indoor feeding trial at Massey University (Hoogendoorn, unpublished), where four cows were offered fresh cut grass and dosed with Cr_2O_3 as explained above, the average recovery rate was 109.5 % (SD = 16.0 %).

Details of the method of estimation of in vivo DMD is outlined in section 2.2.12 below.

2.2.1.5 ANIMAL BEHAVIOUR

The behaviour of cows grazing the assigned sward types was monitored over three (Chapter 4 (T3)) and four (Chapter 5) -24 hr periods respectively throughout the experimental periods.

The activity of each animal monitored was noted at 10 minute intervals during daylight and at 20 minute intervals during darkness. The activities noted were: grazing, ruminating, standing, lying and walking. If the animal appeared to be between activities at the time of monitoring it was allowed up to 20 seconds to equilibrate before it's activity was noted.

Observation commenced at 0800 hours when cows were returned to their paddocks after the morning milking and continued till approximately 0630 hours the next day when cows were brought into the shed for the morning milking.

During both daylight and darkness the observer was positioned central to and approximately 10 meters in front of the area enclosing the animals. During darkness the observer was equipped with a torch to aid in the identification of cows and their behaviour at observation times. Movement amongst the animals was necessary only at night and was kept to a minimum. The cows were accustomed to human presence and did not appear to be disturbed by either the observer or the torch light at night.

The total amount of time spent at each activity during daylight and darkness was taken as the number of times that activity was recorded, multiplied by 10 and 20 minutes respectively. Cow behaviour during daylight was analyzed separately from that during darkness due to the differences inherent in the error structure surrounding values obtained during light and darkness.

The effects of sward type, period, and the interaction between sward type and period on each activity were subject to univariate analysis of variance.

2.2.2 SWARD MEASUREMENTS

2.2.2.1 PRE-GRAZING HERBAGE MASS AND COMPOSITION

Thirty hours before cows were due to graze each 24 hr break an estimate of break size necessary to provide the target allowance was made. Herbage enclosed within ten 0.1875 m² quadrats, evenly spaced along a transect within each estimated break size, was cut to ground level. A sheep shearing hand piece powered by a mobile petrol generator was used to cut the herbage. The ten herbage cuts were bulked, mixed, and subsampled for component estimation, washed to remove soil, and dried at 70 - 80°C for 36 hours. The subsample (approximately 5 gm dry weight) was washed, and hand separated into grass stem, grass leaf, clover (clover leaf and clover stem in Chapter 4 (T3) and Chapter 5),

senescent matter (any herbage that appeared more than 50 % chlorotic) and weed.

The dry weight of total herbage cut was used to estimate pre-grazing herbage mass (kg DM/ha). The data obtained from the herbage dissections were used to calculate the percentage contribution (% by dry weight) and total mass of each component present in the sward before grazing. In Chapter 4 (T1 and T2) clover was not dissected into leaf and stem fractions. In these trials the total mass of leaf was calculated as being the mass of grass leaf plus half the mass of total clover.

2.2.2.2 HERBAGE ALLOWANCE

The amount of herbage present, as calculated from herbage cuts taken 30 hours previously, was used to determine the actual break size required to meet the designated herbage allowance for each 24 hour period of grazing. In Chapter 4 (T3) the amount of herbage DM present and the proportion of grass leaf and clover leaf in that herbage were used to calculate amount of leaf present in each break; the appropriate break size being calculated according to the designated leaf allowance. Since the width of each break was always fixed, the desired area necessary to realize a target herbage allowance was attained by adjusting the break length. No account was made for herbage accumulating or disappearing over the 30 hours between cutting and commencement of grazing.

2.2.2.3 POST-GRAZING HERBAGE MASS (RHM) AND COMPOSITION

Approximately 18 hours after cows were removed from their break, herbage within five 0.1875 m² quadrats, placed at evenly spaced intervals along a transect of the break, was cut to ground level as described in section 1.2.1 above. Cut herbage was subsampled, washed, dried at 70 - 80°C for 36 hours, and the residual herbage mass calculated.

The subsample was dissected into component parts as described in section 2.2.2.1 above and the percentage contribution (% by dry weight) and mass of each component in the residual herbage calculated.

2.2.2.4 DRY MATTER INTAKE (DMI) -BY DIFFERENCE

The amount of herbage which disappeared during grazing was calculated by subtracting the pre-grazing herbage mass from the RHM for each 24 hr break. This was the amount presumed to be eaten by the group of animals in that break. No attempt was made to correct this value for net herbage accumulating during the grazing process. The total amount disappearing for each break was divided by the number of animals grazing that break to give an estimate of per cow DMI.

2.2.2.5 INTAKE COMPOSITION -SWARD SAMPLING METHOD

The masses of each component calculated to be in the sward both pre- and post-grazing (section 1.2.1 and 1.2.2) for each break were used to quantify, by difference, the amount of each component which disappeared during the grazing process. It was assumed that the total amounts of each component disappearing between the pre- and post-grazing cutting had been eaten by the animals. No attempt was made to quantify that material disappearing through death, decay or trampling, or that material accumulating over the 48 hr period between pre- and post-grazing herbage cuts.

2.2.2.6 SWARD SURFACE HEIGHT AND HERBAGE BULK DENSITY

Surface height (cm) of the sward before grazing was estimated by taking measurements of the height of the undisturbed foliage surrounding a graduated aluminum rod (Butler, 1986). Measurements of herbage height were taken at 30 evenly spaced points along a transect of each break 24 hours before being grazed by the experimental animals. Surface height of residual herbage remaining after grazing was measured by taking readings at 15 evenly spaced intervals along a transect immediately after the animals were removed from each break.

Bulk density (kg DM/ha per cm of sward surface height) of the pre-grazing herbage mass was calculated by dividing the pre-grazing herbage mass by the sward surface height.

2.2.2.7 NUMBER OF VISIBLE INFLORESCENCES

The number of visible inflorescences (per m²) in each sward type were estimated throughout the preparation and experimental periods in Chapter 4 (T3). An inflorescence was defined as being visible when at least the tip of the inflorescence was visible at the mouth of the sheath of the flag leaf (Thomas, 1980).

The number of inflorescences in each of fifteen quadrats (12 cm²) placed along a transect in each break were measured and the figure converted to give a number per m².

2.2.2.8 THE PERCENTAGE OF REPRODUCTIVE TILLERS IN A SWARD AND INDIVIDUAL VEGETATIVE AND REPRODUCTIVE TILLER WEIGHTS

In Chapter 4 (T3), the percentage of reproductive tillers in the sward was measured during the preparation and experimental periods. All tillers in a subsample (approximately 15 gm DM) of total herbage cut before grazing were scored as either reproductive (presence of an internode) or vegetative, and the dry weight of each group (reproductive or vegetative) of tillers taken. The percentage of reproductive tillers in the sward were calculated a number basis, and weights of the reproductive and

vegetative tillers expressed on an individual dry weight basis.

2.2.2.9 TILLER DENSITY

The density of grass tillers was measured in Chapter 4 (T2) during the experimental period according to the method of Mitchell and Glenday (1958). The numbers of tillers present in 180 cores (5.2 cm diameter) per sward type per paddock were counted and the number converted to that present per m².

2.2.2.10 VERTICAL DISTRIBUTION OF SWARD COMPONENTS

In Chapter 4 (T3) and Chapter 5 the vertical distribution of sward components before and after grazing was measured on three occasions per week during the experimental period, and before grazing on one occasion per paddock during the preparation period (in Chapter 4 (T3) only).

A 20*30*6 cm area of sod was dug from the sward where the surface height of the herbage was similar to the mean sward surface height of that break. The piece of sod was transported to the field laboratory, tilted on its side, and the herbage cut and separated into strata using manual blade shears. The following stratifications were used: stratum 1, 0-4 cm; stratum 2, 4-12 cm; stratum 3, 12-20 cm; stratum 4, 20-28 cm; stratum 5, 28+ cm. The base of the sward (stratum 1) was cut with electric shears, because the manual blade shears proved to be inadequate

for cutting the tough stems in this stratum.

Herbage cut from strata 1 and 2 was washed to remove soil contamination. Herbage from each stratum was subsampled and separated into grass stem, grass leaf, clover stem, clover leaf, senescent matter and weed. Both the separated herbage and the remaining herbage were dried at 80°C for 24 hours and weighed, and the percentage (by dry weight) of each component in that stratum calculated. The total dry weight in each stratum was used to calculate the proportion of the total weight of herbage from the sod contributed by each stratum.

In Chapter 4 (T2) herbage samples were obtained from each of the above mentioned strata using a rotary lawn mower that had been modified to cut at a range of heights. Herbage was cut in a diagonal transect across each break immediately prior to being grazed by the experimental animals. No attempt was made to separate the macerated herbage into components, however, subsamples of each strata were taken and freeze dried for subsequent N and DMD and OMD analyses (section 2.2.1.11 below)

2.2.2.11 HERBAGE QUALITY

To facilitate herbage quality measurements, dried samples of total herbage in the sward and in vertical strata within the sward as well as various sward components were bulked per paddock and ground to pass a 2 mm sieve. Samples were analyzed for nitrogen

concentration (N %) according to the Kjeldahl method (Hiller et al, 1948). Estimates of in vitro DMD and OMD of herbage samples were obtained using the cellulase incubation method as described in Roughan and Holland (1977) and Dowman and Collins (1982).

2.2.2.12 IN VIVO DRY MATTER AND ORGANIC MATTER DIGESTIBILITY

In Chapter 4 (T1 and T2) and Chapter 5, wether sheep were used to measure the in vivo DMD and OMD of the sward types created. The sheep were randomly assigned to the herbage types (three sheep per herbage type) and allowed to become accustomed to their diets for 10 days before collection commenced. Cut herbage was offered to the sheep at maintenance levels in two allotments per day. Herbage refusals were removed daily and subsampled for dry matter determination. The total collection period was divided into two consecutive 5 day collection periods. These periods coincided with the faecal collection periods of cows receiving Cr_2O_3 to estimate faecal output (section 2.2.1.4 above). Herbage to be fed to the sheep was cut each morning immediately prior to the area being grazed by the cows. The herbage was cut approximately 2 cm above ground level using a rotary lawn mower.

The cut herbage was thoroughly mixed and subsampled for dry matter determination. A separate subsample was stored at 4°C and bulked over a 5 day collection period and subsequently freeze dried and ground to pass a 2 mm sieve for determination of in vitro DMD.

Faeces voided by each sheep were collected daily, a fresh weight taken, and bulked over the 5 day collection period. At the end of a 5 day collection period faeces were thoroughly mixed and subsampled in triplicate for dry matter determination. The DMD of the herbage was calculated as :

$$A = \frac{B - C}{B} * 100$$

where A = DMD of herbage

B = total dry weight of herbage eaten over a five
day period

C = total dry weight of faeces collected over a five
day period

For the calculation of OMD of the herbage samples of herbage and faeces were subject to ashing (500°C for 12 hours) and the organic matter in each determined. Organic matter values were then substituted for dry matter values in the above equation.

APPENDIX 3.1 STATISTICAL ANALYSIS -Split Plot in Space and Time

Split plot designs are frequently used for factorial experiments in which the nature of the experiment and material and operations involved make it difficult to handle all factor combinations in the same manner. For this reason a split plot design was chosen over a randomized complete block design.

The split plot in space and time design gives reduced accuracy on the main plot treatments and increased accuracy on the sub plot treatments and interactions. This is due to the fact that the restriction on the randomization of treatments within a block results in five error terms for the split plot in space and time design. Analysis of variance was performed on the data according to the following linear model (Steele and Torrie, 1980 (section 16.7)):

$$\begin{aligned}
 Y_{ijk1} &= \mu + B_i + M_j + BM_{ij} + G_k + GM_{jk} + (BG_{ik} + BMG_{ijk}) \\
 &\quad + S_l + BS_{il} + MS_{jl} + BMS_{ijl} + GS_{kl} + MGS_{jkl} \\
 &\quad + (BGS_{ikl} + BMGS_{ijkl})
 \end{aligned}$$

where:

Y_{ijk1} = observation in the i th block on the
 j th sward type, for the k th grazing regime,
in season l ;

- μ = overall mean;
- B_i = effect of the i th block where $i = 1, 2$;
- M_j = " " " j th sward type
where $j = 1-3$;
- BM_{ij} = error associated with the i th block and j th
sward type;
- G_k = effect of the k th grazing regime
where $k = 1-4$;
- GM_{jk} = interaction between the k th grazing regime and
 j th sward type;
- $(BG_{ik} + BMG_{ijk})$ = error associated with the i th block, the j th
sward type, and the k th grazing regime;
- S_l = effect of the l th season where $l = 1-5$;
- BS_{il} = error associated with the i th block and the l th
season;
- MS_{jl} = interaction between the j th sward type and the
 l th season;

BMS_{ijl} = error associated with the i th block, the j th sward type and the l th season;

GS_{kl} = interaction between the k th grazing regime and the l th season;

MGS_{jkl} = interaction between the j th sward type, the k th grazing regime and the l th season; and

$(BGS_{ikl} + BMGS_{ijk1})$ = error associated with the i th block, the j th sward type, the k th grazing regime and the l th season,

where: BM_{ij}
 $(BG_{ik} + BMG_{ijk})$ are assumed to be normally
 BS_{il} distributed with a mean
 BMS_{ijl} 0 and variance σ^2 .
 $(BGS_{ikl} + BMGS_{ijk1})$

Appendix 3.2 STATISTICAL ANALYSIS - Percentage and Mass
of Prairie Grass Present in M Swards

An analysis of variance was performed according to the following model:

$$Y_{ijk} = \mu + B_i + G_j + S_k + BG_{ij} + BS_{ik} + GS_{jk} + e_{ijk}$$

where:

Y_{ijk} = the percentage or mass of prairie grass in the
kth season on the jth grazing regime in block i;

μ = overall mean;

B_i = effect of the ith block on the dependent
variable where $i = 1,2$;

G_j = effect of the jth grazing regime on the
dependent variable where $j = 1-4$;

S_k = effect of the kth season on the dependent
variable where $k = 1-5$;

BG_{ij} = effect of the block * grazing regime interaction;

BS_{ik} = effect of the block * season interaction;

GS_{jk} = effect of the grazing regime * season
interaction; and

e_{ijk} = random error associated with the i th block,
the j th grazing regime, and the k th season,
and assumed to be normally distributed with
mean 0 and variance σ^2 .

Appendix 3.3 : ANALYSIS OF VARIANCE OF PRE-GRAZING HERBAGE
COMPOSITION (% DRY WEIGHT). ALL VALUES ARE
F-VALUES

Source of Variation	DF	% Total Grass F-value	Sig.	% Clover F-value	Sig.	% Senescent Matter F-value	Sig.
Block	1	4.3	NS	196.4	***	0.9	NS
Mixture	2	4.6	NS	866.2	****	6.2	NS
Residual	2						
Grazing Regime	3	32.5	****	0.3	NS	47.9	****
M x G	6	0.1	NS	0.6	NS	0.5	NS
Residual	9						
Season	4	89.5	****	133.6	****	90.4	****
Residual	4						
M x S	8	2.6	NS	7.2	***	0.9	NS
Residual	8						
G x S	12	13.9	****	1.2	NS	18.3	****
M x G x S	24	1.3	NS	1.3	NS	2.5	**
Residual	36						

Total Number of Observations = 120

Appendix 3.4 : ANALYSIS OF VARIANCE OF THE PRE-GRAZING PERCENTAGE
AND TOTAL MASS OF PRAIRIE GRASS IN THE M SWARDS ONLY.
ALL VALUES ARE F-VALUES

Source of Variation	DF	% Prairie Grass F-value	Sig.	Total Prairie Grass F-value	Sig.
Block	1	1.5	NS	3.9	NS
Grazing Regime	3	3.6	*	0.8	NS
Season	4	9.3	***	4.1	*
Block x Grazing Regime	3	4.4	*	3.3	NS
Block x Season	4	0.9	NS	1.1	NS
Grazing Regime x Season	12	3.0	*	2.0	NS
Residual	12				

Total Number of Observations = 40

Appendix 3.5 : ANALYSIS OF VARIANCE OF PRE-GRAZING HERBAGE BULK
DENSITY AND OF NET HERBAGE ACCUMULATION. ALL VALUES
ARE F-VALUES

Source of Variation	DF	Bulk Density		DF	Net Herbage Accumulation	
		F-value	Sig.		F-value	Sig.
Block	1	1.9	NS	1	4.3	NS
Mixture	2	8.8	NS	2	10.7	NS
Residual	2			2		
Grazing Regime	3	7.1	***	3	3.9	*
M x G	6	0.8	NS	6	0.4	NS
Residual	9			9		
Season	4	25.9	***	3	1050.7	****
Residual	4			3		
M x S	8	2.5	NS	6	2.0	NS
Residual	8			6		
G x S	12	6.8	****	9	5.7	****
M x G x S	24	0.8	NS	18	0.7	NS
Residual	36			27		

Total Number of
Observations = 120

Total Number of
Observations = 96

Appendix 3.6 : ANALYSIS OF VARIANCE OF PRE-GRAZING MASSES OF TOTAL DIGESTIBLE DRY MATTER AND NITROGEN, AND PRE-GRAZING HERBAGE DRY MATTER DIGESTIBILITY AND NITROGEN CONCENTRATION. ALL VALUES ARE F-VALUES

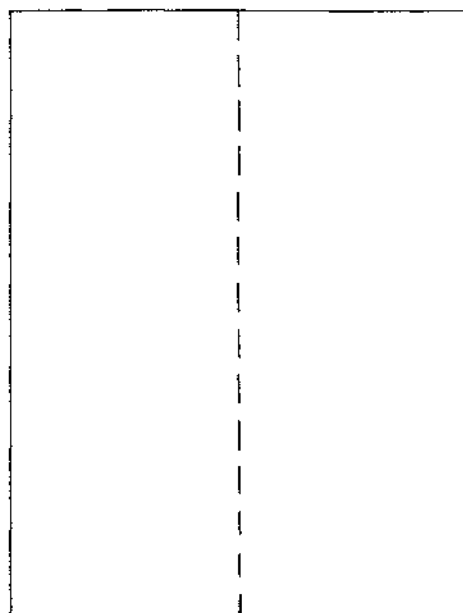
Source of Variation	DF	Total Digestible DM Mass		Total N Mass		DMD %		N %	
		F-Val.	Sig.	F-Val.	Sig.	F-Val.	Sig.	F-Val.	Sig.
Block	1	11.4	NS	6.8	NS	0.1	NS	1.4	NS
Mix	2	23.6	*	4.0	NS	41.7	**	13.0	NS
Residual	2								
Grazing Regime	3	45.9	****	25.7	****	67.6	****	34.3	****
M x G	6	0.6	NS	0.6	NS	1.6	NS	1.0	NS
Residual	9								
Season	4	124.0	****	12.8	**	232.8	****	19.6	***
Residual	4								
M x S	8	5.7	**	2.1	NS	0.8	NS	0.6	NS
Residual	8								
G x S	12	6.4	****	2.0	NS	23.9	****	4.1	****
M x G x S	24	0.7	NS	0.5	NS	2.3	*	0.4	NS
Residual	36								

Total Number of Observations = 120

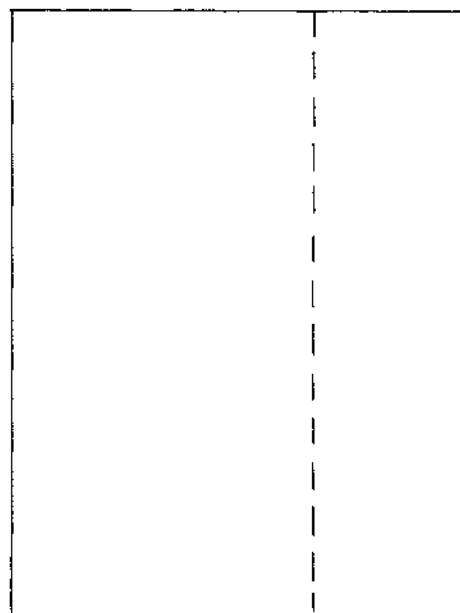
Appendix 3.7 : ANALYSIS OF VARIANCE OF PRE-GRAZING MASSES OF TOTAL DRY, GREEN, AND SENESCENT MATTER. ALL VALUES ARE F-VALUES

Source of Variation	DF	Total Dry Matter		Total Green Matter		Total Senescent Matter	
		F-value	Sig.	F-value	Sig.	F-value	Sig.
Block	1	5.7	NS	40.2	**	0.3	NS
Mixture	2	16.8	NS	59.2	**	4.7	NS
Residual	2						
Grazing Regime	3	74.7	****	41.9	****	47.9	****
M x G	6	0.7	NS	0.7	NS	0.1	NS
Residual	9						
Season	4	133.6	****	63.1	****	425.4	****
Residual	4						
M x S	8	6.5	***	2.0	NS	6.1	***
Residual	8						
G x S	12	5.8	****	5.6	****	15.2	****
M x G x S	24	0.6	NS	1.0	NS	1.4	NS
Residual	36						

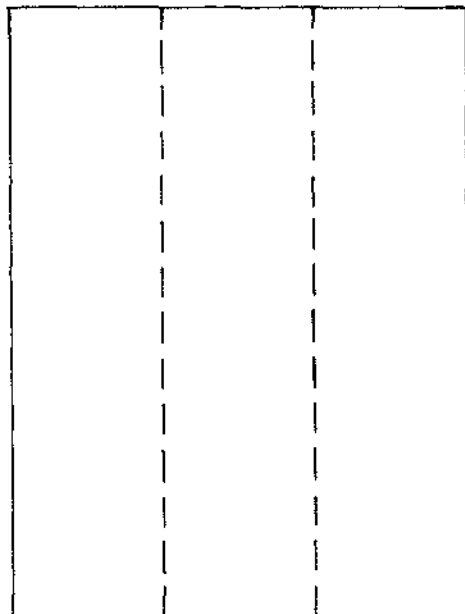
Total Number of Observations = 120



(a) Trial 1



(b) Trial 2



(c) Trial 3

Appendix 4.2 : AN ILLUSTRATION OF THE METHOD OF DIVISION OF EACH EXPERIMENTAL Paddock IN (a) TRIAL 1 (1982/83) (b) TRIAL 2 (1983/84) AND (c) TRIAL 3 (1984/85)

(For interpretation of abbreviations see the relevant methods section for each trial)

Appendix 4.3.1 : DETAILS OF COW AGE (YRS) AND MILK FAT YIELD (KG/COW DAILY) AND UNFASTED LIVEWEIGHT (KG) IN THE PREPARATION PERIOD (TRIAL 1)

Group	Cow No.	Age (yrs)	Milk Fat Yield (Kg/cow daily)	Unfasted Liveweight (Kg/cow)
PL-G	19	5	0.94	420
	23	2	0.64	270
	60	4	1.13	389
	66	2	0.67	321
	101	5	1.07	450
	145	6	0.98	428
			\bar{x} (SD)	0.91 (0.21)
PL-R	42	2	0.82	324
	48	2	0.68	309
	54	8	0.86	478
	65	2	0.63	320
	81	5	1.02	426
	146	6	0.97	411
			\bar{x} (SD)	0.83 (0.15)
PI-G	24	2	0.66	280
	41	2	0.73	332
	46	5	0.75	322
	53	8	0.81	449
	72	4	0.95	346
	102	5	1.17	446
			\bar{x} (SD)	0.85 (0.19)
PI-R	20	5	0.94	417
	45	5	0.84	331
	47	2	0.69	308
	59	4	0.91	399
	71	4	0.92	348
	82	5	0.87	419
			\bar{x} (SD)	0.86 (0.09)

Appendix 4.3.2 : A t-TEST OF THE HYPOTHESIS THAT THE MEAN PERCENTAGE OF A COMPONENT IN THE DIET COMES FROM THE SAME POPULATION AS THE MEAN PERCENTAGE OF A COMPONENT IN THE HERBAGE ON OFFER (SOKAL AND ROHLF, 1981)

where $t_{.05 [60]} = 2.00$

Cow Group	Component	t (Calculated)	Sig. Level
PL-G	% grass leaf	8.05	****
	% grass stem	-0.34	NS
	% clover	1.85	NS
	% senescent matter	-13.57	****
PL-R	% grass leaf	4.09	****
	% grass stem	2.17	*
	% clover	0.16	NS
	% senescent matter	-9.05	****
PI-G	% grass leaf	15.36	****
	% grass stem	-2.38	*
	% clover	-8.70	****
	% senescent matter	-4.94	****
PI-R	% grass leaf	8.83	****
	% grass stem	-0.54	NS
	% clover	-2.50	**
	% senescent matter	-5.47	****

Appendix 4.4.1 : DETAILS OF COW AGE (YRS) AND MILK FAT YIELD (KG/COW DAILY) AND UNFASTED LIVEWEIGHT (KG/COW) IN THE PREPARATION PERIOD (TRIAL 2)

Group	Cow No.	Age (yrs)	Milk Fat Yield (Kg/cow daily)	Unfasted Liveweight (Kg/cow)
PU	150	3	0.84	411
	154	7	1.12	460
	156	7	0.87	473
	169	6	1.07	413
	178	7	1.20	464
	180	7	0.95	446
	191	7	1.11	457
	200	6	0.89	524
			\bar{x} (SD)	1.01 (0.13)
PT	149	6	0.99	577
	163	6	0.78	453
	168	7	0.81	406
	171	6	1.03	490
	176	7	0.82	512
	182	7	1.25	544
	207	6	1.00	499
	214	3	0.73	420
			\bar{x} (SD)	0.93 (0.17)

Appendix 4.4.2 : A t-TEST OF THE HYPOTHESIS THAT THE MEAN PERCENTAGE OF A COMPONENT IN THE DIET COMES FROM THE SAME POPULATION AS THE MEAN PERCENTAGE OF A COMPONENT IN THE HERBAGE ON OFFER (SOKAL AND ROHLF, 1981)

where $t_{.05 [10]} = 2.23$

Cow Group	Component	(Calculated)	Sig. Level
PU	Grass stem	-1.19	NS
	Grass leaf	3.54	***
	Clover	1.14	NS
	Senescent matter	-11.08	****
PT	Grass stem	-0.88	NS
	Grass leaf	2.76	*
	Clover	1.95	NS
	Senescent matter	-10.17	****

Appendix 4.5.1 : DETAILS OF COW AGE (YRS) AND MILK FAT YIELD
(KG/COW DAILY) AND UNFASTED LIVEWEIGHT (KG/COW)
IN THE PREPARATION PERIOD (TRIAL 3)

Group	Cow No.	Age (yrs)	Milk Fat Yield (Kg/cow daily)	Unfasted Liveweight (Kg/cow)
L	149	7	0.82	589
	164	8	0.90	428
	182	8	1.10	527
	191	7	1.09	465
	196	7	1.08	441
	208	4	0.74	383
	216	3	0.95	380
			\bar{x} (SD)	0.95 (0.14)
M	150	4	0.89	429
	166	3	0.91	387
	176	8	1.16	517
	178	8	1.15	474
	188	3	0.96	412
	193	8	1.00	407
	218	3	0.87	580
			\bar{x} (SD)	0.99 (0.12)
I	154	8	1.06	457
	156	8	0.96	479
	168	8	0.97	407
	180	8	1.11	452
	190	7	0.92	442
	192	3	0.83	375
	214	4	0.91	474
			\bar{x} (SD)	.97 (0.09)

Appendix 4.5.2 : THE EFFECT OF GRAZING INTENSITY IN SPRING ON THE PERCENTAGE CONTRIBUTION OF EACH OF FIVE VERTICAL STRATA TO THE PRE-GRAZING TOTAL HERBAGE MASS (% DRY WEIGHT) IN THE EXPERIMENTAL PERIOD (NOV-DEC)

		Sward Type			SE (LSM)	Sig. Level
		L	M	I		
(a) Nov/Dec Stratum						
1.	0-4 cm	39.1 a	58.5 b	81.4 c	1.8	****
2.	4-12 cm	30.8 b	30.6 b	16.2 a	1.4	****
3.	12-20 cm	15.5 c	8.0 b	2.4 a	0.8	****
4.	20-28 cm	7.1 c	2.2 b	0.1 a	0.4	****
5.	28+ cm	7.2	0.7	-	0.5	****
(b) Dec Stratum						
1.	0-4 cm	52.6 a	70.9 b	79.9 c	2.4	****
2.	4-12 cm	36.7 c	25.3 b	17.5 a	2.1	****
3.	12-20 cm	7.4 b	2.6 a	1.0 a	0.7	****
4.	20-28 cm	2.0 b	0.8 a	0.3 a	0.2	****
5.	28+ cm	1.5 b	0.5 a	-	0.3	***

Appendix 4.5.3 : THE EFFECT OF GRAZING INTENSITY ON THE COMPOSITION (% DRY WEIGHT) OF THE PRE-GRAZING TOTAL HERBAGE MASS IN THE SWARD PREPARATION (OCT-NOV), EXPERIMENTAL (NOV-DEC), AND POST EXPERIMENTAL (FEB-MARCH) PERIODS

	Sward Type			SE (LSM)	Sig. Level
	L	M	I		
(a) October–November					
Grass Stem (% dry weight)	44.1	43.1	31.7	4.1	NS
Grass Leaf	29.3	32.1	38.8	3.7	NS
Clover Stem	2.8 a	3.4 ab	5.7 b	0.9	*
Clover Leaf	2.8 a	3.6 a	7.7 b	0.7	****
Senescent Matter	20.5	17.5	13.7	2.6	NS
Weed	0.4	0.3	1.8	0.6	NS
(b) November–December					
Grass Stem	45.8 b	31.3 b	24.6 a	1.8	****
Grass Leaf	18.2 a	27.9 b	35.3 c	1.9	****
Clover Stem	4.5 a	6.2 ab	7.7 b	0.6	***
Clover Leaf	4.5 a	6.6 ab	8.5 b	0.4	****
Senescent Matter	25.7 b	26.0 b	19.7 a	1.7	*
Weed	1.5	1.9	3.2	0.7	NS
(c) December					
Grass Stem	31.3 b	25.0 a	22.7 a	1.4	***
Grass Leaf	15.0 a	23.0 b	33.9 c	1.4	****
Clover Stem	7.9	7.3	9.6	1.2	NS
Clover Leaf	5.5 a	7.2 a	10.7 b	1.1	**
Senescent Matter	38.7 b	33.9 b	20.4 a	1.7	****
Weed	1.7	3.1	2.8	0.8	NS
(d) February–March					
Grass Stem	8.7	10.5	10.3	1.1	NS
Grass Leaf	14.7	18.6	19.2	1.2	NS
Clover Stem	12.4	12.4	15.6	1.8	NS
Clover Leaf	6.0 a	8.3 ab	11.6 b	1.3	*
Senescent Matter	55.7 b	48.3 ab	41.8 a	2.4	**
Weed	2.0	2.0	1.9	0.3	NS

Appendix 4.5.4 : A t-TEST OF THE HYPOTHESIS THAT THE MEAN PROPORTION OF A COMPONENT IN THE DIET COMES FROM THE SAME POPULATION AS THE MEAN PROPORTION OF THAT COMPONENT IN THE HERBAGE ON OFFER (SOKAL AND ROHLF, 1981)

Cow Group	Component	t (Calculated)	Sig. Level
(a) Round 1 where $t_{.05 [48]} = 2.01$			
L	Grass stem	3.25	***
	Grass leaf	4.75	****
	Clover stem	1.90	NS
	Clover leaf	0.71	NS
	Senescent matter	-7.75	****
	Weed	2.44	*
M	Grass stem	0.57	NS
	Grass leaf	8.72	****
	Clover stem	-0.83	NS
	Clover leaf	1.50	NS
	Senescent matter	-8.21	****
	Weed	2.66	*
I	Grass stem	-4.84	****
	Grass leaf	13.90	****
	Clover stem	1.15	NS
	Clover leaf	3.33	***
	Senescent matter	-5.05	****
	Weed	0.85	NS
(b) Round 2 where $t_{.05 [33]} = 2.04$			
L	Grass stem	-0.31	NS
	Grass leaf	2.20	*
	Clover stem	2.89	***
	Clover leaf	7.10	****
	Senescent matter	-9.74	****
	Weed	-1.05	NS
M	Grass stem	-4.20	****
	Grass leaf	1.80	NS
	Clover stem	3.80	****
	Clover leaf	7.70	****
	Senescent matter	-7.90	****
	Weed	0.50	NS
I	Grass stem	-5.60	****
	Grass leaf	8.30	****
	Clover stem	-0.50	NS
	Clover leaf	0.90	NS
	Senescent matter	-3.00	***
	Weed	-1.60	NS

Appendix 4.5.5 : A t-TEST OF THE HYPOTHESIS THAT THE MEAN PERCENTAGE CONTRIBUTION OF A STRATUM TO THE DIET COMES FROM THE SAME POPULATION AS THE MEAN PERCENTAGE CONTRIBUTION OF THAT STRATUM TO THE TOTAL HERBAGE ON OFFER (SOKAL AND ROHLF, 1981)

Cow Group	Stratum	t (Calculated)	Sig. Level
(a) Round 1 where $t_{.05 [48]} = 2.01$			
L	1: 0-4 cm	-5.89	****
	2: 4-12 cm	-1.14	NS
	3: 12-20 cm	7.27	****
	4: 20-28 cm	11.50	****
	5: 28+ cm	8.98	****
M	1: 0-4 cm	-6.07	****
	2: 4-12 cm	4.05	****
	3: 12-20 cm	7.65	****
	4: 20-28 cm	3.08	***
	5: 28+ cm	0.65	NS
I	1: 0-4 cm	-4.30	****
	2: 4-12 cm	4.49	****
	3: 12-20 cm	2.13	*
	4: 20-28 cm	0.13	NS
	5: 28+ cm	-	-
(b) Round 2 where $t_{.05 [33]} = 2.04$			
L	1: 0-4 cm	-6.20	****
	2: 4-12 cm	3.79	****
	3: 12-20 cm	4.90	****
	4: 20-28 cm	5.40	****
	5: 28+ cm	4.46	****
M	1: 0-4 cm	-3.82	****
	2: 4-12 cm	3.85	****
	3: 12-20 cm	0.67	NS
	4: 20-28 cm	1.20	NS
	5: 28+ cm	1.07	NS
I	1: 0-4 cm	-2.70	***
	2: 4-12 cm	3.84	****
	3: 12-20 cm	0.63	NS
	4: 20-28 cm	0.80	NS
	5: 28+ cm	-	-

Appendix 4.5.6 : METEOROLOGICAL DATA FOR THE DAYS WHEN COW
BEHAVIOUR WAS MONITORED

Observation Day	Air Temperature		Sunshine (Total hrs)	Rainfall (mm)	Wind (Km run)
	Max. (°C)	Min.			
Nov. 22	22.7	12.3	5.0	-	519
Nov. 29	22.1	9.5	12.4	-	276
Dec. 5	20.3	16.0	-	4.6	165
Average for Nov.	20.1	11.6	5.4	2.7	354
Average for Dec.	22.6	13.6	6.8	3.3	305

Appendix 4.6.1 : SIMPLE REGRESSION OF THE PERCENTAGE OF A
COMPONENT IN THE DIET ON THE PERCENTAGE OF THAT
COMPONENT IN THE HERBAGE ON OFFER IN T1, T2, and T3
(N = 12)

(a) % grass stem in diet = $-13.5 + 1.36$ (% of grass stem in herbage offered)

$$R^2 = 91.0 \quad p < 0.001$$

(b) % grass leaf in diet = $-3.86 + 1.50$ (% of grass leaf in herbage offered)

$$R^2 = 92.8 \quad p < 0.001$$

(c) % clover in diet = $5.5 + 0.834$ (% clover in herbage offered)

$$R^2 = 5.2 \quad p > 0.05$$

(d) % senescent matter in diet = $-4.08 + 0.674$ (% senescent matter in herbage offered)

$$R^2 = 72.9 \quad p < 0.001$$

Appendix 4.6.2 : SIMPLE REGRESSION OF DRY MATTER INTAKE (DMI)
(KG DM/COW DAILY) ON DRY, GREEN, AND LEAF ALLOWANCE
(DA, GA AND LA RESPECTIVELY) (KG DM/COW DAILY) IN
T1, T2 and T3; AFTER ADJUSTMENT FOR YEAR, COW
TYPE AND GRAZING ROUND (N = 14)

(a) DMI = $9.2 + 0.08$ DA

$$R^2 = 11.4 \quad p > 0.05$$

(b) DMI = $6.4 + 0.2$ GA

$$R^2 = 37.6 \quad p > 0.05$$

(c) DMI = $3.9 + 0.6$ LA

$$R^2 = 84.5 \quad p < 0.001$$

Appendix 5.1 : DETAILS OF COW AGE (YEARS) AND MILK FAT YIELD
(KG/COW DAILY) AND UNFASTED LIVWEIGHT (KG) IN THE
PREPARATION PERIOD

Twin Pair	Cow No.	Age (yrs)	Milk Fat Yield (Kg/cow daily)	Unfasted Liveweight (Kg)
1	53	10	1.12	450
	54	10	1.03	470
2	57	4	0.87	378
	58	4	0.54	350
3	69	3	0.86	336
	70	3	0.81	326
4	85	3	0.97	357
	86	3	0.87	367
5	93	3	0.89	352
	94	3	0.87	323
6	107	3	0.86	354
	108	3	0.86	341
7	115	4	0.71	398
	116	4	1.01	389
8	121	3	0.86	321
	122	3	0.94	298

Appendix 5.2 : DETAILS OF SWARD CHARACTERISTICS AND MANAGEMENT
 DURING THE SWARD PREPARATION PERIOD (MAY - SEPTEMBER
 1984)

	1	Paddock 2	3
May Grazing Dates	21.5	22.5	25.5
Residual Herbage Mass (Kg DM/ha)	781	738	633
Herbage Mass (July) (Kg DM/ha)	2092	1944	1920
July Grazing Dates - SR swards	18.7	20.7	21.7
Residual Herbage Mass - (Kg DM/ha)	831	607	760
Herbage Mass (Sept) - LR swards	4865	4618	4798
(Kg DM/ha) - SR swards	2760	2660	3177
Sept. Grazing Dates - LR swards	13-19.9	20-26.9	27.9-3.10
- SR swards	13-19.9	20-26.9	27.9-3.10

Appendix 5.3 : THE EFFECT OF REGROWTH INTERVAL IN AUTUMN/WINTER
ON THE PRE-GRAZING MASS OF HERBAGE COMPONENTS IN
EACH VERTICAL STRATUM IN EARLY SPRING (KG DM/HA)

	Sward Type		SE (LSM)	Sig. Level
	LR	SR		
(a) Stratum 1 (0-4 cm)				
Grass Stem	987	552	74	****
Grass Leaf	78	232	22	****
Clover Stem	60	184	30	***
Clover Leaf	14	130	25	***
Senescent Matter	493	312	46	**
Weed	1	3	1	NS
(b) Stratum 2 (4-12 cm)				
Grass Stem	664	105	58	****
Grass Leaf	588	629	52	NS
Clover Stem	49	76	13	NS
Clover Leaf	53	244	36	***
Senescent Matter	377	66	35	****
Weed	1	6	3	NS
(c) Stratum 3 (12-20 cm)				
Grass Stem	91	26	22	NS
Grass Leaf	628	232	32	****
Clover Stem	15	7	3	NS
Clover Leaf	41	74	15	NS
Senescent Matter	81	trace	9	****
Weed	3	trace	1	NS
(d) Stratum 4 (20-28 cm)*				
Grass Stem	21 (5)	trace		
Grass Leaf	350 (20)	31 (5)		Not
Clover Stem	2 (3)	18 (15)		Statistically
Clover Leaf	29 (8)	5 (9)		Analysed
Senescent Matter	17 (5)	trace		
Weed	5 (7)	trace		
(e) Stratum 5 (28+ cm)*				
Grass Leaf	200 (18)	9 (5)		Not
Senescent Matter	15 (7)	0		Statistically
				Analysed

* Data in (d) and (e) are raw means, and their standard deviations are placed in brackets

Appendix 5.4 : A t-TEST OF THE HYPOTHESIS THAT THE MEANS OF THE PERCENTAGE CONTRIBUTION OF EACH STRATUM TO THE DIET COME FROM THE SAME POPULATION AS THE PERCENTAGE CONTRIBUTION OF EACH STRATUM TO THE TOTAL PRE-GRAZING HERBAGE MASS (SOKAL AND ROHLF, 1981)

Cow Group	Stratum	t (Calculated)	Sig. level
Grazing LR Swards	0-4 cm	-0.891	NS
	4-12 cm	-0.017	NS
	12-20 cm	1.485	NS
	20-28 cm	2.631	*
	28+ cm	1.290	NS
Grazing LR Swards	0-4 cm	-1.400	NS
	4-12 cm	0.577	NS
	12-20 cm	1.077	NS
	20-28 cm	0.874	NS
	28+ cm	0.400	NS

Critical value for $t_{.05 [32]}$ = 2.041

Appendix 5.5 : A t-TEST OF THE HYPOTHESIS THAT THE MEANS OF THE PERCENTAGE OF A COMPONENT IN THE DIET COME FROM THE SAME POPULATION AS THE PERCENTAGE OF A COMPONENT IN THE PRE-GRAZING HERBAGE MASS (SOKAL AND ROHLF, 1981)

Cow Group	Component	t (Calculated)	Sig. level
Grazing LR Swards	% grass stem	-7.860	****
	% grass leaf	1.980	NS
	% clover stem	-0.590	NS
	% clover leaf	0	NS
	% senescent matter	-2.440	*
Grazing LR Swards	% grass stem	-7.880	****
	% grass leaf	1.140	NS
	% clover stem	-0.990	NS
	% clover leaf	5.429	****
	% senescent matter	-1.570	NS

Critical value for $t_{.05 [32]}$ = 2.041

Appendix 5.6 : METEOROLOGICAL DATA FOR THE DAYS WHEN COW BEHAVIOUR
WAS MONITORED

Day	Air Temperature (°C)		Sunshine (hrs)	Rainfall (mm)	Wind (Km run)
	Min.	Max.			
1	15.2	10.5	5.0	1.0	583
2	16.0	9.8	4.2	6.5	678
3	15.0	9.5	0.1	-	361
4	18.0	10.2	2.1	-	191
Average for September	15.1	6.9	3.8	2.1	238

Appendix 5.7 : SAMPLE CALCULATION OF THE ME CONCENTRATION OF HERBAGE
INGESTED AND OF TOTAL ME INGESTED (PER COW DAILY)

Sample Calculation for Cows on SR Swards
(where dry matter intake = 12.8 Kg DM/cow daily)

	1	2	Stratum 3	4	5
Intake (Kg DM daily)	1.74	7.58	2.80	0.54	0.14
MJ ME/Kg DM*	11.09	11.82	14.86	11.87	11.76
ME Intake (MJ daily)	19.30	89.60	41.61	6.41	1.65

Total ME intake (MJ/cow daily) = 159

ME Concentration of Diet (MJ/Kg DM) = 12.4

* Calculated from the relationship (cited in Bryant and Trigg
(1982)): ME (MJ/Kg DM) = 0.181 ± 0.01 OMD % - 2.68 ± 0.66

For cows on LR swards, Total ME intake (MJ/cow daily) = 140
ME Concentration of Diet (MJ/Kg DM) = 11.2

Appendix 5.8 : SAMPLE CALCULATION OF ME INTAKE NEEDED TO SUSTAIN
PRODUCTION LEVELS MEASURED IN THE EXPERIMENTAL
PERIOD (PER COW DAILY)

Sample Calculation for Cows on SR Swards

where $ME \text{ allowance} = Mm + Ml + Mg$ (MAFF, 1975)

and $Mm = \text{maintenance allowance} = 8.3 + 0.09 (\text{liveweight})$

$Ml = \text{allowance for milk production}$
 $= (0.4 (\text{milk yield}) + 15 (\text{Fat yield})) \times 5.31$

$Mg = \text{allowance for liveweight change}$
 $= 34 \text{ MJ per Kg gain}$

for cows on SR swards

liveweight	=	366 Kg/cow
milk yield	=	18.3 Kg/cow daily
fat yield	=	0.86 Kg/cow daily
liveweight gain	=	0.333 Kg/cow daily

ME needed to support these levels of production:

$= 41.2 + 107.4 + 11.3$
 $= 159.9 \text{ or } 160 \text{ MJ/cow daily}$

for cows on LR swards, ME needed = $41.6 + 97.4 + 4.5$
 $= 143.5 \text{ or } 144 \text{ MJ/cow daily}$

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