Grazing behaviour of dairy cows on simple and diverse swards in summer and autumn

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Abstract

Increasing the proportion of dicotyledonous species such as herbs and legumes in dairy pastures may increase herbage dry matter intakes through ease of prehension. Simple swards consisting of either standard perennial ryegrass, high sugar ryegrass or tall fescue cultivars with white clover were established at the Lincoln University research dairy farm. Diverse swards were created by adding chicory and plantain to all mixtures, plus prairie grass and red clover to the perennial ryegrass, and praire grass and lucerne to the tall fescue. Grazing behaviour of cows during a two hour grazing session was monitored in summer and autumn. In summer, Diverse swards had a greater compressed sward surface height, lower mass and bulk density. Cows grazing Simple swards achieved a greater bite rate (49.3 vs 43.8 bites/min respectively ($P < 0.05$)). In autumn, all pasture swards had lower mass and contained a higher proportion of grass species than in summer. Bite rate was greater on Diverse compared with Simple swards (60.3 vs 54.3 bites/min respectively ($P < 0.05$)). Lower bite rate on Simple swards was compensated for by increasing grazing duration ($P < 0.001$). Sward type influenced bite rate adaptations.

Keywords: foraging behaviour; *Lolium perenne*; *Festuca arundinacea*; *Trifolium repens*; *Cichorium intybus*; *Plantago lanceolata*; *Bromus wildenowii*; *Trifolium pratense*; *Medicago sativa*

Introduction

One of the biggest limitations to milk production in dairy grazing systems is dry matter intake (DMI). DMI of grazed herbage is a function of time spent grazing and intake rate (Dillon 2006) and may be constrained by limitations to either factor. Mechanical properties of pasture plants and sward architecture also have a strong influence on intake rate (MacKinnon et al. 1988; Inoue et al. 1994) and cows can adjust grazing strategies such as bite rate and bite mass to achieve an optimal intake rate.

Within species such as perennial ryegrass, intake rate increases with increasing sward height as a result of increased bite depth and bite mass. Alternative species to increase intake rate include legumes such as white clover. Clover has high intake rates which can be attributed to reduced mechanical resistance and greater bulk density in the upper sward horizon (Edwards et al. 1995). Although clover provides an opportunity to increase DMI, compared with ryegrass, it has a shorter growing season and its higher nitrogen concentration poses an environmental risk. Recognition of these factors has led to increasing interest in alternative broadleaf species of herbs such as chicory and plantain, and alternative grasses such as high sugar ryegrasses or prairie grass for year round growth and nitrogen balancing.

A large proportion of a dairy cow's daily DMI is consumed during the first few hours after each new allocation (Gregorini et al. 2009). Thus foraging strategies in this period are likely to influence total daily DMI. Swards containing legumes and herbs have different sward architecture and may affect a cow's foraging strategy as sward height is depleted. There is little information on the extent to which grazing behaviour may be altered by combining grasses with herbs or legume species in pasture swards. The aim of the study was to compare DMI and grazing behaviour of dairy cows when offered either Simple grass/clover mixtures or Diverse mixtures containing a range of herbs, grasses and legumes.

Materials and methods

Site and sward treatments

Experiments were carried with the approval of the Lincoln University Animal Ethics committee. The experiment was conducted at the Lincoln University Research Dairy farm during summer (January 2011, Experiment 1) and autumn (April 2011, Experiment 2). Grazing behaviour of lactating dairy cows was recorded throughout the first grazing session following afternoon milking on six sward types. Swards were categorised as either Simple or Diverse. They were established in January 2010 on three replicated 0.5 ha areas. Three Simple sward mixtures which all included white clover (*Trifolium repens*, cv. Kopu II) were sown with either a standard diploid perennial ryegrass (*Loliun perenne* cv. One50 AR1) (RG), a diploid ryegrass selected for high sugar concentration (*Lolium perenne* cv. Abermagic AR1) (HS) or tall fescue (*Festuca arundinacea*, cv. Advance MaxP) (TF). The three Diverse mixtures included the same grass/white clover components but with the addition of chicory, plantain, prairie grass and red clover in the RG mix (RGD); chicory and plantain in the HS mix (HSD); and chicory, plantain, prairie grass and lucerne in the TF mix (TFD).

Grazing behaviour measurements

Summer - Experiment 1. Seventy two mixed age Holstein Friesian cows (473 ± 6 (standard error) kg

body weight, 154 ± 3 days in milk, 16.8 ± 0.3 L/d of milk) were randomly divided into 12 groups of six cows and assigned to the six sward treatments with two replicates per treatment. Cows grazed their allocated sward treatment for a total of 10 days between 27 January and 6 February 2011 including a four day adaptation period. All groups were strip grazed on an allowance of 15 kg DM/cow/day above a 1,500 kg DM/ha residual. Daily allocations were determined by pre-grazing mass estimates derived from 60 readings of a rising plate meter (Jenquip F150 Electronic Pasture Meter, Feilding, New Zealand). The new daily allocations were offered at 1540 h following the afternoon milking and behaviour measurements during the grazing session took place on Days 5 and 8 for two hours upon entry to their new allocation. The two hour observation period was based on evidence that cows spent the largest proportion of time grazing in the first 120 minutes of a new allocation (Gregorini et al. 2009). Three cows in each group were marked and two observers were assigned to recording bite rate as bites per minute, of a continuous grazing bout. Each observer recorded bite rate for six mobs (a total of 18 cows) taking approximately 30 minutes to complete one circuit. Two further observers were assigned to record grazing activity of all cows in each group which was recorded at 15 minute intervals.

Autumn - Experiment 2. In April 2011, reduced herbage growth rates and low mass restricted the number of cows able to be managed on the available plots to 48 cows (495 ± 7 kg BW, 237 ± 3 DIM, 13.4 ± 0.3 L/day of milk). The cows were again randomly divided into 12 groups of four with two replicates per sward treatment. Cows were allocated 14 kg DM/cow/day due to lower energy requirements. Groups were strip-grazed as described for Experiment 1 and grazing behaviour observed on Days 7 and 8 of the experiment. A review of data from Experiment 1 prompted the decision to increase the number of observations. Bite rate measurements were increased from 30 to 15 minute intervals by recording the time taken to prehend 10 consecutive bites and were recorded for all four cows in each group. The frequency of observations for grazing activity was also increased from 15 to 5 minute intervals.

Herbage measurements

Compressed herbage height, as measured by a rising plate meter, was calibrated for herbage mass in summer and autumn for each sward type from duplicate daily quadrat cuts. All plant material within 0.2 m^2 quadrats was harvested to soil level and the dry weight recorded. Snip samples for botanical composition were collected immediately prior to behaviour observations by cutting plant material at eight random locations in each paddock to grazing residual height. The cut sample was thoroughly mixed and a sub-sample was manually separated into each sown plant species, weed and dead material, and oven-dried at 60°C for 48 hours before weighing. Herbage mass at the beginning and end of the grazing session was determined from the mean rising plate meter height (60 readings/break) and the calibration equation. Rising plate meter height was recorded again on the final post grazing residual after 24 hours for estimation of total DMI. Bulk density (g/cm^3) of the compressed height was estimated from sward height (cm) x area of quadrat (cm^2) x dry weight of herbage cut from quadrat (g).

Statistical analysis

Data from foraging behaviour observations and plate meter readings were used to estimate bite rate, mass, and daily and grazing session herbage intake using the following equations:

Bite rate (bites/minute) = Number of bites/second taken x 60

Daily DMI = ((Pre-graze mass – Post-graze mass) x Area) / Number of cows

Herbage DMI during grazing session = ((Pre-graze mass – Mass at end of grazing session) x Area) / Number of cows

Bite mass (g DM/bite) = DMI during the grazing session (kg DM/cow) / Grazing time (minutes) x Bite rate (bites/minute)

The effect of sward treatment on grazing behaviour variables and DMI were analysed using the repeated measures procedure of Genstat (Payne et. al 2009) for general linear models using group means. Group averages were used and analyses based on 12 experimental units per day of sampling. Sward treatment, time and their interaction were fixed effects. The effect of diversity was further investigated by combining means for Simple and Diverse mixtures and using diversity as a fixed term in the analysis. Herbage mass, sward height and botanical composition were analysed for variance using the GLM (Payne et. al 2009) procedure using sward treatment or diversity as a fixed effect. Means were separated using Fishers protected least significant difference test where significance was reported at $P < 0.05$.

Results

Summer - Experiment 1

Botanical composition and herbage mass are presented in Table 1. A high proportion of herb in the Diverse swards resulted in taller swards in Diverse compared with Simple mixtures (12.24 vs 11.0 ± 0.6 cm, respectively). Of the two herb species chicory dominated and consisted mainly of stem (RH Bryant, Unpublished data). In spite of the greater compressed height, the Diverse treatments had lower mass and lower bulk density of compressed herbage compared to the Simple mixtures. The proportion of legume exceeded 10% in all sward types, though the highest proportion was recorded in the RGD and TF treatments. Red clover dominated in the RGD

Table 1 *Experiment 1*: Sward characteristics and grazing behaviour for groups of six cows in two replicates grazing Simple swards consisting of perennial ryegrass (RG), high sugar content ryegrass (HS) and tall fescue (TF) and Diverse swards containing perennial ryegrass + chicory + plantain + prairie grass + red clover (RGD), high sugar ryegrass + chicory + plantain (HSD) and tall fescue + chicory + plantain + prairie grass + lucerne (TFD) in summer. DM = Dry matter. P values in bold indicate significance at (P< 0.05) while P values in italics indicate approaching significance with a P value between 0.05 and 0.10.

Measurements	Diversity groups	Simple			Diverse			Standard error of difference	P value	
	Treatment groups	RG	HS	TF	RGD	HSD	TFD		Diversity	Treatment
Sward characteristics										
Sward height (cm)		11.9^{a}	9.7^{b}	11.4^{ab}	12.4^{a}	12.6^{a}	13.3^{a}	1.0	**0.01**	**0.04**
Mass (kg DM/ha)		3,827^{a}	3,370^{b}	3,148^{bc}	2,924^{cd}	3,039^{bc}	2,605^{d}	201	**<0.001**	**<0.001**
Bulk density (g/cm^{3})[1]		3.22^{b}	3.49^{a}	2.80^{c}	2.39^{d}	2.42^{d}	1.97^{e}	0.06	**<0.001**	**<0.001**
Proportion grass (%)		80^{a}	70^{ab}	54^{b}	30^{c}	31^{c}	26^{c}	8	**<0.001**	**<0.001**
Proportion legume (%)		16^{cd}	28^{abc}	43^{a}	37^{ab}	10^{d}	22^{bcd}	8	0.35	**0.004**
Proportion herb (%)		0	0	0	31^{b}	56^{a}	50^{a}	8	**<0.001**	**<0.001**
Proportion dead (%)		4	3	1	2	3	2	1	0.88	0.11
Grazing behaviour										
Daily DM intake (kg DM/d)		11.9	12.5	14.7	14.9	14.8	13.3	1.0	0.12	*0.09*
Intake during grazing session (kg DM)		5.32	4.53	4.3	4.64	5.54	4.34	1.46	0.86	0.92
Proportion of daily DM intake consumed during grazing session (%)		46	36	29	32	38	35	12	0.77	0.82
Time grazing during grazing session (min)		106	93	96	107	107	113	7	**0.03**	0.18
Bite rate (bites/min)		47.8	51.0	48.9	41.4	42.1	48.0	4.5	**0.05**	0.31
Bite mass (g DM/bite)		1.15	0.96	0.97	1.09	1.31	0.81	0.43	0.85	0.87

[a-d] Means within the same row with different superscripts differ (P < 0.05.

treatment as 86% of total legume, while in the TF treatment slow establishment of tall fescue enabled establishment of a high proportion of clover. Botanical composition of the ryegrass treatments, RG and HS were similar, though herbage mass of RG was 450 kg DM/ha greater than HS (P < 0.001).

Differences in sward characteristics did not alter total DMI or grazing behaviour during the two hour grazing session allocation. Cows spent 86% of the two hour observation period grazing and consumed 36% of their daily allowance. Mean intakes for the grazing session were similar across treatments with 4.8 kg DM consumed on Diverse and 4.7 kg DM consumed on Simple treatments. However, cows grazing Simple sward treatments had faster bite rates than those grazing Diverse mixtures (49.3 vs. 43.9 ± 1.75 bites/minute respectively, P = 0.05). The slower bite rate in the Diverse treatments was compensated for by the greater duration of grazing (109 vs 98 ± 3.05 minutes. P < 0.05) and increasing bite mass (1.07 vs 1.03 ± 0.15 g DM/bite, P > 0.05), though differences in bite mass were not significant.

Autumn - Experiment 2

The lower proportion of herb and legume in the cooler autumn season resulted in lower herbage mass of Diverse compared with Simple mixtures (1,812 and 2,222 kg DM/ha respectively, P < 0.001). Grass species contributed to 90% of the DM in Simple mixtures and 60% of the DM of Diverse treatments, with the exception of TFD which contained 46% grasses (Table 2). The three Diverse treatments contained similar proportions of herb (32%), while the two tall fescue mixtures (TF and TFD) contained the highest legume proportion (12.8%). The high sugar mixes containing the lowest proportion of legume (3.2%). Compressed sward height was low at little more than 6.5 cm.

Treatment did not affect total DMI, intake during the grazing session or bite mass (Table 2). During the grazing session, cows on Diverse swards had faster bite rates compared with those on Simple mixtures (60.3 vs 54.3 bites/minute respectively, P < 0.01). Cows on Simple mixtures compensated by spending more time grazing relative to cows on Diverse treatments (118 vs 108 minutes respectively, P<0.001). Among Diverse mixtures cows spent an extra nine minutes grazing the HSD compared with the RGD swards (P < 0.05).

Discussion

In spite of considerable treatment variation in botanical composition the differences in grazing behaviour were relatively small. One of the arguments for increasing the proportion of herb and

Table 2 *Experiment 2*: Sward characteristics and grazing behaviour for groups of four cows in two replicates grazing Simple swards consisting of perennial ryegrass (RG), high sugar content ryegrass (HS) and tall fescue (TF) and Diverse swards containing perennial ryegrass + chicory + plantain + prairie grass + red clover (RGD), high sugar ryegrass + chicory + plantain (HSD) and tall fescue + chicory + plantain + prairie grass + lucerne (TFD) in autumn. DM = Dry matter. P values in bold indicate significance at (P< 0.05) while P values in italics indicate approaching significance with a P value between 0.05 and 0.10.

Measurements	Diversity groups	Simple			Diverse			Standard error of difference	P value	
	Treatment groups	RG	HS	TF	RGD	HSD	TFD		Diversity	Treatment
Sward characteristics										
Sward height (cm)		6.9	7.4	5.8	6.9	7.0	6.2	0.6	0.98	0.17
Mass (kg DM/ha)		2,278^{ab}	2,407^{a}	1,981^{bc}	1,861^{c}	1,873^{c}	1,703^{c}	151	**<0.001**	**0.001**
Bulk density (g/cm^3)[1]		3.32^{b}	3.28^{b}	3.45^{a}	2.72^{c}	2.71^{c}	2.77^{c}	0.06	**<0.001**	**<0.001**
Proportion grass (%)		93^{a}	94^{a}	88^{a}	63^{b}	62^{b}	46^{c}	6	**<0.001**	**<0.001**
Proportion legume (%)		4^{bc}	4^{bc}	11^{ab}	8^{abc}	3^{c}	14^{a}	4	0.41	**0.03**
Proportion herb (%)		0^{b}	0^{b}	0^{b}	26^{a}	35^{a}	36^{a}	6	**<0.001**	**<0.001**
Proportion dead (%)		3^{a}	3^{ab}	1^{b}	3^{a}	1^{b}	3^{a}	1	0.91	**0.05**
Grazing behaviour										
Daily DM intake (kg DM/d)		12.8	13.6	10.9	10.6	11.2	10.1	2.4	0.17	0.66
Intake during grazing session (kg DM)		7.14	6.99	6.49	5.63	5.96	4.93	1.01	0.21	0.34
Proportion of daily DM intake consumed during grazing session (%)		58	56	64	59	55	52	18	0.80	0.99
Time grazing during grazing session (min)		118^{a}	117^{a}	119^{a}	104^{c}	113^{ab}	108^{bc}	3	**<0.001**	**0.01**
Bite rate (bites/min)		53.1^{b}	56.6^{ab}	53.2^{b}	59.6^{a}	62.6^{a}	58.7^{ab}	2.6	**0.003**	**0.05**
Bite mass (g DM/bite)		1.12	1.02	1.02	0.95	0.85	0.76	0.19	0.29	0.50

[a-d] Means within the same row with different superscripts differ (P < 0.05.

legume in grazed herbage was to improve rumen degradation and fractional outflow rates (Barry 1998) and reduce rumen fill. Rumen fill is regarded as an intake constraint (Boudon et al. 2009) that can impact on grazing behaviour (Gregorini et al. 2007; Chilibroste 1999). However in the current study cows consumed similar quantities of DM during the grazing session regardless of sward type. While a two hour grazing session does not address the long term effects of diet on rumen fermentation, the similarity in DMI suggests any differences in rumen fermentation between sward treatments were small.

In summer dairy cows consumed 37% of their total DMI in the first grazing session after milking while in autumn cows consumed 57% of their total DMI. These values are less than previously reported for ryegrass (Gregorini et al. 2009) and chicory diets (McCoy et al. 1999) who have shown 66% to 69% of the diet consumed in slightly longer grazing bouts. These authors attributed hunger, particularly after deprivation, as a key motivator for rapid intake rates. In the current study accessibility of feed was not limiting and it is possible cows may have reduced intake rate in favour of increased nutritive value. Increased chicory stem in the diet could have constrained bite rate by increasing handling time, or variation in choice of species slowed bite rate due to dietary preference (Rutter 2006). This is reflected by the slower bite rate on Diverse compared with Simple mixtures (44 vs. 49 bites/minute respectively).

Seasonal effects on sward composition and herbage mass also affected grazing behaviour. Greater bulk density in autumn allowed cows to maintain similar bite mass as summer herbage but low herbage height may have restricted bite depth resulting in more rapid bite rate. These results are consistent with previous studies which show bite mass to be the main driver for intake rate as cows will alter foraging to increase intake per bite (Hodgson 1985; Newman et al. 1994). However, total DMI in autumn was likely to have been restricted by low herbage mass, particularly on Diverse treatments. Although grazing areas were large, it is argued that a critical grazing height of approximately 9 cm is necessary in order to acquire sufficient DMI (Gibb et al. 1997).

In conclusion, small differences in grazing behaviour on different sward types were evident, but were not as great as might be expected given differences in botanical composition and sward architecture. By maintaining a constant bite mass and adjusting bite rate and grazing time, cows demonstrated their ability to maintain DMI on a range of sward types.

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