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The use of a novel approach to determine the influence of sward characteristics on the discriminatory grazing behaviour of dairy cows

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ABSTRACT

Dairy cows were offered choices of patches of vegetation ($0.8m^2$) on a perennial ryegrass (*Lolium perenne* L.) sward providing combinations of five levels of sward height (8.9 - 19.6 cm) and three levels of herbage bulk density (1.3 - 1.6 mg DM/cm^3) in linear sequence. Four cows were used, each of which grazed two out of a balanced set of eight sequences, each sequence being replicated three times in a set of 27 patches in linear sequence. Animal responses were monitored in terms of grazing time and number of bites per patch.

Bite number per patch increased from zero to 54 (SEM ± 1.63) across the range of grazing heights ($P<0.001$) with evidence of an asymptotic relationship on the taller patches. Likewise, grazing time per patch increased with sward height, ranging from zero to 55 seconds (SEM ± 1.56, $P< 0.001$). Effects of variation in bulk density at equivalent height were not significant. However, measurement of trade-offs in grazing choice between variations in sward height and bulk density requires greater control of herbage mass and bulk density than was achieved in this study.

Keywords: discriminatory behaviour; grazing preference; sward height; bulk density; herbage mass; grazing bites; grazing time; dairy cows.

INTRODUCTION

Grazing animals normally exist in a multi-variate dietary environment (Gordon and Lascano, 1993). A proper understanding of the processes which determine their discriminatory behaviour in these circumstances is becoming of increasing importance (Hodgson *et al.*, 1994). This will be especially relevant to current proposals for modifying either plant structure or plant biochemistry in order to meet particular objectives for manipulating forage consumption or the end-products of digestion (FRST, 1995). There is accumulating information which quantifies the influence of specific pasture variables on selective grazing behaviour (Kenney and Black, 1984; Illius *et al.*, 1992), but much of the current evidence is subjective and qualitative.

The objective in this paper is to describe a patch-grazing methodology which makes it possible to evaluate the choices made by animals grazing in an environment offering a structured series of options involving two or more variables, and to quantify responses in terms of ingestive behaviour. The procedures are based on a technique developed originally by Laca *et al.* (1993) to test optimal foraging theory. The methods used in this preliminary study now form the basis for an extended study of discriminatory behaviour in dairy cows at this laboratory.

MATERIALS AND METHODS

The experiment was carried out on the Dairy Cattle Research Unit, Massey University, over late summer/early autumn 1995, involving combinations of sward height (5) and bulk density (3) established in patches ($0.8m^2$) in a simple perennial ryegrass pasture (*L. perenne* cv Agriseeds Yatsyn). Variation in bulk density was created by regular cutting at 3, 2 and 1 week intervals for 9 weeks, and variation in height by synchronising 4, 3, 2, 1.5 and 1 week final periods of regrowth before grazing. The choice of levels of height and bulk density was intended to provide comparability in herbage mass within patch sets (Table 1). The sets of nine height*density (H*D) combinations were arranged at random in linear series, with three replicate blocks of each set over a sequence of 27 patches. Combinations were randomised within each replicate with a restriction so that low, medium and high swards followed each other with equal frequency down the sequence. Four separate sequences were used and each was divided in half longitudinally so that each side could be grazed separately, doubling the number of observations. Within sequences, individual patches were defined by 0.45m marginal strips cut to 2 cm.

Four mature lactating dairy cows were used after preliminary training, each cow grazing two of the four H*D sequences in a balanced design. Each cow was required to follow one sequence of 27 patches at one time, movement being confined within a 2 m wide raceway by double strand electric fences, and discriminatory behaviour was monitored in terms of the time (sec) spent grazing, the number of bites taken, or herbage removed (g DM/m^2) per patch. The four cows were used on each of two days. They had limited opportunity to graze between morning milking and experimental observations 2-3 hours later. Grazing time and grazing bites were monitored directly and by video recorder. The amount of herbage removed was estimated from the difference between estimates of herbage mass per

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patch derived from cutting with a rotary mower to 2 cm before grazing from a marginal zone (0.41m^2) and after grazing from the grazed patches (0.80m^2). Sward height per patch was measured using a sward stick with 10 random pre-grazing readings and up to 10 post-grazing readings from the grazed areas.

The data was analysed using the statistical package Minitab (Minitab, 1995) fitting sequences, blocks within sequences and treatment combinations.

RESULTS

The sward preparation procedures produced patches varying significantly in height ($P<0.001$), although they were less effective in balancing variations in herbage mass and bulk density (Table 1). The coefficients of variation (c.v.) for bite number and grazing time were 6.4% and 6.2% respectively. Difficulties were encountered in obtaining reliable estimates of herbage mass, particularly pre-grazing herbage conditions, due largely to fluctuations in growth across reseeded strips, and the c.v. of herbage mass removed was 137%. As a consequence, only data for grazing bites and grazing time are reported.

Cows consistently removed more bites of herbage per patch and increased their residence time as sward height increased, both within and across levels of bulk density (Table 2). The similarity of ingestive behaviour patterns shown in Table 2(a) and 2(b) is reinforced by the strong correlation between bite number and grazing time ($r=0.987$). Combining Tables 2(a) and 2(b) provides data on biting rate (Table 2(c)). Bite rates were highest on patches 13-14 cm tall, and declined on both taller and shorter patches ($P<0.001$).

Initial analysis of variance indicated major effects of both herbage mass and bulk density on bite number, and relatively limited effects of patch sequence and block. However, because control of herbage mass within patches was poor, an alternative model using patch height and density nested within patch height (Table 3) was preferred. This showed that variation in sward height exerted the major impact on bite number, with herbage bulk density having a limited additional effect. The effect of treatment sequence was also significant, reflecting in part differences between cows. The significant block effect (Table 3) reflected the observation that cows took more bites per patch at the beginning and end than in the middle of a grazing sequence.

DISCUSSION

The experimental procedure described provided an objective basis for quantifying discriminatory behaviour and the basis for grazing choices. The example described relates only to physical sward characteristics, but the methodology has been adapted to incorporate modifications in plant biochemistry also. The procedure adopted was preferred to the usual open-access cafeteria procedure in order to formalise the sequence of choices normally presented in a random series to grazing animals moving through a heterogeneous paddock.

The percentage of grazing time on a selected patch, and amount of herbage removed or mouthfuls of herbage taken, all define forage preference for grazing animals (Skiles, 1984). Under the procedures described, it was hypothesised that animals would concentrate their time and remove more bites on patches considered to be of high

TABLE 1: Mean values of (a) sward height (cm), (b) herbage bulk density (mg DM/cm^3) and (c) herbage mass (g DM/m^2) for nine treatment combinations (means of four replicates * 3 sets per replicate).

		(a) Sward height (cm)			(b) Bulk density (mg M/cm^3)			(c) Herbage mass (g DM/m^2)		
	5			19.6			1.86			363
	4		16.0	16.8		1.67	1.72		267	292
Height	3	13.2	13.2	13.5	1.38	1.53	1.43	182	203	192
	2	10.2	10.4		1.23	1.34		125	138	
	1	8.9			1.37			121		
	1	1	2	3	1	2	3	1	2	3
			Bulk Density			Bulk Density			Bulk Density	
			SEM ± 0.24			SEM ± 0.09			SEM ± 13.96	

TABLE 2: Mean values of (a) grazing bites, (b) grazing time (sec) and (c) biting rate (bites/min) for nine treatment combinations (means of four replicates * 3 sets per replicate).

		(a) Grazing bites			(b) Grazing time (sec)			(c) Biting rate (bites/min)		
	5			53.5			55.3			58.2
	4		45.5	46.7		42.8	43.1		64.3	65.1
Height	3	31.3	30.8	32.0	27.1	25.7	27.5	70.3	72.2	71.1
	2	4.2	4.8		3.2	3.7		35.1	58.4	
	1	0.2			0.1			10.0		
	1	1	2	3	1	2	3	1	2	3
			Bulk Density			Bulk Density			Bulk Density	
			SEM ± 1.63			SEM ± 1.56			SEM ± 4.21	

TABLE 3: Modified ANOVA for bites per patch, based on matrix of sward height*bulk density combinations (Table 1(a) and 1(b)).

Source	DF	SS	MS	F	P
Sequence	7	7442	1063	16.6	***
Block	16	3429	214	3.3	***
Height	4	77289	19322	302.0	***
Density (Height)	4	40	10	0.2	NS
Error	184	11794	64		
Total	215	99995			

(NS not significant, *** P<0.001)

priority. Animals walked the sequence of choices, taking between 8 and 15 minutes to cover a sequence of 27 patches, and regularly sampled from all but the shortest of swards (see Table 2(a)). This repetitive sample grazing follows the conclusions drawn by Illius and Gordon (1990) on the unpublished work of Clark and co-workers, where it was suggested that ruminants may have poor information uptake and retention. However, the evidence collected suggests that this methodology, comprising a raceway of patches in linear sequence, was extremely effective in defining behaviour patterns with a limited number of animals. Treatment effects were clearly defined, though the confounding of cow and sequence effects meant that it was not possible to clearly identify between-cow differences.

This study showed that sward height exerted a major influence on grazing preference, with the number of bites and grazing time per patch tending to a maximum as sward height increased (Table 2). These results support and extend the evidence of Bazely (1990), working with sheep offered choice of patches of long vegetation in an existing short sward, and that of Clark and co-workers (reported in Illius and Gordon, 1990), who showed that sheep, cattle and goats all tended to preferentially graze the taller of pairs of swards offered in a graded sequence. It has generally not been possible to define the separate effects of sward height and bulk density on grazing preferences, and in the current study there was limited variation in bulk density between patches, as opposed to the controlled contrasts in sward height (Table 1(a) and 1(b)). As a consequence, the limited influence of herbage bulk density on grazing preferences should be treated with caution when considering possible trade-offs between sward height and bulk density. Even so, the behavioural pattern that has emerged from this study runs parallel to the work of Mitchell *et al.* (1991) and Laca *et al.* (1992) where sward height largely controlled variations in bite weight and rate of herbage intake, and provides further support for the argument that potential rate of intake largely influences grazing decisions (Kenney and Black, 1984; Laca *et al.*, 1993). However, limitations in the estimates of herbage removed precluded calculation of rate of intake in this study.

CONCLUSIONS

The evidence from this study confirms the underlying importance of the influence of sward height on animal behaviour. The linear sequence of choices provided controlled procedures for monitoring the decisions animals made about the alternative patch structures on offer. The consistency of the related patterns of grazing provide confidence in the use of the experimental procedures for monitoring discriminatory behaviour at the patch level.

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