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Differences in grazing behaviour and herbage intake between genotypes of Holstein-Friesian dairy cows grazing short or long swards

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ABSTRACT

The objective of this work was to compare dry matter intake and grazing behaviour of different strains (S) of Holstein-Friesian dairy cows during early lactation. Three strains of different origin [two 1990's genotypes of Holstein-Friesian from Overseas (OS90) or New Zealand (NZ90) origin and a 1970's NZ Friesian (NZ70)] were offered low or high pre-grazing herbage mass (HM) (2100 vs 2800 kg DM/ha) at a common daily allowance (35 kg DM/cow) between September and November 2004. Pasture dry matter intake (IT) and digestibility (D) were determined using the n-alkanes methodology. Time spent grazing (GT) and ruminating (RT) were observed for 24 hours. Intake per empty body live weight unit (ILW) and rate of intake (IRATE) were calculated. There was a significant SxHM interaction ($P < 0.001$) for IT and ILW. IT was similar at low HM across strains, whereas at high HM, a lower IT was recorded for the NZ70 while it was higher for the OS90. At low HM, ILW was slightly lower in the OS90 than in the NZ90 ($P = 0.06$) while at high HM both NZ90 and OS90 showed a higher ILW. *In vivo* digestibility was similar across strains but was higher at high HM ($P < 0.001$). There was a significant SxHM interaction for GT ($P < 0.01$) with both NZ strains spending more time grazing at low HM, in contrast, GT was similar across strains at high HM. RT was higher for the OS90 strain than for both NZ strains ($P < 0.05$) and greater at high HM ($P < 0.001$). There was a significant SxHM interaction for IRATE ($P < 0.05$) with the NZ90 and OS90 strains showing similar IRATE at low HM but different at high HM. Results indicate a difference in the ability of the strains to adjust their grazing behaviour to different pre-grazing herbage mass.

Keywords: Holstein-Friesian; high-merit dairy cow; intake; grazing behaviour, herbage mass.

INTRODUCTION

Overseas (OS) Holstein-Friesian genetics have been introduced into New Zealand (NZ) during the last 20 years (Harris & Winkelman, 2000; Harris & Kolver, 2001) in order to take advantage of their high protein yields. In NZ, these cows achieved very high milk solids yields when fed on a total mixed ration (Kolver *et al.*, 2002), however, the modern NZ genotype produced slightly more milk solids and had slightly higher pasture intake (% live weight) than the OS genotype when fed only on pasture during early lactation (Kolver *et al.*, 2002). Additionally, both modern genotypes fed only pasture produced more milk solids than the NZ Friesian of the 1970s during early lactation, with a slightly higher pasture intake for the modern NZ cow than for the OS due to a superior bite size and rate of intake (Rossi *et al.*, 2004). In contrast, and despite the high pasture allowance offered, the OS cows spent less time grazing during late lactation, which resulted in less time to consume and process each unit of DM (Thorne *et al.*, 2003). As yield potential is known to be higher in the OS genotype (Kolver *et al.*, 2002), intake should be increased if pasture is not limiting.

Herbage allowance is a determinant of pasture intake (Combellas & Hodgson, 1979; Le Du *et al.*, 1979; Peyraud *et al.*, 1996; Wales *et al.*, 1998; Maher *et al.*, 1999), additionally, intake is near maximum when daily herbage allowance per cow is equivalent to twice the pasture intake (Combellas & Hodgson, 1979). Increments in daily herbage allowance can be obtained by increasing either the pre-grazing herbage mass (HM) or the area allocated to each cow. In both situations, the herbage availability and the cow's ability toprehend leaf become increasingly limited as the sward is grazed down (McGilloway *et al.*, 1999).

At similar daily herbage allowance per cow, pasture dry matter intake may increase at high HM, and may be higher in the OS and NZ modern genotypes than in the former NZ Friesian. Additionally, cows may adapt their behaviour to changes in pasture condition by increasing grazing time at low intake rates. This opportunity for compensation is reduced in short swards where cows are unable to eat enough even if the area offered is large (McGilloway & Mayne, 1996) and grazing ceases once leaf material is exhausted. This may occur earlier for those cows grazing at a higher rate.

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This experiment was designed to investigate the differences in pasture intake and grazing behaviour between different genotypes of Holstein-Friesian dairy cows grazing contrasting pasture conditions in a controlled grazing experiment, during early lactation.

MATERIALS AND METHODS

This experiment was conducted at Ruakura No 1 Dairy, in Hamilton, New Zealand, from September to November 2004, using cows from the Dexcel Holstein-Friesian Strain Trial. Sixteen cows (three to five year olds) of three different strains (S) of Holstein-Friesian dairy cows [high breeding worth 1990's Holstein-Friesian of overseas (OS90) or NZ origin (NZ90), and a low breeding worth 1970 NZ strain of Friesian (NZ70), see Rossi *et al.*, 2004; breeding worth being an indication of the genetic merit of the strains] were allocated to low or high pre-grazing HM but with a common daily herbage allowance per cow (low HM: 2100 kg DM/ha, high HM: 2800 kg DM/ha; daily allowance: 35 kg DM/cow) balanced by lactation number, live weight, body condition score, calving date and pre-experimental milksolids production.

Paddocks used in the experiment were in one area of the farm, with a similar soil type and pasture composition. Cows grazed together under conditions similar to those defined for the high HM treatments before the start of the experiment. Cows were allocated to the treatment groups ten days before the start of measurements. There were two experimental periods (16 days each) separated by a three-week period, when the cows grazed again as one mob. The first experimental period was coincident with the start of mating. To avoid oestrus affecting daily intake and behaviour during the experiment, all cows had a CIDR® progesterone-releasing device inserted for the duration of the first period and were inseminated just after it finished. The three herds allocated to low HM in the first period grazed at high HM in the second period. During each period, the three herds allocated to similar HM treatment grazed the same paddock. Within each paddock, herds were allocated at random to different strips of pasture separated by electric fences and offered water in separate troughs.

Thirty cuts to ground level (20 before and 10 after grazing) was used to calibrate a rising plate meter (RPM) to the experimental pasture conditions. This instrument was used to measure pre- and post-grazing HM in the experimental paddocks and to estimate the area needed daily to allocate the herds.

Pasture dry matter intake (IT) and *in vivo* digestibility (D) were estimated in each experimental period for each individual cow using the n-alkane technique (Dove & Mayes, 1991). Each cow was dosed orally at each milking (a.m. and p.m.) with pellets

containing 347 mg of the C32 alkane for a 10 day period, and faecal samples were taken per rectum from each cow before milking (a.m. and p.m.), during the last five days of the dosing period. In addition, pasture samples were obtained from the grazed stratum of each paddock grazed during the faecal collection period. Individual faecal and pasture samples were bulked on a weekly basis and analysed (Mayes *et al.*, 1986).

In the same week when intake was determined (both periods), the time the cows spent grazing (GT) and ruminating (RT) were recorded at 10 minutes intervals for one 24-hour period in each experimental period. Additionally, cows were weighed and condition scored (BCS) weekly (Macdonald & Roche, 2004) and the individual milk volumes measured daily. Weekly, a consecutive p.m.-a.m. milk sub-sample was analysed to determine milk fat, milk protein and lactose concentration using a FT120 (Foss Electric, Hellorod, Denmark).

From IT and GT, the average intake per hour was estimated (IRATE). To reduce the bias due to differences in gut fill between HM treatments, the empty body weight of each animal (LWE) was estimated as the actual live weight (LW) after the a.m. milking minus the estimated daily individual intake (Tamminga *et al.*, 1997). Intake was also expressed per LW unit (ILW).

Statistical analysis

Treatments were arranged in a factorial design with three cow strains and two HM treatments replicated in time with a cross-over arrangement of herds between HM treatments between periods. The effect of S, HM and their interactions were analysed using the statistical procedures of SAS (SAS, 2002), as a mixed model (PROC MIXED) with S, HM, period and the SxHM interaction as fixed effects and strain and cow as random effects. In this report only intake and grazing behaviour results are reported.

RESULTS

There was a significant SxHM interaction ($P < 0.001$) for IT and ILW (Table 1). Daily intake was similar across the three strains at low HM but there were significant differences between the strains at high HM with the OS90 strain having the highest IT and the NZ70 strain the lowest. The estimated ILW was statistically similar between strains at low HM, however, the OS90 strain had lower ILW (by 9%) than the NZ90 strain ($P = 0.06$). At the high HM, ILW was similar for both high-merit strains, which were about 29% higher than for the NZ70 strain. *In vivo* D was similar across the three strains but higher at the high HM ($P < 0.001$).

TABLE 1: Live weight, body condition score, pasture dry matter intake and grazing behaviour of three strains of Holstein-Friesian dairy cows grazing at low (2100 kg DM/ha) or high (2800 kg DM/ha) pre-grazing herbage mass in early lactation.

HM		Low			High			Significance			
		NZ70	NZ90	OS90	NZ70	NZ90	OS90	SED	S	HM	S*HM
LW	kg cow ⁻¹	392	396	449	403	394	441	9.71	***	ns	***
BCS		4.49	4.26	3.75	4.46	4.33	3.79	0.169	***	ns	ns
I _T	kg DM cow ⁻¹	13.63	14.06	14.48	15.77	19.20	21.59	0.64	***	***	***
I _{LW}	kg DM LW ⁻¹	3.47	3.56	3.23	3.93	4.92	4.89	0.17	***	***	***
D	g kg ⁻¹	789	791	786	826	832	841	6.67	ns	***	0.08
G _T	min day ⁻¹	568	572	517	444	465	473	17.5	ns	***	**
R _T	min day ⁻¹	275	278	314	358	366	379	14.9	*	***	ns
G _T + R _T	min day ⁻¹	843	850	831	802	831	852	21.9	ns	ns	*
I _{RATE}	kg DM h ⁻¹	1.45	1.49	1.69	2.16	2.50	2.76	0.12	***	***	*

NZ70: low breeding worth Friesian strain representative of selection and breeding policies in New Zealand in the 1970s; NZ90: high breeding worth Holstein-Friesian of New Zealand; OS90: high breeding worth Holstein-Friesian of overseas origin. LW: empty body live weight; BCS: body condition score; IT: daily intake; ILW: daily intake per 100 kg LW; D: dry matter digestibility; GT: grazing time; RT: ruminating time; IRATE: intake rate. S: strain of Holstein-Friesian, HM: pre-grazing herbage mass, SxHM: S by HM interaction, min: minutes; .SED: maximum standard error of the differences of least squares means; ns = not significant; *P < 0.05; ** P < 0.01; *** P < 0.001

There was a significant SxHM interaction for GT (P < 0.01) with both NZ strains spending more time grazing than the OS90 at the low HM, whereas GT was similar for all strains at high HM. However, there was a trend for a shorter GT for the NZ70 strain when grazed at the high HM compared with the OS90 strain (P = 0.13). The time the cows spent ruminating was higher for the OS90 strain than for both NZ strains (P < 0.05), and highest at the high HM (P < 0.001).

Total grazing activity (GT + RT) showed a significant SxHM interaction (P < 0.05) with a similar activity for the three strains at low HM, but with the NZ70 strain having a much lower activity than the OS90 strain at high HM. The difference observed between the NZ90 and NZ70 strains was almost similar to that between the NZ90 and the OS90 strains at high HM. There was a SxHM interaction for IRATE (P < 0.05), with the high merit strains showing similar IRATE at low HM (P = 0.07) but different at high HM (P < 0.05).

There was a SxHM interaction (P < 0.001) for LW, with the NZ70 having at high HM a higher LW than at low HM and vice versa for the OS90. The OS90

cows were heavier than both NZ strains but presented a lower BCS (P < 0.001), which was similar between pre-grazing HM.

DISCUSSION

At high HM, the IT for the NZ70 cows was probably limited by a lower metabolic demand and feeding drive than for both high-merit strains. Although the high merit cows ate more than the NZ70, their energetic demand may not be completely satisfied on pasture, even at the high HM offered (McGilloway & Mayne, 1996). Moreover, the larger increase in IT and D between HM observed for both high merit strains (OS90 and NZ90) is probably indicating a higher pasture constraint for these strains when grazed at low HM than for the NZ70. This constraint could be assumed to be higher in the OS90 as indicated by the higher ILW estimated for the NZ90 at low HM. Additionally, IT was probably limited by the ingestion capacity of the genotypes, determining the size of the bite and the digestibility of the herbage consumed.

The fact that a lower digestibility of the herbage consumed was estimated at the low HM indicates that cows were grazing closer to the ground and probably ingested a higher proportion of stems (post-grazing residuals were 1703 and 1922 kg DM/ha for low and high HM respectively). This would be expected to have had a negative effect on digestion rate and intake. The improved *in vivo* digestibility of the herbage consumed at the high HM indicates that these cows had selected plant parts with the highest nutritive value, which should have produced a positive effect on digestion rate and intake. This increment was superior for the OS90 strain.

Despite the higher IT, the time spent grazing in all the strains was reduced at the high HM as result of a higher IRATE, however, more time was required to process the additional herbage ingested. The difference in RT between HM was higher for both NZ strains, in addition the NZ strains showed the highest reduction in GT, both activities representing a net saving of time in both NZ genotypes at high HM. The possibility to extend GT can be limited by the rumination requirement of the cow (Gordon & Lascano, 1993), which explains why the OS genotype did not graze for longer despite the high allowance offered in Thorne's work (Thorne *et al.*, 2003). Nevertheless, rumination was not recorded while the cows were not in the paddock (270 minutes/day) so the assumption for a trend of a higher rumination rate (kg DM/h) for the OS90 at high HM cannot be validated from the present data.

Both bite weight and bite rate are determinants of IRATE thus, as grazing progresses and pasture is depleted, bite size should be reduced. Because of the superior IRATE of the OS90, the pasture should have been depleted faster by these cows, especially at low HM. A reduced sward height, an increased bulk density and the presence of a pseudostem layer are the main factors suggested as causes of reduction in bite size. At very low sward heights, the compensatory effect between bite rate and GT cannot override the effect of a very small bite size, and IT falls (Gordon & Lascano, 1993).

The low ILW and D recorded for the OS90 strain at low HM indicate the energy consumed per unit of LW in this strain was the lowest of the three strains compared in this experiment, indicating a superior ability of the NZ genotypes to deal with short swards.

CONCLUSION

These results suggest that a different pre-grazing HM should be targeted for cows of different genetic merit to maximise pasture dry matter intake in early lactation. The NZ90 and OS90 genotypes had the highest daily intake when grazed at high HM, and reduced the quantity and quality of the pasture

consumed at low HM. Both NZ strains spent more time grazing and less time ruminating at low HM, which should have contributed to the small difference in intake between pasture conditions, especially for the NZ70 strain. Additionally, the lower live weight of these genotypes resulted in their superior pasture consumption per unit of LW at low HM.

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