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## Diet and genotype affect feeding behaviour of Holstein-Friesian dairy cows during late lactation

P. L. THORNE, J. G. JAGO, E.S. KOLVER AND J.R. ROCHE

Dexcel, Private Bag 3221, Hamilton, New Zealand

### ABSTRACT

Ingestive behaviour of New Zealand (NZ) and overseas (OS) Holstein-Friesian (HF) dairy cows grazing pasture only or fed a total mixed ration (TMR) was observed in late lactation. Data from visual observations every 10 minutes over a 48-h period were used to evaluate differences in time spent feeding, ruminating, standing and lying. OS HF and cows fed TMR had greater dry matter intakes (DMI) than their respective comparisons. Cows grazing pasture spent more time feeding, less time ruminating, less time standing and the same time lying, compared to cows fed TMR. OS HF spent less time feeding, the same time ruminating, the same time standing, and more time lying compared to NZ HF. When expressed in terms of DMI, OS HF took less time to consume a kg of DM, and spent less time ruminating each kg of DM compared to NZ HF, irrespective of diet. A genotype x diet interaction was observed for time spent standing, with NZ HF spending more time standing when fed TMR, but standing for a similar time as OS HF when grazing. These results suggest feeding and grazing behaviour differences between HF cows of differing genotype, but similar breeding worth.

**Keywords:** grazing behaviour, Holstein Friesian, genotype, diet.

### INTRODUCTION

The use of Holstein-Friesian (HF) genetics from overseas (OS), principally North America and the Netherlands, has increased substantially in New Zealand over the last ten years (Harris & Kolver, 2001). Previously, genotypes suited for one dairying environment were assumed to be best for another, different, dairying environment. Increasingly however, cow suitability for a particular dairying system is being considered important (Holmes *et al.*, 2002). For grazing systems, this requires an animal with a high capacity and drive to harvest forage (Holmes *et al.*, 2002).

Recent comparisons of NZ and OS HF (Kolver *et al.*, 2002) have reported that NZ HF performed better than OS HF when grazing pasture, but OS HF performed better than NZ HF when fed a total mixed ration (TMR). Differences appeared to be associated with a lower intake (% live weight; LW) by OS HF grazing pasture compared to NZ HF grazing pasture, particularly in early lactation, and to a higher intake (% LW) by OS HF fed TMR compared to NZ HF fed TMR in late lactation.

The reasons for the lower intake by OS HF grazing pasture were speculative, but may have been because they were not "good grazers", because the intake limitations of fresh pasture become more evident with larger dairy cattle, or because they were lacking some metabolic adaptation that NZ HF have made (Kolver *et al.*, 2002).

Although previous behavioural observation studies have been reported for grazing HF cows (e.g. O'Connell *et al.*, 2000; Bargo *et al.*, 2003), genotype comparisons have been confounded with differences in genetic merit and level of milk production. The unique aspect of the current study is that genotype comparisons can be made between animals of similar genetic merit for milk production (Kolver *et al.*, 2002).

The current study compared the ingestive behaviour of OS and NZ HF cows grazing pasture or fed TMR. Based on previous observations, it was expected that

pasture intake by OS HF may be constrained by the time available for grazing.

### MATERIALS AND METHODS

#### Experimental design and treatments

Behavioural observations were conducted in March 2001 (late lactation) at Dexcel No 1 Dairy, Hamilton, in the third year of a four-year genotype comparison trial (described by Kolver *et al.*, 2002). OS HF and NZ HF cows were fed either a TMR diet or grazed pasture (Grass) according to a 2 x 2 factorial design. The four treatment groups were NZ TMR (n=14), OS TMR (n=14), NZ Grass (n=14), and OS Grass (n=13). Each group consisted of primiparous and multiparous cows and each group had an equivalent age structure (4.7 ± 1.1 years; Mean ± SD).

#### Feeding and management

Feeding and management of the treatment groups have been described previously by Kolver *et al.* (2002). Briefly, cows fed TMR were managed as separate herds but grouped together twice daily at milkings. During late lactation, cows were confined to one of three loafing paddocks (0.25 ha/paddock) and genotypes were separated by electric fences.

The TMR was comprised of maize silage (18%), grass silage (35%), hay (2%), whole cottonseed (8%), and concentrate (37%), and was mixed in a Jaylor mixer wagon. This ration was formulated to represent a diet typical of North American and European systems. To ensure *ad libitum* feeding, herd residuals were weighed daily and a 10% refusal rate was maintained. This TMR mix was split between the two genotypes, ensuring that each herd received the same TMR. Feed was offered once at 0900 h, and again at 1700 h.

The two grazing herds were managed separately, except when grouped twice daily at milkings. Both NZ and OS herds grazed the same paddock, separated by an electric fence. Fresh pasture breaks were offered

following morning (approximately 0745 h) and afternoon (approximately 1545 h) milkings. During the observation period in late lactation, pre-grazing herbage mass was 2900 ± 450 kg DM/ha, post-grazing herbage mass was 2150 ± 450 kg DM/ha, and pasture allowance was 103 ± 17 kg DM/cow/d. This high pasture allowance was targeted to ensure that intake was not constrained.

**Behaviour observations**

The ingestive behaviour of each herd was observed and recorded over a 48-h observation period. Observations started at the return of each herd to their paddock after morning (0745 h) and afternoon (1545 h) milking. Observations stopped once the stock handler entered the paddock to yard cows for morning (0645 h) and afternoon (1445 h) milking. Cows fed TMR were miked between 0800 and 0900h, and between 1600 and 1700h. Thus, two data sets from two consecutive 22-hour periods (excluding two hours of milking per d) were collected. Two observers were present at all times, working in three-hour shifts, and were situated in a caravan or van in a paddock adjacent to the subject cows.

Cows were identified by large numbers painted on their sides. Confirmation of identification was made, if necessary, by ear tag or freeze brand identification on the cows rumps. The behaviour of individual cows was recorded at 10-min intervals. At each visual observation, individual cows were recorded as either grazing pasture (G) or eating TMR (E), lying (L), lying and ruminating (LR), standing (S), standing and ruminating (SR), drinking (D), or walking (W). All recorded behaviours were grouped into four categories for analysis; feeding (G, E), standing (S, SR, W, D), ruminating (LR, SR), and lying (L, LR).

**Intake measurements**

A 5-d intensive intake-measurement period immediately followed the behavioural observations. During this period, individual cow intakes were recorded

using the n-alkane marker method (Dove & Mayes, 1991). Milk production, LW, and efficiency of milksolids production were measured as described by Kolver *et al.* (2002).

**Statistical analysis**

All data were analysed using residual maximum likelihood (REML) for a factorial design using the statistical procedures of GenStat (Version 6.1). Significant effects were declared at P<0.05 and trends at P<0.10. Data from one cow in the NZ Grass herd was excluded, as she was in oestrus during the observation period. The number of occurrences of each behaviour was summed for individual cows and then averaged across herds to obtain a percentage of time spent in each activity during the observation period.

**RESULTS**

Compared with NZ HF, OS HF spent less time feeding (6.6 h vs. 7.1 h, SED 0.16), the same time ruminating (8.2 h vs. 8.1 h, SED 0.19), the same time standing (5.2 h vs. 5.7 h, SED 0.29), and more time lying (10.2 h vs. 9.2 h, SED 0.28) each day. Compared to cows fed TMR, cows grazing pasture spent more time feeding (8.9 h vs. 4.8 h, SED 0.16), less time ruminating (7.5 h vs. 8.9 h, SED 0.19), less time standing (3.6 h vs. 7.3 h, SED 0.29) and the same time lying (9.5 h vs. 9.9 h, SED 0.28) each day (Table 1). A genotype x diet interaction was observed for time spent standing, with NZ HF spending more time standing than OS HF when fed TMR, but a similar amount of time standing when grazing pasture. A trend for an interaction for time spent feeding was observed, with OS Grass spending less time feeding than NZ Grass, but with no difference between genotypes when fed TMR. A trend for an interaction was also observed for time spent lying.

Cows fed TMR had a greater milksolids yield, LW and dry matter intake (DMI) than grazing cows, when intake was expressed as either kg DMI/d or as a %LW (Table 2). Even though OS HF had a greater milksolids

**TABLE 1:** Time<sup>1</sup> (h) spent feeding, standing, lying and ruminating by New Zealand (NZ) and overseas (OS) Holstein-Friesian (HF) dairy cows grazing pasture (Grass) or fed a total mixed ration (TMR) in late lactation.

	NZ		OS		SED	Genotype	P Diet	G x D
	Grass	TMR	Grass	TMR				
Feeding	9.3	4.9	8.5	4.7	0.22	0.004	<0.001	0.054
Standing <sup>2</sup>	3.5	7.9	3.8	6.6	0.41	0.118	<0.001	0.009
Lying <sup>3</sup>	9.2	9.2	9.7	10.6	0.40	0.001	0.116	0.091
Ruminating	7.5	8.8	7.4	8.9	0.27	0.753	<0.001	0.635

<sup>1</sup> Excluding 2 hours per day for A.M. and P.M. milkings.

<sup>2</sup> Including time spent standing and ruminating.

<sup>3</sup> Including time spent lying and ruminating.

**TABLE 2:** Milksolids production, live weight, daily dry matter intake (DMI) and time spent feeding and ruminating, by New Zealand (NZ) and overseas (OS) Holstein-Friesian (HF) dairy cows, grazing pasture (Grass) or fed total mixed ration (TMR) in late lactation.

	NZ		OS		SED	Genotype	P Diet	G x D
	Grass	TMR	Grass	TMR				
Milksolids (kg/d)	1.23	1.69	1.24	2.19	0.132	0.014	<0.001	0.010
Live weight (kg)	489	601	549	668	20.1	0.002	<0.001	0.743
DMI (kgDM/d)	14.4	18.1	15.9	22.0	0.60	<0.001	<0.001	0.004
DMI (%LW)	2.96	3.04	2.92	3.32	0.138	0.267	0.014	0.075
Feeding (h/kg DM)	0.66	0.27	0.55	0.22	0.029	<0.001	<0.001	0.189
Ruminating (h/kg DM)	0.53	0.49	0.48	0.41	0.026	<0.001	0.005	0.517

production, LW and DMI (kg DM/d) than NZ HF, intakes were similar when expressed as a %LW. When observational data are expressed as h/kg DMI, OS HF spent less time feeding (0.38 h vs. 0.47 h/kg DM, SED 0.02), and less time ruminating (0.44 h vs. 0.51 h/kg DM, SED 0.02), than NZ HF. Cows grazing pasture spent more time feeding (0.60 h vs. 0.25 h/kg DM, SED 0.02), and more time ruminating (0.50 h vs. 0.45 h/kg DM, SED 0.02), than cows fed TMR. A genotype x diet interaction was observed for milksolids yield and DMI (kg DM/d), and a trend for an interaction for DMI (%LW).

## DISCUSSION

The grazing behaviour results from this study helped explain part, but not all, of the relatively poorer performance of OS HF compared to NZ HF previously reported for cows of similar genetic merit grazing pasture (Kolver *et al.*, 2002). In this late lactation study, OS HF cows consumed more pasture than NZ HF, but this was in proportion to their heavier live weight. As a result, milksolids production was similar between genotypes grazing pasture, with the increased energy intake of OS HF being used to meet the greater maintenance requirements of the larger animal.

Previous reports of this genotype comparison study (Kolver *et al.*, 2002) indicated that OS HF did not achieve the same intake (as a %LW) as NZ HF in spring/early lactation, presumably when energetic demands were higher, but that by late lactation, intake (as a %LW) was similar between genotypes. However the current results show that grazing behaviour between genotypes was quite different, even in late lactation when intakes (as a %LW) were similar between genotypes. OS HF actually consumed more pasture (1.5 kg DM) in a shorter time (0.8 h) than NZ HF. Hence, rate of pasture intake by OS HF was faster than NZ HF. The faster rate of intake may be related to a higher bite rate by OS HF (O'Connell *et al.*, 2000).

It is unclear why OS HF did not graze pasture for longer, as the longer hours spent grazing by NZ HF indicated that hours available during the day for grazing were not limiting. It may be argued that achieving an intake of almost 3% LW in late lactation may be reaching the upper limits of pasture intake for this stage of lactation. This intake limit might be related to cows reaching the upper limits of neutral detergent fibre intake (NDF intake as a %LW; NRC, 2001), whereas in spring maximum intake may be limited by hours available for grazing (Kolver & Muller, 1998). Alternatively, ruminal or metabolic feedback mechanisms influencing intake may be different between genotypes.

It is likely that the faster rate of intake of pasture by OS HF was associated with the shorter time required by OS HF to ruminate each kg of DM. A quicker rumination time would be expected to increase the rate of digesta passage from the rumen, allowing a greater rate of intake. Dado & Allen (1994) reported that high-producing cows process more feed during a given chewing period. Mastication efficiency was thought to be greater due to a shorter time between boluses, more chews per unit time, or more efficient regurgitation of long particles. Physical

differences between animals, in particular mouth size, were also considered possible reasons for increased mastication efficiencies (Dado & Allen, 1994).

The unexpected but significant effects of genotype in rumination efficiency provided an intriguing result from this trial, especially as genotype effects applied to both diets. This effect may be linked to the lower production of methane (g/kg DMI) reported for OS HF cows in this genotype comparison study (Robertson & Waghorn, 2002). One reason why methane emissions were lower in OS HF may be because of a faster rumen outflow rate, possibly resulting from more efficient rumination.

The current comparison of HF genotypes is unique in that the comparison is not confounded by differences in genetic merit. Previous reports of grazing behaviour between genotypes have typically compared cows with different levels of genetic merit for milk production (O'Connell *et al.*, 2000; Bargo *et al.*, 2003). The review of Bargo *et al.* (2003) concluded that high-yielding/high-merit cows grazed for longer, had more bites per day, and had a higher rate of intake than low producing cows. However, O'Connell *et al.* (2000) observed behaviour of high and medium-merit HF during daylight hours only, and reported no genotype difference in time spent grazing. Higher intakes achieved by high-merit cows were a result of more grazing bouts of shorter duration, higher biting rates, and a greater proportion of time spent ruminating compared to medium-merit cows.

The side-by-side behavioural observations of cows grazing pasture or fed TMR was a unique aspect of the current study. Time spent grazing and ruminating were in agreement with previous reports of cows grazing pasture (Wales *et al.*, 1998; Dalley *et al.*, 2001) or fed TMR (Dado & Allen 1994). Cows spent more than twice as long grazing as they did eating TMR. This might be expected as the DM content of pasture (18%) was less than half that of the TMR (44%), requiring larger quantities of fresh pasture to be consumed to meet energy requirements. Grazing also requires more time to walk and harvest the forage, as opposed to a TMR which is offered in troughs.

Of particular interest is the small difference in rumination time between diets. Cows spent a small, but significantly longer period of time (5%) ruminating each kg of pasture DM compared to a kg of TMR. This is of interest because rumination time reflects adequacy of dietary fibre content. This result suggests that the fibre content of autumn pasture (49% NDF) had similar or better effectiveness at stimulating rumination compared to fibre in a balanced TMR containing 34% NDF.

Feeding behaviour differed between New Zealand and overseas Holstein-Frisian cows of similar breeding worth in late lactation. OS HF spent less time grazing or feeding, had a faster rate of intake, and spent less time ruminating each kg of DM than NZ HF. This may explain some, but not all, of the relatively poorer performance of OS HF cows compared to NZ HF cows grazing pasture.

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