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Herbage intake, grazing behaviour and feed conversion efficiency of lactating Holstein-Friesian cows that differ genetically for live weight

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ABSTRACT

Two experiments were carried out to compare the feed conversion efficiency at high pasture allowances in early (EXP1) and mid-lactation (EXP2) of genetically heavy (H) or light (L) Holstein-Friesian cows (H = 487, L = 410 kg, P<0.001). Average milksolids (MS) yield was not significantly different in EXP1 (H = 1.73, L = 1.64 kg MS), but the H line had higher MS yield than the L line in EXP2 (H = 1.70, L = 1.54 kg/cow/day, P < 0.001). The mean individual dry matter intakes (DMI, kg/cow/day), measured using the *n*-alkanes technique, were higher for H cows in both EXP1 (H = 15.5 and L = 13.9; P < 0.05) and EXP2 (H = 12.2 and L = 10.8; P < 0.05). However, herbage intake was not significantly different between the H and L cows when adjusted to a common MS yield. Feed conversion efficiency (g MS/kg DMI) was slightly higher for the L cows during EXP1 (H = 114, L = 120, P = < 0.1), but not different for H and L cows during EXP2 (H = 144, L = 143). The calculated bite size of the H cows was on average 0.095 g DM/bite (pooled for the two experiments) heavier (P < 0.05) than that of the L cows, but the L cows showed a consistently faster rate of biting than the H cows (H = 51, L = 56 bites/min, P < 0.05). Although the H cows had higher MS yield than the L cows, especially in EXP2, the higher MS yield was not associated with increased efficiency, presumably because the H cows required more energy for maintenance than the L cows.

Key words: Feed conversion efficiency; grazing behaviour; dairy cows; live weight.

INTRODUCTION

Live weight (LW) of the lactating cow is included in the genetic evaluation of dairy sires and cows in New Zealand and is given a negative relative economic value (Livestock Improvement Corporation, 1996). Higher feed conversion efficiency of phenotypically light cows compared to heavy cows was reported by Holmes *et al*., (1993). There are only a few genetic experiments designed to evaluate the effect of genetic differences in the LW of dairy cows on feed conversion efficiency (Hansen *et al*., 1998). Results from indoor conditions in Minnesota (Yerex *et al*., 1988) which compared the feed conversion efficiency of genetically heavy or light USA Holstein cows, showed that cows from the light line had a slightly higher gross energy efficiency than cows from the heavy line. However, there are no experimental data which have compared the feed conversion efficiency of genetically heavy or light Holstein-Friesian cows under grazing conditions.

This paper presents the results of two short term grazing experiments carried out during early (EXP1) and mid-lactation (EXP2) which were intended to compare the feed intake, feed conversion efficiency and grazing behaviour of Holstein-Friesian cows from the heavy (H) and light (L) LW selection lines at Massey University. Details of the formation of the two lines have been given by García-Muñiz *et al*., (1998a) and García-Muñiz *et al*., (1998b in press, this volume).

MATERIALS AND METHODS

In EXP1 (from the 1st to the 10th October) and EXP2 (from the 14th to the 23rd November), 21 early lactation cows and 30 mid lactation cows from each line, were rotationally grazed as a single mob and offered a generous daily herbage allowance of 45 kg DM/cow as assessed by a calibrated rising plate meter (Stockdale, 1984). The two groups of cows in both experiments were balanced by age and calving date.

Milk yield was measured thrice during both experiments using in-line milk meters. Concentrations of fat, protein and lactose in milk were measured using a Milkoscan 104 infrared analyser (A/S N. Foss Electric, Denmark). The average of the three herd tests for each cow was used as the daily milk production. Live weight (LW) and body condition score (BCS assessed by three observers) of the cows were measured at the start and at the end of the trials. The mean of the two BCS and LW measures were used in the analyses.

Individual cow DMI and digestibility (DMD) were measured using the *n*-alkanes technique (Dove and Mayes, 1991). In both experiments, cows were fitted with slow release alkane capsules (Captec (NZ) LTD, New Zealand) and faecal and grass samples were collected during 10 days in each experiment after an equilibration period of 6 days. Alkane concentration in pasture and faeces samples were analysed for each of a 5-day periods of faeces collection. Samples were analysed for *n*-alkane content at the Dairy Research Corporation, Hamilton, New Zealand, using the analytical procedure described by Mayes *et al*., (1986). Feed intake was estimated from the concentrations of C_{33} (natural odd chain) and C_{32} (dosed even chain) alkanes in the pasture and faeces as described by Dove and Mayes (1991). Estimates of DMD were calculated from the con-

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centrations of C_{33} and C_{31} (Dove and Mayes, 1991), assuming 0.86 and 0.83 as the recovery rates for C_{33} and C_{31} (Stakelum and Dillon, 1990). In the case of EXP2, due to the extreme variation in the concentration of C_{33} in faeces in the second period, DMI and DMD were estimated only for the first 5-days .

Grazing behaviour was monitored on two occasions in each experiment during the periods of intake determination. Grazing time of all the experimental cows (42 in EXP1 and 60 in EXP2) was estimated by recording grazing activity every ten minutes during 24 hours. Biting rate was measured in 12 (EXP1) and 15 cows (EXP2) per genetic line by counting the number of bites per cow in two minutes (Hodgson, 1982). Bite size was calculated from the DMI, grazing time and biting rate as described by Gibb *et al*., (1996).

Differences between genetic lines for intake and feed conversion efficiency variables, were tested by one way analysis of variance using PROC GLM (SAS, 1995). The model included the effect of genetic line as the main factor, and parity and days since calving as covariates. In the case of DMI, MS yield was also included as a covariate because this was the main factor affecting intake. Biting rate was analysed using a split plot design with the effect of genetic line tested against the error mean square of the interaction Line* Time of the day*Day.

RESULTS

The least square means for LW, days in milk, DMI, DMD, MS yield and feed conversion efficiency for the H and L lines in EXP1 and EXP2 are presented in Table 1. Cows from the H line were heavier by 75 kg in EXP1 and by 78 kg in EXP2. The differences in MS yield were not significant in EXP1, but the H cows produced 8% more (P< 0.01) MS than the L cows in EXP2. The H cows ate more DM than the L cows in both experiments, but when DMI was adjusted by milksolids yield, age at calving, and days from calving, the differences were not significant. There was no difference in DMD between H and L cows in any of the experiments. However, L cows had slightly higher (P < 0.1) DMD in EXP2 when it was calculated using the concentration of the C_{33} alkane in faeces.

Although the L line tended to have a slightly higher feed conversion efficiency than the H line in EXP1 (H = 114, L = 120 g MS/kg DM, P < 0.09), the differences between the lines were not significant in any of the two trials.

The grazing time, biting rate, and the calculated bite size for the two lines in the two experiments are presented in Table 2. Grazing time was similar for the H and L lines. However, in both experiments, the L cows had a faster biting rate than the H cows. As expected, the calculated bite size of the H cows was larger than that of the L cows.

DISCUSSION

The average difference in actual LW between the two lines in the current two experiments was larger than that reported by García-Muñiz *et al*., (1998b) for the mature weight of the two lines using growth curve analysis, because LW and milk production were the two main criteria used to choose the cows for the current 2 experiments.

TABLE 1: Least squares mean values for live weight, dry matter intake, dry matter digestibility, milksolids yield and feed conversion efficiency of genetically heavy or light Holstein-Friesian cows during Experiment 1 (n_1 = 21 H; n_2 = 21 L-cows) and Experiment 2 (n_1 = 30 H; n_2 = 30 L-cows)

Item	Genetic line		
	Heavy	Light	Significance[a]
Experiment 1			
Live weight (kg)	482.0 ± 14.4	407.0 ± 15.2	***
Days in milk	46.0 ± 2.6	49.5 ± 2.8	n.s
Dry matter intake (kg/cow/day)			
Measured	15.5 ± 0.6	13.9 ± 0.5	*
Adjusted[b]	15.1 ± 0.5	14.3 ± 0.5	n.s
Dry matter digestibility from C_{33} (%)	78.0 ± 0.6	77.8 ± 0.7	n.s
Dry matter digestibility from C_{31} (%)	78.0 ± 0.6	77.6 ± 0.5	n.s
Milksolids yield (kg/cow/day)[c]	1.74 ± 0.07	1.63 ± 0.06	n.s
Feed conversion efficiency (g MS/kg DM eaten)[c]	114.0 ± 3.0	120.0 ± 3.3	†
Experiment 2			
Live weight (kg)	492.0 ± 10.0	414.0 ± 10.0	****
Days in milk	84.5 ± 3.0	91.0 ± 3.0	n.s
Dry matter intake (kg/cow/day)			
Measured	12.2 ± 0.38	10.8 ± 0.39	*
Adjusted[b]	11.8 ± 0.3	11.2 ± 0.3	n.s
Dry matter digestibility from C_{33} (%)	72.0 ± 0.4	73.0 ± 0.4	†
Dry matter digestibility from C_{31} (%)	70.0 ± 0.6	71.0 ± 0.6	ns
Milksolids yield (kg/cow/day)[c]	1.70 ± 0.03	1.54 ± 0.03	**
Feed conversion efficiency (g MS/kg DM eaten)[c]	144.0 ± 4.0	143.0 ± 3.8	n.s

[a] n.s = nonsigificant; † = P < 0.1; * = P < 0.05; ** = P < 0.01; *** = P < 0.001; **** = P < 0.0001.

[b] Adjusted by parity, days from calving and milksolids yield.

[c] Adjusted by parity and days from calving.

TABLE 2: Least square mean values for grazing time, biting rate and bite size of genetically heavy or light Holstein-Friesian cows grazing rye-grass white clover pastures during early (Experiment 1) and mid-lactation (Experiment 2)

		Genetic line		
Item	n	Heavy	Light	Significance1
Experiment 1				
Grazing time (minutes/day)	42	515.0 ± 8.0	521.0 ± 9.0	n.s
Biting rate (bites/minute)	24	50.0 ± 0.8	55.0 ± 0.8	*
Bite size (g DM/bite)	24	0.600 ± 0.03	0.480 ± 0.03	**
Experiment 2				
Grazing time (minutes/day)	60	508.4 ± 10.0	522.0 ± 9.8	n.s
Biting rate (bites/minute)	30	53.2 ± 0.78	57.5 ± 0.79	**
Bite size (g DM/bite)	30	0.463 ± 0.02	0.395 ± 0.03	*

1 n.s = nonsigificant; † = P < 0.1; ** = P < 0.01.

Although MS yield was measured during a short period in these two experiments, the higher MS yield of the H cows (especially in EXP2) is in agreement with the reported moderate to high genetic correlation between LW and MS yield for New Zealand dairy cows (Ahlborn and Dempfle, 1992; Van der Waaij *et al*., 1997). However, in Minessota, after 30 years of divergent selection for body size the heavy and light lines produced the same amount of fat corrected milk (Hansen *et al*., 1998).

The pasture DMI measured by the *n*-alkanes technique in EXP1 was similar to the theoretical DMI required for the average cow from each line, calculated from their actual MS yield and maintenance requirements (Holmes and Wilson, 1987). However, in EXP2 the herbage intakes were lower than expected, which was probably related to the relatively low concentration of C_{33} measured in the feacal samples. Despite this, the data for DMI in EXP2 was used to compare the DMI and feed conversion efficiency between the H and L lines, since the low concentration of C_{33} was present across both lines.

To measure the effect of difference in LW between the H and L cows on DMI capacity, the measured DMI was adjusted by MS yield. After adjustment, the H cows ate more DM in both experiments, but the differences were not significant. The differences in adjusted DMI between the H and L lines (0.8 and 0.7 kg DM/cow in EXP1 and EXP2, respectively) are similar to the range of increases in DMI of dairy cows (0.8-2 kg DM) by each increase of 100 kg of LW (Wallace, 1961; Jarrige *et al*., 1986; Stakelum and Connolly, 1987; Holmes *et al*., 1993). In Minnesota, the DMI of the genetically heavy (575 kg) or light (525 kg) cows differed by 0.7 kg DM when fed three diets with different concentrate/roughage ratio (Donker *et al*., 1983). Maintenance requirements (MJ ME) estimated as $0.6*LW^{0.75}$ (Holmes and Wilson, 1987) indicated that the H line required an extra 7.4 MJ ME for maintenance, which corresponded to 0.65 kg of extra DMI required in EXP1 and to 0.7 kg DMI required in EXP2. The observed differences in adjusted DMI for H and L cows fell within this range, which suggests that most of the increased DMI showed by the H cows would have been used to satisfy their increased maintenance requirements.

There was no difference in DMD between the two lines. It has been suggested that across species, heavier ruminants fed on high fibrous diets achieve higher digestibility of their diets because their increased ruminal capacity and longer retention time (Demment and Van Soest, 1985). However, these principles do not necessarily apply in the present study because: i) the animals compared were from the same species, ii) the difference in LW between the two lines was probably not large enough to cause a detectable difference in digestibility of the herbage grazed by the cows, or iii) the highly digestible herbage grazed by cows can not be considered a ‘fibrous’ diet.

Most of the reports in the literature suggest that the phenotypic and genetic correlations between size and feed conversion efficiency are moderate to high and negative (Mason *et al*., 1957; Van Arendonk *et al*., 1991; Persaud *et al*., 1991). Data from Yerex *et al*., (1988) comparing the feed conversion efficiency of genetically heavy (575 kg) and light (525 kg) USA Holstein-Friesian cows showed that heavy and light cows had similar feed conversion efficiency during early lactation, but, over the whole lactation, the lighter cows were 2.8% more efficient than the heavier cows. Holmes *et al*., (1993), and Stakelum and Connolly (1987) compared the feed conversion efficiency of Holstein-Friesian cows which differed phenotypically for LW. They concluded that at similar levels of milk production, the lighter cows were more efficient than the heavier cows because the lower maintenance requirements of the former. In the present trial, the cows were in early lactation (EXP1), had similar MS yield and L cows had slightly higher (P < 0.1) feed conversion efficiency than H cows. In EXP2, H and L cows had similar feed conversion efficiency because the H cows produced higher MS yield which compensated for their higher maintenance requirements.

The values measured for grazing time and biting rate are similar to those reported in the literature under similar sward conditions (Macgilloway and Mayne, 1996; Gibb *et al*., 1996). No difference was detected in the grazing time between the two genetic lines, but the L cows had a faster biting rate than the H cows. Although the limitations in estimating bite size from biting rate, grazing time and DMI are recognised (Hodgson, 1982), the H cows had mean bite weights significantly heavier than those of the L cows. These values conform with most estimates from the literature (McGilloway and Mayne, 1996; Gibb *et al*., 1996), and in agreement with the present results, large mature LW beef heifers showed increased bite size compared to small mature LW heifers (Erlinger *et al*., 1990). From the results of the present experiments it can be suggested that the faster biting rate shown by the L cows was a compensatory strategy to overcome their lighter bite weight.

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