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Milk production and grazing behaviour during early lactation of three strains of Holstein-Friesian dairy cows managed in different feeding systems

J.L. ROSSI, K.A. MACDONALD[1], B. THORROLD[1], C.W. HOLMES, C. MATTHEW[2], AND J. HODGSON[2]

Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North, New Zealand

ABSTRACT

The objective of this work was to compare individual intake and grazing behaviour of different strains of Holstein-Friesian dairy cows. Strains tested were high breeding worth 1990's Holstein-Friesian of overseas (**OS90**) or NZ origin (**NZ90**), and a 1970 NZ strain of Friesian (**NZ70**), farmed under different feeding systems defined by feed allowance per cow per year. Feed allowance ranged from 4.5 to 7.0 t DM cow^{-1} year^{-1}, based on different stocking rates and supplement inputs. Each system (one strain at one total annual allowance) was managed using a common set of decision rules and all the strains were in similar body condition score (BCS) at calving. Milksolids production, liveweight and BCS were measured routinely, and during September 2002 (55-75 days in milk) daily DMI and digestibility (DMD) were estimated for each cow by the n-alkane method. Grazing behaviour was observed visually.

Daily milksolids yield (per cow and per 100 kg LW) were similar for NZ90 and OS90, which were higher than NZ70 ($p<0.01$). At the start of the season OS90 cows were heavier ($p<0.05$) than cows of the other two strains and NZ90 cows heavier ($p<0.05$) than NZ70 cows, however they were similar in BCS. During September OS90 cows were just slightly heavier than the other two strains ($p=0.16$), but with lower BCS ($p<0.01$). Between the start of the season and September, LW and BCS decreases for OS90 cows were significantly higher ($p<0.05$) than for cows in the other two strains. Slightly higher DMI (per cow and per 100 kg LW) were recorded for the NZ90's than for NZ70 and OS90. Grazing time, ruminating time or biting rate was similar across strains. These results suggest that the OS90 was not able to eat sufficient pasture and used more body energy reserves to produce similar MS yield as NZ90.

Keywords: Strain of Holstein-Friesian, high merit cows, grazing behaviour.

INTRODUCTION

Dairy selection objectives and production systems in USA and Europe are very different from those in New Zealand (NZ). The use of overseas semen in New Zealand in the last 20 years has diluted the genetic base of the former NZ strain (Harris & Kolver, 2001; Harris & Winkelman, 2000) and potential implications of this change in NZ systems are of great economic importance. When these different strains were farmed in New Zealand, NZ Friesian performed better on pasture but overseas Friesian (OS) performed better on total mixed ration (TMR)(Kolver et al. 2002). Overseas cows had a lower body condition score (BCS) and were less fertile than NZ cows when fed on pasture. These differences were associated with reduced intake (% liveweight) by OS cows in early lactation.

Pasture intake is the key determinant of production in pasture-based systems, dependent on the cow, the sward and their interactions. High-yielding/high-merit dairy cows require a significantly higher daily allowance to meet their increased demands (Butler et al. 2003), graze for longer, have more bites per day and a higher intake rate than low producing cows (Bargo et al. 2003), consequently high merit cows should be able to process more feed (Dado & Allen 1994). Cows with the ability to maintain intake rate as grazing progresses have a higher energy intake from pasture.

This is a preliminary report of data collected in August-October 2002, during the early lactation period, from the Dexcel Holstein-Friesian Strain Trial established as a long-term farm system study at Dexcel No 2 dairy, Hamilton, in 2001. The objective was to compare individual pasture intake and grazing behaviour of different strains of Holstein-Friesian dairy cows, and to determine if differences in their performance could be explained by differences in energy intake from pasture.

MATERIALS AND METHODS

Three strains of Holstein-Friesian dairy cows were farmed in a range of feeding systems. Strains were high breeding worth Holstein-Friesian cows of overseas origin (OS90) and NZ origin (NZ90), and a 1970 NZ Friesian strain (NZ70). Systems were designed to provide moderate to generous feed allowances (FA), ranged from 4.5 to 7.0 t DM cow^{-1}year^{-1} based on different stocking rates and supplement inputs. (see Table 1 for details). Those systems that received 6.0 t cow^{-1}year^{-1} or higher of the NZ90 and OS90 strains were offered pasture silage in the paddock

[1] Dexcel, Private Bag 3221, Hamilton, New Zealand
[2] Institute of Natural Resources, Massey University, Palmerston North, New Zealand

(late August-early September). In addition, systems at the highest feed allowance of each strain were offered 2 kg $cow^{-1}d^{-1}$ of maize grain during each milking from July to November, except for a ten-day period in September while individual pasture intake was measured.

Systems were managed as eleven self-contained farmlets (15-20 cows) farmed separately according to a set of decision rules (Macdonald & Penno 1998). Within strain, two and three year old cows were allocated to feeding level balanced by sire, lactation, liveweight (LW), breeding worth, body condition score (BCS) and calving date.

During September 2002 (55-75 days in milk), milksolids production (MS), LW and BCS were recorded once a week during a three-week period. In the second week, dry matter intake (DMI) and the digestibility of the grazed herbage (DMD) for each individual cow were estimated using the n-alkane method (Dove & Mayes, 1991). Dry matter digestibility was estimated as described by Dillon (1993). These measurements were made on all the cows in the eleven systems. Grazed pasture was the only source of feed during these measurements.

Herbage mass (HM) was estimated on three consecutive days each week using a Rising Plate Meter (RPM). Pasture samples were taken pre-grazing three times per week at grazing level and bulked weekly for chemical analysis.

Grazing behaviour of all the cows in systems with the lowest and highest feed allowance of each strain was measured on three different days (FA: NZ70: 4.5 and 6.0; NZ90: 5.0 and 6.5; OS90, 5.5 and 7.0 t DM cow^{-1} $year^{-1}$). Cows were identified with big numbers painted on both sides. A trained team of twelve assistants, who shifted at random between systems every three hours after resting for a similar period, observed visually all the cows every ten minutes from 5 am to 11 pm (18 h) on three different days for each strain. Behaviour was recorded as grazing or ruminating. Bite rate was measured after each milking for one hour while cows were actively grazing, recorded over a period of 30 seconds repeated four times (morning and evening) for each cow individually. A bite was identified as a head movement associated with the severance of a bunch of herbage (Hodgson, 1982). Rate of intake and bite weight were estimated.

The statistical procedures of SAS (SAS, 2002) were used in all the analyses. Milksolids yield, LW, BCS, DMI and DMD were analysed as a mixed model (PROC MIXED) with strain and a linear effect of feed allowance as fixed effects. The weekly average pre and post-grazing HM and daily herbage allowance recorded in different paddocks of the low and high feed allowance systems were analysed as a mixed model (PROC MIXED) with strain, feed allowance and their interactions as fixed effects and paddock as random effect. To analyse grazing behaviour the records of a random one third of the cows of each system observed on different days when they grazed different paddocks (group). Grazing time, ruminating time and biting rates were analysed using a mixed model (PROC MIXED) with strain, feed allowance and their interactions as fixed effects and group as random effect.

RESULTS

There was a significant ($p<0.05$) strain*feed allowance interaction for pre and post-grazing HM during the period, values were higher at low feed allowance in the NZ90 and OS90 strains, but higher at high feed allowance for NZ70 cows (Table 2). In contrast, daily herbage allowance was higher ($p<0.01$) in systems farmed at high feed allowance.

TABLE 1: Design of the trial, with description of stocking rate and annual feed allowance for each system.

		Systems										
Strain		NZ70			NZ90				OS90			
Stocking rate	Cow ha^{-1}	3.8	3.1	3.1	3.4	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Pasture allowance	T DM $cow^{-1}y^{-1}$	4.5	5.5	5.5	5.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Supplement allowance	T DM $cow^{-1}y^{-1}$			0.5			0.5	1.0		0.5	1.0	1.5
Annual Feed Level	T DM $cow^{-1}y^{-1}$	4.5	5.5	6.0	5.0	5.5	6.0	6.5	5.5	6.0	6.5	7.0
Average Feed level	T DM $cow^{-1}y^{-1}$		5.3			5.8				6.3		

NZ70: 1970 New Zealand Friesian strain. Strain representative of selection and breeding policies in New Zealand in the 1970's. Animals were generated using semen set aside from that time. Dams were representative of the cows in the New Zealand population in the 1970's selected for high milk fat only.
NZ90: High breeding worth Holstein-Friesian of New Zealand. Strain generated using sires and dams with a low proportion of overseas genes and representative of the 1990's New Zealand selection and breeding policies.
OS90: High breeding worth Holstein-Friesian of Overseas origin. Strain established by breeding NZ born cows with a high proportion of overseas genetics in their ancestry to sires of overseas origin (principally North American).

TABLE 2: Daily pre and post-grazing herbage mass and daily herbage allowance at the low and high feed allowance for each strain.

		Strain									
		NZ70		NZ90		OS90					
		Low	High	Low	High	Low	High		Significance		
Feed allowance	t DM cow^{-1} y^{-1}	4.5	6.0	5.0	6.5	5.5	7.0	Sed	S	FA	S*FA
$HM_{PRE-GRAZING}$	k ha^{-1}	2097	2335	2625	2066	2653	2132	199	NS	*	*
$HM_{POST-GRAZING}$	k ha^{-1}	1598	1851	1857	1692	1823	1692	113	NS	NS	*
$H_{ALLOWANCE}$	kg $cow^{-1}d^{-1}$	28	41	35	40	35	43	3.2	NS	***	NS

HM: herbage mass; *p<0.05; *** p<0.001

Daily MS yield (either kg MS cow^{-1} or kg MS 100 kg LW^{-1}) of the NZ70 strain was lower ($p<0.001$ and $p<0.05$ respectively) compared with NZ90 and OS90 strains (Table 3).

Liveweight was higher ($p<0.01$) in August for OS90 cows compared with the other two strains and for NZ90 compared with NZ70 but similar for cows across strains in September (Table 3). A substantial decrease in LW was recorded for cows in the OS90 strain between August and September, significantly greater ($p<0.05$) than for the other two strains. BCS was similar for the strains in August but lower ($p<0.01$) in September for OS90 cows compared with the other two strains and for NZ90 cows compared with NZ70. Additionally, a greater ($p<0.05$) loss in BCS was estimated for cows in the OS90 strain between August and September.

There was no significant effect of strain on DMI ($p=0.14$) or DMD ($p=0.27$), although a numerical increase was observed for both variables in the NZ90 strain (Table 3).

Total grazing and ruminating time and the average biting rate were similar across strains and feed allowance (Table 3).

DISCUSSION

These results show the expected increase in milksolids yield by the NZ90 cows when compared with NZ70. They also show that, although selected for different systems, the two 90's strains produced similar milksolids yield on pasture.

Body condition score at calving was similar for all the strains (5.0±0.09)(McNaughton et al. 2003). The change in LW and BCS between August-September and the difference in BCS between strains at 55-75 DIM indicates a different rate of mobilisation of body reserves during the first part of the lactation.

Although the difference in DMI between strains was not significant, the values of DMI, MS yield and change in BCS or LW after calving and the energetic estimates from them were logical. The NZ90 strain produced more MS than the NZ70 (+0.32 kg $cow^{-1}d^{-1}$) related to greater intake from pasture. The difference in milksolids production between strains represents approximately +22 MJ ME d^{-1} (Holmes et al., 2002), equivalent to +1.9 kg DM $cow^{-1}d^{-1}$ consumed. Dry matter intake was 1.74 kg DM $cow^{-1}d^{-1}$

TABLE 3: Milksolids production, body condition score, liveweight, intake, digestibility, and grazing behaviour of cows in the three strains.

		Strain				
		NZ70	NZ90	OS90	Sed	P
MS_{YIELD}	MS cow^{-1} d^{-1}	1.70	2.02	2.06	0.09	***
$MS_{LW (100 kg LW^{-1})}$	kg MS cow^{-1} d^{-1}	0.40	0.46	0.46	0.02	*
LW_{AUGUST}	kg cow^{-1}	426	445	479	14	*
$LW_{SEPTEMBER}$	kg cow^{-1}	432	436	450	10	NS
$LW_{CHANGE\ AUG-SEP}$	kg cow^{-1}	5	- 9	- 29	9	*
BCS_{AUGUST}		4.89	4.80	4.71	0.11	NS
$BCS_{SEPTEMBER}$		4.70	4.46	4.20	0.11	**
$BCS_{CHANGE\ AUG-SEP}$		- 0.20	- 0.34	- 0.51	0.10	*
DMI	kg DM cow^{-1} d^{-1}	13.51	15.25	13.86	1.01	NS
$DMI_{LW (100 kg LW^{-1})}$	kg DM cow^{-1} d^{-1}	3.14	3.51	3.09	0.26	NS
DMD	mg kg DM^{-1}	770	790	760	17	NS
Grazing time	Min	489	509	505	17	NS
Ruminating time	Min	233	250	238	16	NS
Bite rate	bites min^{-1}	66	65	65	2.4	NS
Intake rate	kg DM h^{-1}	1.65	1.81	1.64		
Bite weight	mg DM $bite^{-1}$	418	460	422		

BCS: body condition score; LW: liveweight; MS: Daily milksolids production per cow; $MS_{(LW)}$: Milksolids production per liveweight unit; DMI: Daily dry matter intake; DMI_{LW}: Daily dry matter intake per LW unit; DMD: Dry matter digestibility; * p<0.05; ** p<0.01; *** p<0.001

higher for NZ90 and covered most of their energy requirements for production while body tissue mobilisation supplied the balance during early lactation. The OS90 strain also produced more MS than the NZ70 (+0.36 kg $cow^{-1}d^{-1}$) but had similar intake, thus production was mainly supported by mobilisation of reserves. NZ90 and OS90 had the same MS production, but while NZ90 had the higher DMI (+1.39 kg DM $cow^{-1}d^{-1}$, although not significant), OS90 lost more BCS.

The limitation to energy intake from grazing should also be manifested as changes in the short-term activity of the animals. Although there were no differences in behaviour across strains, increases in intake rate and bite size for NZ90 probably had resulted in the trend for a superior DMI in this strain.

Behaviour was not observed during the night. As grazing mostly occurs during daylight hours (Orr et al, 2001), grazing time was not expected to be affected by the absence of night observation. However, high yielding cows in the first part of the lactation curve could extend grazing time during the night. As changes in grazing behaviour should be related to changes in pasture condition, differences between strains in response to different HM should be further investigated. Herbage intakes were probably affected by the differences observed for pre-grazing HM (Table 2).

The animal's genetic potential to use energy is an important determinant of its feed intake (Weston, 1981). Genetic potential milk yield of OS Holsteins is higher than for NZ Holsteins as demonstrated when they were fed a TMR (Kolver et al. 2002), thus, DMI should reflect a difference in this potential, but similar MS production recorded in both 90's strains indicates a limit for reaching potential on grazed pasture. The similar MS yield supported by energy consumed or mobilised from body reserves could indicate a different intensity of the signal driving metabolism and affecting feeding drive for the two 90's strains. The apparent inability of the OS90 to translate its high-energy demand into a high pasture intake is of great practical importance in New Zealand pasture's based systems.

CONCLUSION

Daily milksolids production was similar for both 90's strains in early lactation and higher than NZ70. However, despite the high feeding drive expected during early lactation in OS90 cows, they used more energy from body reserves instead of increased grazing activity. The present results are preliminary and not conclusive, but they provide further evidence of the superiority of the NZ strains in a pasture-based system.

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