

Diet or strain: effects on postpartum anovulatory interval in dairy cows

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ABSTRACT

Changes in cow genetics and systems of farming have had large effects on the reproductive performance of dairy cows. The objective of this study was to determine if grain supplementation modified the previously identified effects of Holstein-Friesian (HF) strain on the postpartum anoestrus interval (PPAI). Thirty multiparous Overseas (OS) HF and 30 New Zealand-HF cows from a 1990s strain (NZ) were offered unrestricted access to fresh pasture and randomly allocated to three levels of a maize and barley-based concentrate supplementation (0, 3 or 6 kg DM/day). Postpartum anovulatory interval (PPAI) was not significantly affected by either strain or diet, and there was no significant strain x diet interaction. Results suggest that the nutritional requirements necessary for multiparous NZ or OS HF cows to resume oestrous cycles before 40 days postpartum can be achieved when offered unrestricted access to high quality pasture. In this circumstance, additional concentrate feeding did not alter the length of the postpartum anoestrus interval.

Keywords: dairy cows; strain; diet; postpartum anovulatory interval

INTRODUCTION

In a seasonal dairy system it is important to maintain a 365-day calving interval. Assuming a gestation length of 282 days (Macmillan & Curnow, 1976), this requires that cows resume cyclicity, display oestrous behaviour, be mated and conceive within 83 days postpartum. An early return to oestrus is therefore important to maintain the necessary concentrated calving pattern. In New Zealand, the breeding objective of increased milksolids production has resulted in an increase in the percentage of Overseas (OS) Holstein-Friesian (HF) genetics (Harris & Kolver, 2001). This trend has resulted in a cow that produces more milk with a greater output of energy in milk, a greater propensity to mobilise body condition in early lactation, and one that partitions less energy to improving body condition in mid- and late lactation (Roche *et al.*, 2006). These characteristics have been associated with poorer reproductive performance (Beam & Butler, 1999; Buckley *et al.*, 2003; Kolver *et al.*, 2002; Kolver *et al.*, 2005) and are consistent with evidence from New Zealand, where a decline in reproductive performance and survival of HF cows has been reported on commercial dairy farms (Harris & Winkelman, 2000; Harris, 2005).

It has previously been demonstrated that cows from divergent genetic strains or those that have undergone more intense selection pressure for production related traits differ in their postpartum anovulatory interval (PPAI; McNaughton *et al.*,

2003). In New Zealand, the genetic selection within the HF strain has led to an extended PPAI, while the influx of OSHF genetics has shortened the period of anoestrus (McNaughton *et al.*, 2003).

Pre- and postpartum level of nutrition have been shown to affect reproductive performance (Chagas *et al.*, 2006; Lucy, 2003). Meyer *et al.* (2004) reported an effect of postpartum feed allowance on PPAI in NZ cows but not OS cows, which inherently cycle earlier.

Recent results have shown that nutritional supplementation produced significant benefits in reduced PPAI when the cows were supplemented with gluconeogenic precursors during early lactation (Chagas, 2003, Burke *et al.*, 2006), suggesting a possible method by which PPAI may be reduced in both strains. The objective of this study was to determine if grain supplementation modified the previously identified effects of HF strain on the PPAI.

MATERIALS AND METHODS

Experimental design and treatments

The study was conducted in 2005 in Hamilton, New Zealand, and all treatments and measurements were approved by the Ruakura Animal Ethics Committee, Hamilton, New Zealand (#10586).

Sixty multiparous HF cows (30 OS and 30 NZ) were randomly allocated to one of three diets in a completely randomised design and a 2x3 factorial arrangement of treatments. All cows were offered unrestricted access to fresh pasture and

supplemented with either 0, 3 or 6 kg DM of a maize and barley-based concentrate/cow/day (NZ+0, NZ+3, NZ+6, OS+0, OS+3 and OS+6).

The average day of calving was August 7 (\pm 4 days) and August 8 (\pm 4 days) for OS and NZ, respectively. A detailed description of the HF genetic lines used in this study has been summarized by Harris *et al.* (2003). Cows were rotationally grazed as one herd for the duration of the experiment and only returned to the same area when a minimum of two leaves had appeared on the majority (>75%) of perennial ryegrass tillers. Cows had access to a fresh allocation of pasture daily. Pasture allowance (>45 kg DM/cow/day) was sufficient to ensure unrestricted dry matter intake of fresh pasture in the unsupplemented cows. Pasture was of high quality throughout the experiment and was maintained, despite the high grazing residuals, through strategic use of mowing. For 15 days prepartum, all cows were offered 2 kg DM concentrate/day and following calving the NZ+3 and OS+3 cows received 3 kg DM concentrate/day, and the NZ+6 and OS+6 cows were gradually stepped up to 6 kg DM concentrates/day over the following 4 days (0.75 kg DM concentrates/day). A flat rate of either 1.5 or 3 kg DM of concentrates (31% crushed barley, 60% crushed maize, 2% broil, 7% molasses; CP = $11.2 \pm 1.46\%$ DM; NDF = $9.8 \pm 1.99\%$ DM; lipid = $2.7 \pm 1.22\%$ DM; NSC = $71.9 \pm 2.16\%$ DM) were fed individually to the appropriate treatments twice daily during milking.

Production measurements

Milk production and milk composition (protein percentage, fat percentage, and lactose percentage) were determined on two consecutive milkings (pm and am) each week. Milk composition was determined using near infrared spectroscopy. Net energy of lactation (NE_L) was calculated with the following equation (NRC, 2001).

$$NE_L(\text{MJ/day}) = 4.186 * (9.29 \times \text{kg fat} + 5.47 \times \text{kg protein} + 3.95 \times \text{kg lactose}) * \text{milk yield.}$$

Liveweight (LW) and body condition score (BCS) were determined weekly following the a.m. milking. Body condition score was assessed on a 10-point scale, where 1 is emaciated and 10 is obese (Macdonald & Roche, 2004).

Interval to first ovulation and milk progesterone analyses

Progesterone concentrations were measured in fresh whole milk samples collected twice weekly using an enzyme-linked immunosorbant assay kit (Ridgeway Sciences, Gloucestershire, UK) validated for use in cattle (Sauer *et al.*, 1986). The PPAI was defined as the interval from calving to

the first of two consecutive sampling days that progesterone concentrations in milk were > 3 ng/ml.

Statistical analyses

Mean daily milk production (milk, fat, protein, net energy in milk), LW and BCS for the first 6 weeks of lactation, as well as BCS and LW change from one week before calving to six weeks after calving were calculated for each cow. These summary values for each cow were analysed using linear models including strain, diet and the interaction of these as fixed effects in GenStat 8.1.

The PPAI was analysed initially using the CENSOR procedure in GenStat, with a seven level treatment factor created from the strain-diet combinations as the fixed effect. Following this, the actual PPAI and the estimates obtained from this initial analysis (for the cows with censored data for which the recorded PPAI was estimated) were then analysed using linear models including strain, diet and interaction as fixed effects as described above for the milk data.

RESULTS

Table 1 shows the effect of strain and diet on the average PPAI. On average cows were anoestrous for 36.7 ± 6.0 days postpartum, and this was not affected by either strain ($P = 0.85$) or diet ($P = 0.83$), and there was no strain x diet interaction ($P = 0.92$). The proportion of animals that were still anoestrous after 12 weeks after calving was similar between strains (7% for the OS and 11% for the NZ cows) and it was not affected by postpartum feeding.

TABLE 1: Mean (\pm SEM) postpartum anovulatory interval (days) in NZ or OS Holstein-Friesian cows supplemented with either 0, 3 or 6 kg DM of a maize and barley-based concentrate/cow/day.

	Grain	0	3	6	SEM
Strain					
NZ		36.2	36.2	35.2	5.9
OS		38.0	38.9	33.2	5.9

Overseas HF produced more ($P < 0.05$) milk protein and lactose than NZ cows, and milk NE_L was greater during the first 6 weeks postpartum (Table 2). Concentrate supplementation increased ($P < 0.05$) total milk yield (kg), protein and lactose yields during the first 6 weeks postpartum, and increased ($P < 0.05$) the amount of energy secreted in milk. Milk fat production was not significantly affected by strain ($P = 0.65$) or diet ($P = 0.59$).

TABLE 2: Mean (\pm SEM) total milk production, fat, protein production and net energy in milk during the first 6 weeks postpartum in NZ or OS Holstein-Friesian cows supplemented with either 0, 3 or 6 kg DM of a maize and barley-based concentrate/cow/day.

Strain	Grain	0	3	6	SEM
Total milk (kg)					
NZ		26.6	30.3	31.5	1.6
OS		27.8	30.6	37.0	1.5
Fat (kg)					
NZ		1.23	1.38	1.38	0.08
OS		1.28	1.29	1.50	0.07
Protein (kg)					
NZ		0.91	1.07	1.13	0.53
OS		0.74	1.06	1.29	0.53
NE_L(MJ/day)					
NZ		21.5	24.5	25.0	1.3
OS		22.4	23.5	27.9	1.2

Net energy of lactation (NE_L) = 4.186 *(9.29 x kg fat + 5.47 x kg protein + 3.95 x kg lactose) * milk yield.

TABLE 3: Mean (\pm SEM) liveweight, body condition score (BCS) and BCS change during the first 6 weeks postpartum in NZ or OS Holstein-Friesian cows supplemented with either 0, 3 or 6 kg DM of a maize and barley-based concentrate/cow/day.

Strain	Grain	0	3	6	SEM
BCS Before calving					
NZ		5.1	5.0	4.9	2.7
OS		4.5	4.4	5.1	2.6
Six weeks postpartum					
NZ		4.3	4.4	4.3	0.18
OS		3.5	3.9	3.8	0.17
BCS change					
NZ		-0.83	-0.55	-0.65	0.18
OS		-1.0	-0.55	-1.25	0.17
Liveweight (kg) Before calving					
NZ		611	624	623	20.1
OS		676	640	671	19.1
Six weeks postpartum					
NZ		500	522	516	17.4
OS		534	528	548	16.5

One week before calving, the OS cows were heavier ($P < 0.05$) than NZ cows, but LW was not significantly different at six weeks postpartum, highlighting the greater ($P < 0.05$) loss in liveweight in the OS cows compared with NZ cows. Before calving, BCS did not differ between treatments ($P > 0.10$). At six weeks after calving the BCS of the NZ cows was higher ($P < 0.05$) than that of the OS cows, but there was no significant effect of diet on BCS at this time. There was no effect of strain on BCS change during the first 6 weeks after calving. Interactions with diet

and strain were not significant for BCS and LW before calving or six weeks after calving ($P > 0.10$; Table 3).

DISCUSSION

Additional concentrate feeding did not alter the length of the PPAI, and there was no effect of genetic strain on PPAI in this study. These results are not consistent with those presented by McNaughton *et al.* (2003), who reported that PPAI was 20 days shorter respectively for first and second calvers of OS than NZ cows. A possible reason for the inconsistency could be due to insufficient number of cows to accurately represent PPAI in the present study. However, an additional possibility is the different age structure of the herds in both studies, or possibly a failure of McNaughton *et al.* (2003) to fully represent the effect of strain on PPAI, as only the cows that calved within the first six weeks of the calving period were reported in the McNaughton *et al.* (2003) study. This conjecture is supported by the fact that only 197 of 331 cows ovulated before one week prior to the planned start of mating in the McNaughton study.

An effect of pre- and postcalving nutrition on PPAI has been shown previously (Chagas *et al.*, 2006; Lucy, 2003). However these effects are generally a result of supplementing underfed cows, or an effect of precalving nutrition on calving BCS. There was no difference in BCS at calving in the current experiment and pasture allowances were generous, possibly nullifying any effect of supplementary feeding. This argument is supported by Meyer *et al.*, (2004) who demonstrated that increased feeding allowance or providing a supplement to cows that would otherwise have been restricted could shorten the PPAI in NZ cows.

The greater post-calving LW loss and the lower nadir BCS in OS cows is consistent with the literature (Kolver *et al.*, 2002; Horan *et al.*, 2005; Roche *et al.*, 2006) and indicates that much of the additional milk produced by OS cows in grazing systems is derived from body tissue. It also points to a significant negative energy balance in OS and NZ cows in early lactation. Horan *et al.* (2006) reported greater dry matter intake in OSHF cows when compared with NZHF cows of lower genetic merit for milk production. The increase in body tissue-derived milk production in OS in early lactation in the current study therefore suggests a genetic selection influence on homeorhetic mechanisms or that OSHF cows are not able to consume enough of pasture to support high milk production. However, the present trial demonstrated that regardless of the differences in

BCS and milk production, cows are able to cycle within 40 days of calving if fed well on pasture, suggesting that either strains have different minimal requirements in body stores and intakes for oestrus to occur or that there is little relationship between postcalving energy balance and onset of oestrus. This hypothesis is supported by the results from Burke *et al.* (2006) and from by Kolver *et al.* (2005) that used the same trial design.

CONCLUSIONS

The nutritional requirements necessary for NZ or OS strains of multiparous Holstein-Friesian cows to resume oestrous cycles before 40 days postpartum can be achieved when offered unrestricted access to high quality pasture. In this circumstance, additional concentrate feeding did not alter the length of the postpartum anoestrous interval.

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