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# Compact-calving systems are better suited to dual-purpose than dairy cow breeds, particularly when nutrient supply is limited

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## Abstract

This study aimed to explore adaptive trajectories of dairy and dual purpose breeds in contrasting grazing-based feeding systems (FS). About 500 lactations were recorded at the INRA farm of Le Pin-au-Haras, equally distributed among breeds (Holstein: HO or Normande: NO) and FS (High or Low). It was possible to study the different steps of the reproductive process by combining milk progesterone information (three times a week) with intensive oestrous behaviour recording and pregnancy diagnosis (ultrasonography). Holstein produced more milk (+2294 kg in the High FS, +1280 kg in the Low FS) and lost more body condition than NO. Cows in the Low FS produced less and lost more body condition than in the High FS. NO resumed ovarian activity earlier (-5 d) and showed a higher proportion of normal cyclicity patterns (+22%) than HO. There was no difference in ovulation detection rates between breeds or FS. The NO had a higher re-calving rate than HO (+19%). Feeding system was not associated with cyclicity and re-calving rate. By limiting their milk yield, NO did not experience a severe negative energy balance, unlike HO. This resulted in better reproductive performance for NO, suggestive of greater suitability to a compact calving system.

**Keywords:** dairy cow, breed, feeding system, reproduction, adaptive strategies

## Introduction

In grass based systems, implementing a system with compact calving in winter (January to March) represents a good opportunity to optimise grass use. This relies on good reproductive performance. However, abnormal ovarian activity, low oestrus expression and low fertility are common in the modern day dairy cow (Walsh *et al.*, 2011). The consensus in the literature is that reproduction is impaired because dairy cows are investing most of their resources in milk production. This is mostly influenced by genetic characteristics and feeding strategies. The association between nutrition and reproductive performance is not straightforward but nutrition may affect both milk yield and body condition, known risk factors for impaired reproduction (Friggens *et al.*, 2010; Butler, 2014). This study aimed to characterise the robustness of dairy cows through examining breed by feeding system interactions. Our hypothesis is that the success of the reproductive process depends upon adaptive trajectories of milk production and body condition to periods of inadequate nutrition in dairy cows.

## Materials and methods

Between 2006 and 2015, an experiment was conducted at the INRA experimental farm of Le Pin-au-Haras (Normandy, France). Dairy cows were equally distributed among two breeds and two grass-based feeding systems (FS). About 30 Holstein cows (HO) and 30 Normande cows (NO) were involved each year. Cows were randomly assigned to a High or Low FS and remained in the same FS until they were culled. In the High FS, diet was based on maize silage in winter and grazing with concentrates at pasture, this FS aimed to maximise milk yield while limiting body condition loss. In the Low FS, diet was based on grass silage in winter and grazing with no concentrate at pasture; this FS aimed to limit milk yield while inducing a large body condition loss.

All cows were managed under a three month compact calving system. Oestrus behaviour was recorded five times a day using the standardised recording procedure of Kerbrat and Disenhaus (2004). The voluntary waiting period was set to 42 days *postpartum*. Cows were inseminated on observed oestrus only. Pregnancy was diagnosed through ultrasonography examination.

Cows were milked twice a day, milk yield was recorded each time, fat and protein contents were estimated three times a week over two milkings. Morning milk samples are taken thrice a week to determine milk progesterone concentration for the monitoring of ovarian activity. Thresholds were estimated to distinguish ovulatory and luteal phases using the methodology of Cutullic *et al.* (2011). Commencement of luteal activity (CLA) was set as the time from calving to the first luteal phase. Based on CLA and cycle lengths, cyclicity profiles could be classified as normal or abnormal (CLA lower than 50 d with regular cycles ranging from 20 to 25 d). Body condition score (BCS) was assessed once a month (0 - 5 scale, Bazin *et al.*, 1984).

Overall, 101 records on HO in the High FS, 116 records on HO in the Low FS, 140 records on NO in the High FS and 143 records for NO in the Low FS were analysed. Continuous variables (e.g. milk yield) were analysed using linear mixed models and dichotomous variables (e.g. ovulation detection) through generalised mixed models, with cow included as a random effect.

## Results and discussion

HO produced more milk than NO (+2,294 kg in the High FS, +1,280 kg in the Low FS; Table 1) with lower fat and protein contents. The HO cows had a lower BCS at calving than NO cows (-0.65 BCS in the High FS, -0.35 BCS in the Low FS), and lost more body condition (-1.00 BCS in the High FS, -0.80 BCS in the Low FS). This is consistent with the literature (Walsh *et al.*, 2008). As expected, cows in the High FS produced more milk (+2,495 kg for HO, +1,481 kg for NO) than cows in the Low FS. At calving, BCS was similar in both FS, and cows in the High FS lost less body condition to nadir than in the Low FS (+0.40 BCS for HO, +0.60 BCS for NO).

Table 1. Adjusted productive and reproductive performance for Holstein (HO) and Normande (NO) cows in the High or Low feeding system.

	HO		NO		Significance levels <sup>1</sup>		
	High	Low	High	Low	B	FS	B×FS
Number of lactations	101	116	140	143			
Number of ovulations	279	301	415	423			
Production							
Total milk yield (kg)	8,475 <sup>c</sup>	5,980 <sup>b</sup>	6,181 <sup>b</sup>	4,700 <sup>a</sup>	***	***	***
Average fat content (g kg <sup>-1</sup> )	37.4 <sup>a</sup>	38.7 <sup>b</sup>	40.8 <sup>b</sup>	42.1 <sup>c</sup>	***	***	NS
Average protein content (g kg <sup>-1</sup> )	31.9 <sup>b</sup>	30.8 <sup>a</sup>	34.9 <sup>d</sup>	33.3 <sup>c</sup>	***	***	*
BCS at calving	3.00 <sup>a</sup>	2.90 <sup>a</sup>	3.65 <sup>c</sup>	3.25 <sup>b</sup>	***	***	**
BCS at nadir	1.90 <sup>b</sup>	1.50 <sup>a</sup>	2.90 <sup>b</sup>	2.30 <sup>c</sup>	***	***	+
Reproduction							
CLA (d)	37 <sup>c</sup>	33 <sup>bc</sup>	32 <sup>ab</sup>	28 <sup>a</sup>	**	+	NS
Normal cyclicity (%)	47	47	64	73	***	NS	NS
Ovulation detection rate (%)	67	73	69	69	NS	NS	NS
Re-calving rate (%)	54	49	73	68	***	NS	NS

<sup>1</sup> Effects of breed (B), feeding system (FS) and their interaction (B × FS). Significance levels: \*\*\*  $P \leq 0.001$ ; \*\*  $P \leq 0.01$ ; \*  $P \leq 0.05$ ; +  $P \leq 0.10$ ; NS  $P > 0.10$ .

<sup>a,b,c,d</sup> Distinguish adjusted means that are different between breeds and feeding systems.

The NO cows had a higher re-calving rate than HO (70 vs 52%), which is consistent with other studies (Dillon *et al.*, 2003). This final reproductive outcome is due to an earlier CLA (-5 d), a higher proportion of normal cyclicity pattern (68 vs 46%), and less pregnancy losses (6 vs 12%; data not shown) in NO than in HO. However, visual ovulation detection rate was excellent and similar in both breeds (70%). Reproductive performance of dairy cows was not affected by the FS. This is partly explained by compensative effects: milk yield could be a risk factor for impaired oestrus expression and late embryo mortality whereas body condition loss for impaired cyclicity and non-fertilisation or early embryo mortality (Cutullic *et al.*, 2012).

## Conclusion

To conclude, this study showed that Normande cows had earlier resumption of luteal activity, identical ovulation detection rate and higher re-calving rates than Holstein cows. Nutritive supplementation did not support reproductive performance: Holstein cows prioritised milk production and Normande cows body reserves all the more with high nutritive inputs. The adaptive response of Normande probably limited the duration and intensity of negative energy balance and may have contributed to preserving their reproductive performance. With such a low re-calving rate, the use of high yielding Holstein cows does not appear to be a sustainable solution in pasture-based systems.

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