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Relationships between, milk production, nutrition and reproduction in “benchmark” herds[1]

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ABSTRACT

Inter-relationships between nutrition, milk production and reproduction in dairy cows were investigated in dairy herds with previous high reproductive performance. Ten herds were selected as ‘benchmark’ farms from one area of the Waikato. Pasture and supplement intakes, and milk production were monitored on a herd basis. Bulk milk samples were taken weekly from calving through to the first three weeks of mating and assayed for levels of progesterone, urea nitrogen and β-hydroxybutyrate (BOH). Pre-mating oestrus, mating (AI) and pregnancy data were recorded. All data was expressed in relation to the planned date of mating (PSM) for each farm. Significant between farm differences were detected in all the reproductive parameters but there was no effect of supplement feeding. The mean proportion of cows cycling at PSM was 65.6 ± 3.3% (range 50.5 to 81%).The mean proportion of cows pregnant to AI at PSM + 3 weeks was 51.3 ± 2.1% (range 43 to 61.5%); at PSM + 6 weeks the mean was 74.5 ± 3.3% (61 to 89.5%); at PSM + 9 weeks it was 84.7 ± 2.2% (74.9 to 91.6%) and at PSM + 12 weeks it was 91.3 ± 1.2% (85.6 to 95.4%). Bulk milk progesterone rose linearly from a mean of 0.5 ng/ml at 8 weeks before PSM to 5.0 ng/ml at PSM and to 6.0 ng/ml three weeks later. The difference between farms at PSM ranged from (2.1 to 7.1 ng/ml). While the pattern of increase in bulk milk progesterone tended to mimic the overall pattern of oestrus activity, there was no relationship in the ranking of farms for these parameters at any time. Bulk milk BOH showed no consistent pattern over the period of measurement and levels ranged between farms in any one week from 0.01 to 0.05 mM. Bulk milk urea nitrogen concentration also showed little change on average (7.25 mM) over the pre-mating and mating periods. The significant between-farm differences in these bulk milk parameters did not appear to be related to reproductive performance. Metabolic indicators measured in bulk milk samples appear of little value for predicting reproductive performance at herd level.

Keywords: milk production; reproduction; nutrition

INTRODUCTION

A basic tenet of biological systems is that reproduction is a luxury function and will only occur successfully when there is adequate nutrition. Thus, nutrition plays a critical role in determining the success of reproductive function, but this occurs in a complex and dynamic manner, especially in the pasture-fed dairy cow.

Effects of cow live weight, body condition score and the level of circulating metabolites reflective of nutritional intake, have all been linked to the incidence of postpartum anoestrus and conception rates (Moller *et al*., 1993; McDougall, 1994; Rhodes *et al*., 1998; Verkerk & Guiney, 1999; Clark *et al.*, 2000). However, the physiological mechanisms by which these factors exert their effects are still unclear. To expedite the investigation of these effects at the herd level there is a need to establish baseline data in herds with high reproductive performance against which other herds can be benchmarked.

The current project was established to collect information on the temporal relationships between dry matter intake, hormone and nutritional metabolite levels in milk and reproductive performance at a herd level, in herds with high previous reproductive performance. Two feed management systems, one involving maize silage supplementation and one pasture-only, were compared. The information obtained was to be regarded as benchmark information that will be used to characterise farm systems.

MATERIALS AND METHODS

Farms

Ten commercial dairy farms were selected, based on their regular contact with Dairy Production Systems™ consultancy services (Te Awamutu) and having had high reproductive performance in previous years (interval between start of calving and mid-point [50% cows calved] of 18 days or less), with minimal pharmacological intervention. Five of the farms had a management system that included the feeding of additional maize silage supplement with pasture during early lactation while the remaining five farms had pasture-only systems.

Data Collection

Data collection began three weeks after the start of the calving period and continued to the end of the first three weeks of the mating period.

On each farm, at weekly intervals, pre-grazing and post-grazing assessments of herbage mass were made to determine the average pasture DM intake for the herds (DMI kg/ cow /d). Farm managers determined herd dry matter intakes of supplements on a weekly basis on each farm.

A bulk milk sample was collected from the vat of each farm at weekly intervals and the milk volume recorded. Milk samples were analysed for urea nitrogen (BMUN) and β-hydroxybutyrate (BOH) concentrations using a FT-120 auto-analyser (Foss Electric, Denmark). Milk progesterone concentration was detected using a commercial RIA kit (Coat-A-Count, Diagnostic Products Corporation, CA, USA).

Reproductive data collected included individual cow pre-mating heats, anoestrous cow treatment, and artificial breeding and natural mating information. This data was used to calculate the herd submission rate in the first three weeks of mating, herd conception rate to first insemination and, finally, herd pregnancy rate on a time-from-start-of-mating basis.

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Data Analysis

All time-based data were centred on the planned start of mating (PSM) date for individual farms. Data for the non-reproductive parameters were analysed using the method of residual maximum likelihood to model the variation between and within farms. Reproductive data was analysed using log-linear regression.

RESULTS AND DISCUSSION

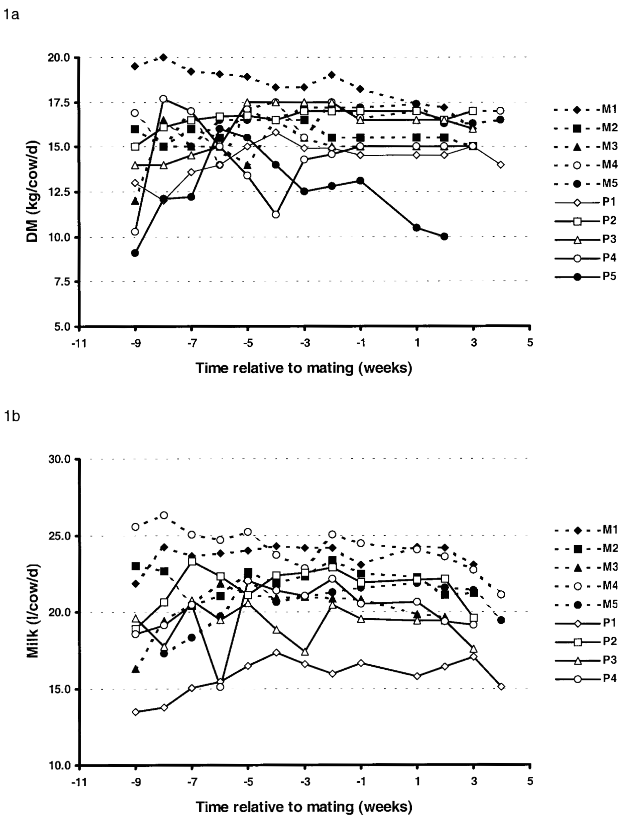
The information is presented mainly in graphical form for the individual farms and data is plotted over time relative to the planned start of mating date (PSM).

There were significant between-farm differences in the levels of DMI, milk production, BMUN and progesterone, over the period from -9 weeks PSM to the fourth week of mating. On average the maize-supplemented farms differed from pasture-only farms only for milk production and BMUN.

There was considerable between farm variation in reproductive performance, and this was unexpected as farms were selected on the basis of their past high reproductive performance. There was no significant difference between maize-supplemented and pasture-only farms on average. There were no significant overall relationships between reproductive performance and the other parameters.

The weekly mean DMI (kg/cow/d) for the farms are presented in Figure 1a and ranged from 9 to 20. There were significant between-farm differences and a tendency for the DMI of cows on the maize-supplemented farms to be higher than those on the pasture-only farms but this was not significant. The between week variability was more marked

FIGURE 1: a) Mean farm Dry Matter Intake (kg per cow per day) and b**)** Mean farm Milk Production (litres per cow per day) - relative to the planned start of mating date. (Maize silage supplemented herds (M) in dotted lines and pasture-only herds (P) in solid lines).

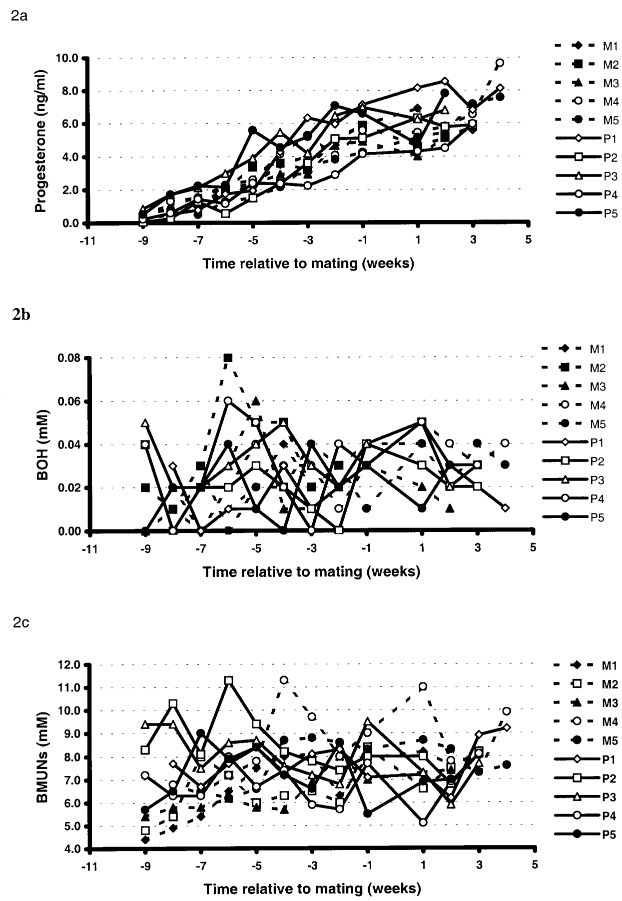


on the pasture only farms and two of these exhibited a marked drop in the DMI during a period of low pasture growth.

Milk production for the herds is shown in Figure 1b and the maize-supplemented farms on average had a higher level of milk production per cow (P<0.05)

Bulk milk progesterone concentration rose linearly from a mean of 0.5 ng/ml at 9 weeks before PSM to 5 ng/ml at PSM and to 6 ng/ml three weeks later (P<0.001; Figure 2a). The values at PSM ranged from 4 to 8 ng/ml between farms. While, the pattern of increase in bulk milk progesterone concentration tended to mimic the overall pattern of oestrous activity there was no relationship in the ranking of farms for these parameters at any time. This means that bulk milk progesterone concentrations have very limited diagnostic value in terms of herd reproductive performance.

FIGURE 2: a) Mean herd milk progesterone concentration (ng/ml); b**)** Mean herd β-hydroxybutyrate (BOH) concentration (mM) and c) Mean farm milk urea nitrogen (BMUN) concentration (mM) – relative to the planned start of mating date. (Maize silage supplemented herds (M) in dotted lines and pasture-only herds (P) in solid lines).



Bulk milk BOH showed no consistent pattern over the period of measurement and in any one week concentrations ranged between farms from 0.00 to 0.08 mM(Figure 2b).

BMUN concentration also showed little average change over the pre-mating and mating periods with average levels of 7.25 mM (Figure 2c). However, there was a significant (P<0.001) difference between the maize-supplemented and the pasture-only farms in the pattern of levels over the period, the maize farms being significantly lower at the

TABLE 1: Reproduction summary showing the means and sem for the proportion of the herd that were exhibiting oestrus or were pregnant at various times relative to the start of mating.

Farm	**M1**	**M2**	**M3**	**M4**	**M5**	**P1**	**P2**	**P3**	**P4**	**P5**
PSM	20-Oct	18-Oct	22-Oct	10-Oct	06-Oct	13-Oct	15-Oct	16-Oct	15-Oct	25-Oct
#cows	350	307	485	426	294	301	191	352	244	135
%cyc	**68.0**	**54.4**	**50.5**	**81.0**	**71.1**	**70.1**	**68.1**			
sem	2.5	2.8	2.3	1.9	2.6	2.6	3.4			
%P3	**52.4**	**54.3**	**43.0**	**56.2**	**49.5**	**44.0**	**57.0**	**58.7**	**43.6**	**61.5**
sem	2.7	2.9	2.3	2.4	2.9	2.9	3.6	2.6	3.2	4.3
%P6	**74.8**	**86.5**	**61.0**	**89.5**	**74.7**	**64.8**	**78.5**	**81.2**	**65.1**	**77.7**
sem	2.3	2.0	2.3	1.5	2.5	2.8	3.0	2.1	3.1	3.7
%P9	**86.2**	**94.4**	**74.9**	**91.6**	**85.0**	**79.5**	**81.2**	**90.0**	**79.3**	**81.5**
sem	1.8	1.3	2.1	1.4	2.1	2.3	2.9	1.6	2.6	3.4
%P12	**94.0**	**95.1**	**87.0**	**93.8**	**88.7**	**85.6**	**86.6**	**95.4**	**92.5**	**93.1**
sem	1.3	1.2	1.6	1.2	1.8	2.0	2.5	1.1	1.7	2.2

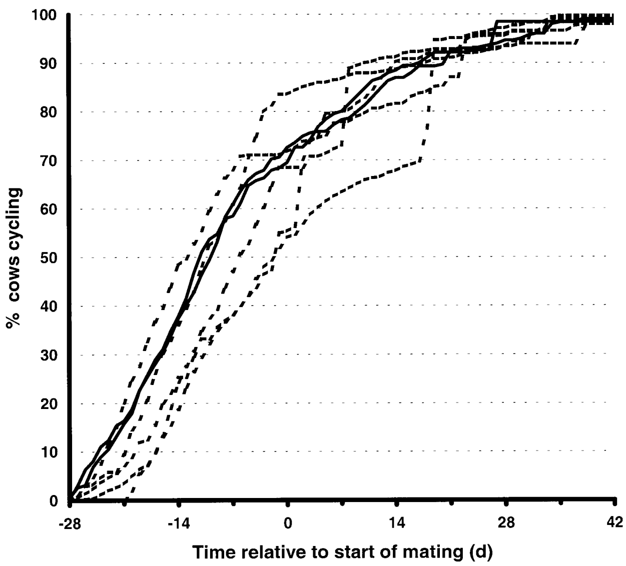
* Farm- M= pasture +maize silage supplementation, P= pasture-only; PSM = date for start of mating; %cyc= proportion of herd detected in oestrus by PSM; %P3= proportion of herd pregnant at 3 weeks of mating (similarly for %P6, %P9 and %P12).

earlier times and rising to similar levels by the start of mating.

The significant between-farm differences in these bulk milk parameters did not appear to be related to reproductive performance. Detailed examination of the type of feed consumed on one farm and the changes in the BMUNs for that farm indicate that the interpretation of BMUN data would be extremely difficult without detailed feed intake and composition data.

The reproductive performance of the herds is summarised in Table 1. and detailed in Figures 3 to 5. The mean proportion of cows cycling at PSM was 65.6 ± 4.4% and ranged from 50.5 to 81% (Figure 3). Nine of the ten herds had a submission rate to AI after three weeks of mating, over 80 % and six of these were above 86%. This performance indicates that these six herds are comparable with the top 20% of herds in the North Island (Smith *et al.*, 2001; Xu & Burton, 2000).

FIGURE 3: Proportion of cows cycling relative to the start of mating. (Maize silage supplemented herds in dotted lines and pasture-only herds in solid lines. Note: data available from only two of the five pasture-only herds).



The mean proportion of cows pregnant to AI at PSM + 3 weeks (%P3) was 51.3 ± 2.1 % range 43 to 61.5%; at PSM + 6 weeks (%P6) the mean was 75.3 ± 3.3% (61 to 89.5%); at PSM + 9 weeks (%P9) it was 84.7 ± 2.2% (74.9 to 91.6%) and at PSM + 12 weeks (%P12) it was 91.3 ± 1.2% (86.5 to 95.4%). The overall pregnancy rates at the end of mating (16 weeks) were all between 93 and 96% (Figure 4) and this places them all in the top 20% of herds in the North Island (Smith *et al.*, 2001; Xu & Burton, 2000).

FIGURE 4: Distribution of conception date from the start of mating. (Maize silage supplemented herds in dotted lines and pasture-only herds in solid lines).

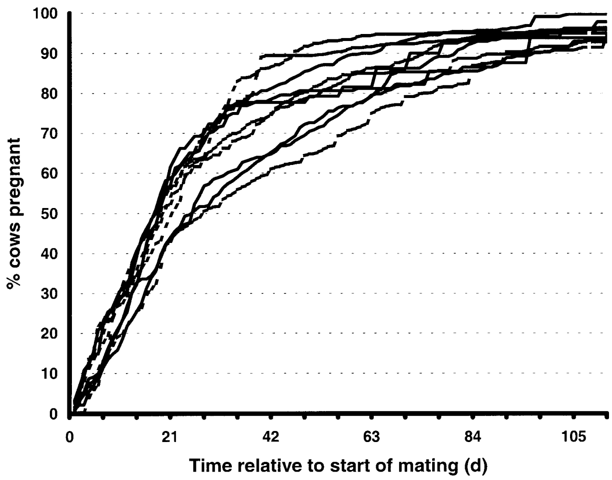
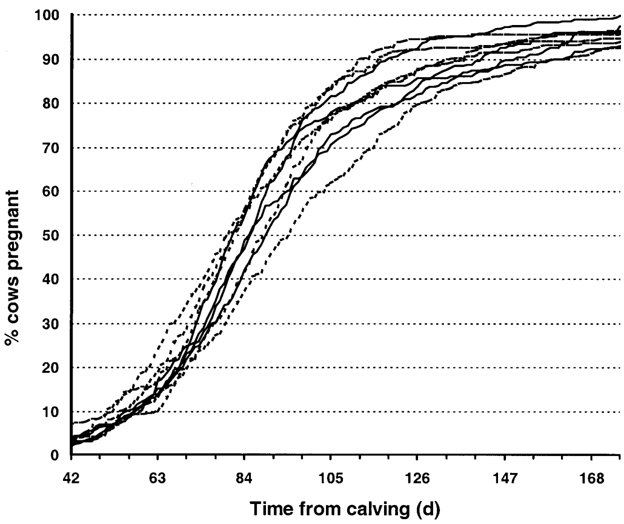


Figure 5 presents the pattern for the interval from calving to conception. While these benchmark herds are regarded as having previously had very good reproductive performance, only four of the nine herds had a median conception date (50% of cows pregnant) within an 83-day interval of calving (the time needed to maintain a 365-day calving interval), although for another two herds the median interval was 86 days. This, coupled with the conception rate by 21 days after start of mating (six of the ten herds greater than 50%), indicate that some of these herds were meeting the expected targets. Examination of the data, on the pattern of calving relative to the planned start of mating for the preceding calving in theses herds, showed that in all herds over 95% of cows had calved three weeks before the

FIGURE 5: Distribution of interval from calving to conception. (Maize silage supplemented herds in dotted lines and pasture-only herds in solid lines).



planned start of mating . This indicates that, while the overall number of empty cows in these herds is low, in some of these herds there must be considerable culling of the cows with later conception dates and their replacement by earlier-calving heifers or the use of induction to maintain the annual calving pattern.

One of the objectives of the New Zealand Dairy industry is to have a "reduction in induction" but these data indicate that even with high reproductive performance herds it will be difficult to achieve this and still maintain a concentrated calving pattern.

The lack of difference between the maize-supplemented and the pasture-only herds indicate that management factors other than post-partum feed supply are exerting effects on herd reproductive performance.

The lack of relationships between the bulk milk measures and herd reproductive performance indicate that these milk measures do not provide any useful criteria for reproductive management. While the data from this project would restrict that conclusion to herds with high reproductive performance. A similar conclusion, in relation to the use of BMUNs, was reached using data from herds with a much greater range in reproductive performance (Smith *et al.*, 2001).

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