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Associations between milk protein concentration at various stages of lactation and reproductive performance in dairy cows

John M. Morton,*[1] Martin J. Auldist,† Meaghan L. Douglas,† and Keith L. Macmillan‡
*Jemora Pty Ltd., Geelong, Victoria 3220, Australia
†Department of Economic Development, Jobs, Transport and Resources, Ellinbank Centre, Victoria 3821, Australia
‡Department of Veterinary and Agricultural Sciences, The University of Melbourne, 250 Princes Highway, Werribee, Victoria 3030, Australia

ABSTRACT

Milk protein concentration has been positively associated with a range of measures of reproductive performance in dairy cows. These beneficial associations are most likely due to factors affecting both milk protein concentration and reproductive performance possibly being mediated, in part, by energy balance during early lactation. However, it is likely that factors other than energy balance are also involved in these relationships. A retrospective single cohort study was conducted using subsets of data collected from 74 dairy herds with seasonal or split calving patterns. Associations between milk protein concentration at various stages of lactation and reproductive performance in Holstein dairy cows were assessed using random effects logistic regression and survival analysis with milk protein concentration during the cow's breeding period fitted as a time-varying covariate. The beneficial associations between milk protein concentration and each of the 4 selected indices for measuring reproductive performance were evident when milk protein concentration was derived for each 30-d period from calving up to 300 d in milk. For the first 150 d of lactation the adjusted odds ratios were highest from 31 to 60 d and only slightly lower for all periods up to 150 d of lactation. Estimated associations for 31 to 60 d were stronger than for 0 to 30 d. In addition, milk protein concentration during a cow's breeding period was positively associated with the subsequent daily hazard of conception, even after adjusting for milk protein concentration in the cow's first or second month of lactation. Milk protein concentrations from 0 to 30 d of lactation were less closely correlated with concentrations measured at subsequent 30-d intervals; correlations were closer between other periods in lactation. These results indicate that the association between milk protein concentration and reproductive performance is partly due to factors other than the extent of negative energy balance in early lactation. However, it is possible that energy balance accounts for some of the relationship as the magnitude and direction of energy balance can vary within and between cows throughout lactation. Factors determining milk protein concentration during the first 30 d of lactation are not identical to the causes of milk protein concentration later in lactation, and some of the latter causes of milk protein concentration may be more closely related to the underlying mechanisms contributing to the milk protein concentration-reproductive performance relationship. Milk protein concentrations from a single test day from any day of lactation predict subpopulations of cows with differing average reproductive performance; milk protein concentrations measured after 30 d of lactation are more useful than concentrations measured in the first 30 d for identifying these subpopulations. Further research is required to identify the causes of these associations.

Key words: milk protein concentration, reproductive performance, dairy cow

INTRODUCTION

Milk protein concentration has been positively associated with a range of measures of reproductive performance in dairy cows in both year-round calving herds (Opsomer et al., 2000; Moss et al., 2002; Madouasse et al., 2010) and pasture-based, seasonally calving herds in Ireland (Patton et al., 2007; Yang et al., 2009), New Zealand (Xu and Burton, 2003; Harris and Pryce, 2004), and Australia (Fahey et al., 2003; Morton, 2004). These positive associations have also been reported in strains of Holstein-Friesians, with marked differences in milk yields and reproductive performance (Patton et al., 2007; Yang et al., 2009), and are most likely to be due to factors affecting both milk protein concentration and reproductive performance. They are thought to be mediated, in part, by energy balance during early lactation (Yang et al., 2009; Madouasse

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[1]Corresponding author: john.morton@optusnet.com.au

et al., 2010). This hypothesis arises because milk protein concentration during the first 3 mo of lactation is higher in cows with better (i.e., less negative) energy balance (Grieve et al., 1986; Garvin, 1999) and more severe negative energy balance has adverse effects on reproductive performance (Canfield et al., 1990; Reist et al., 2003; Patton et al., 2007). Factors other than energy balance during early lactation may also contribute to these relationships. Milk protein concentration for the whole lactation has been positively associated with reproductive performance (Buckley et al., 2003; Harris and Pryce, 2004; Yang et al., 2009), even though negative energy balance is mostly confined to early lactation (de Vries and Veerkamp, 2000; Coffey et al., 2004; Friggens et al., 2007; Pedernera et al., 2008) when milk protein concentrations are more variable (Silvestre et al., 2009). The whole of lactation associations are also of particular interest, as milk protein concentration in early lactation is not closely correlated with milk protein concentrations in mid and late lactation (Haile-Mariam and Goddard, 2008). Further, milk protein concentration in first-lactation heifers is associated with their first calving date (J. Fahey, Department of Veterinary Science, University of Melbourne, Victorian Institute of Animal Science, Werribee, Victoria, Australia, personal communication), reflecting their reproductive performance as yearlings, a period when mechanisms related to lactation would not occur and when negative energy balance would not be expected. Although energy must be partitioned to the udder for production of milk protein (Hanigan et al., 2001, 2002), milk protein synthesis is complex, also being affected by availability of EAA (Lapierre et al., 2012). In addition, milk protein concentration is determined not just by the rate of production of milk protein but also by milk volume, which, in turn, is determined by rate of lactose synthesis (Hanigan et al., 2001). Milk protein concentration responses to increased energy intake are small (Coulon and Rémond, 1991), suggesting that concentrations are determined by major mechanisms other than dietary energy supply.

Because the extent of negative energy balance reduces as lactation progresses, if the association between milk protein concentration and reproductive performance is primarily caused by negative energy balance in early lactation, the association when milk protein concentration is assessed after early lactation should be weaker. No previous study has systematically compared strengths of associations between milk protein concentration measured throughout lactation and a range of reproductive measures. This knowledge could help our understanding of the biology of the associations. In addition, milk protein concentration could be used as an indicator of likely reproductive performance for herd management purposes, such as selecting cows most likely to conceive to inseminations with expensive or sexed semen. For the greatest predictive accuracy, it would be preferable to use milk protein concentration data derived from the stage or stages of lactation when it has the strongest positive association with measures of reproductive performance.

The objective of our study was to assess the strengths of associations between milk protein concentration at various stages of lactation and selected measures of reproductive performance in Holstein cows in pasture-based, seasonally and split-calving dairy herds, and to assess associations between milk protein concentration during each cow's breeding period and subsequent hazard of conception.

MATERIALS AND METHODS

Study Overview

A retrospective single cohort study was conducted using subsets of data collected from 74 seasonally and split-calving dairy herds. Associations between milk protein concentration at various stages of lactation and reproductive performance in Holstein cows were assessed using random effects logistic regression and survival analysis, with milk protein concentrations during each cow's breeding period fitted as a time-varying covariate.

Calvings in seasonally calving dairy herds occur within a short period each year, and inseminations occur from the breeding period start date, the calendar date that is 282 d (i.e., one gestation length) before the herd manager plans the next calving period to commence. Typically, AI is used exclusively for 4 to 8 wk, and then bulls graze with the lactating herd for a further period. In split-calving study herds, all calvings each year occurred within 2 or 3 distinct temporal periods commencing 4 to 8 mo apart. These herds have 2 or 3 distinct breeding periods, each commencing with a breeding period start date that is 282 d before the desired commencement date for the corresponding calving period.

Herd Selection

In 2010, 58 commercial dairy herds that met the study's herd-selection criteria were selected from clients of each of 4 veterinary practices in Victoria and Tasmania. For the 2009 calving period (or, for split-calving herds, for the largest calving group in 2009), whole-herd rectal pregnancy tested within 17 wk after the breeding period start date using rectal ultrasound or manual examination must have been conducted, with