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Associations between milk protein concentration, milk yield, and reproductive performance in dairy cows

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ABSTRACT

Milk protein concentration in dairy cows has been positively associated with a range of measures of reproductive performance. It was possible that these associations were due to confounding by milk volume. A retrospective single cohort study was conducted using data collected from 74 dairy herds with seasonal or split calving patterns. Associations between milk protein concentration and reproductive performance in Holstein dairy cows were assessed using random effects logistic regression. The key finding from this study was that the associations between milk protein concentration in early lactation and reproductive performance were not due to confounding by milk yield. Associations between milk protein concentration and reproductive performance were weaker at higher early lactation milk yields, but positive associations were evident at all milk volumes assessed. The second major finding was that increases in milk yield were associated with improved proportions of cows pregnant by wk 6 and 21 at low to moderate milk protein concentrations but with decreases in these reproductive measures at high milk protein concentrations. Thus, no simple relationship is present between milk yield and reproductive performance; effects of milk yield depend on milk protein concentration. These results indicate that mechanisms causing the associations between milk protein concentration and reproductive performance may be linked to milk yield but these mechanisms operate over a wide range of milk yields ($<$2,000 to $\geq$5,000 kg in the first 120 d of lactation). Further research is required to identify the causes of these associations.

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

INTRODUCTION

Milk protein concentration has been positively associated with reproductive performance in dairy cows in both seasonally calving (Fahey et al., 2003; Harris and Pryce, 2004; Patton et al., 2007) and year-round calving herds (Lampo et al., 1963; Kaufmann, 1976; Miettinen and Setala, 1993). Higher milk protein concentration has been associated with shorter calving to first estrus intervals among primipara (McGowan et al., 1996), shorter calving to first service intervals (Miettinen and Setala, 1993), higher submission (Buckley et al., 2003) and conception rates (Leaver, 1983; Pinto et al., 2000), reduced risk of requiring multiple inseminations (Moss et al., 2002), and increased pregnancy rates by wk 6 of the breeding period (Buckley et al., 2003) and at the end of the breeding program (Kennedy et al., 2003). Among cows treated for anestrus, milk protein concentration is also positively associated with pregnancy rates (McDougall, 2003). Increased conception rates among cows with higher milk protein concentration appear to be due to increased fertilization rates, decreased early embryonic mortality, or both (Pinto et al., 2000), but not to reduced late embryonic mortality (Silke et al., 2002).

It is possible that this association between milk protein concentration and reproductive performance is due to effects of milk yield, as milk yield is negatively associated with both milk protein concentration and reproductive performance. The genetic and phenotypic correlations between milk protein concentration and milk yield in New Zealand cows were estimated to be −0.61 and −0.44, with heritabilities of 0.52 and 0.35, respectively (Harris and Pryce, 2004). Shanks et al. (1982) reported correlation coefficients of 0.13 to 0.19 for associations between peak milk yield and calving interval. Hamudikuwanda et al. (1987) observed increases in calving interval of 6 d for every 1,000 L increase in 60-d cumulative milk yield, and Eicker et al. (1996) found that cows producing more than 2,541 L in the first 60 d of lactation had a slightly lower chance of conception. Laben et al. (1982) detected increases in

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calving interval of 6 d per 1,000 L increase in 180-d cumulative milk yield and Kinsel et al. (1998) reported increases in days open of 2 d for every extra 10 L of peak daily milk yield. Mean days open was 17 d longer among cows partitioning over 125 MJ/d to milk in early lactation, relative to cows partitioning less than 65 MJ (Klaas et al., 2004).

Thus, the primary objectives of the current study were (1) to assess the strengths of associations between milk protein concentration in early lactation and various measures of reproductive performance in Holstein cows after adjusting for milk yield, and (2) to assess interactions between milk protein concentrations and milk yield. A secondary objective was to assess effects of milk yield on reproductive performance.

MATERIALS AND METHODS

Study Overview

A retrospective, single cohort study was conducted using data collected from 74 Australian dairy herds. Associations between early lactation milk protein concentration and reproductive performance, and interactions with early lactation milk yield, were assessed in Holstein dairy cows using random effects logistic regression. Full details of the study have been reported elsewhere (Morton et al., 2016). Briefly, in 2010, veterinarians from 4 practices in Victoria and Tasmania, Australia, selected commercial client herds with accessible electronically stored data that met the study's herd selection criteria. The primary criteria were adequate pregnancy testing and complete and accurate calving, AI, pregnancy test, and culling data in an electronic database. For the 2009 calving period (or, for split-calving herds, the largest calving group in 2009), whole-herd rectal pregnancy testing within 17 wk after breeding period start date using rectal ultrasound or manual examination must have been conducted, with cows not diagnosed pregnant retested after the end of the breeding period. In addition, all herd-years with sufficient early pregnancy test data in the Australian Dairy Herd Improvement Scheme (ADHIS, 2015) national database were identified and enrolled. In selecting herds from the ADHIS data, herds from throughout Australia were eligible. However, the only herds that met the selection criteria were from Victoria. All relevant data in the respective databases for the selected herds were obtained and used where study criteria were met. Breeding periods from 1996 to 2009 were used in analyses.

Every enrolled herd had either a seasonally concentrated or a split calving pattern (i.e., 1 to 3 distinct calving periods within each year). For each breeding period, most initially used AI exclusively for some weeks before running bulls with the lactating herd. Start of breeding period dates were determined within each herd based on daily numbers of services (i.e., AI and natural services). As dates that bulls were removed from the lactating herds and bull services were generally not recorded, end dates for each breeding period were defined based on conception dates. Conception dates were assigned only for cows with positive pregnancy diagnoses. These were identified based on estimated stages of pregnancy from positive rectal pregnancy diagnoses in combination with AI and any recorded bull services.

All lactations by Holstein cows commencing between 120 d before and 30 d after their nearest breeding period start date were selected and allocated the nearest breeding period start date. Where the herd had 2 breeding periods commencing 120 d or less apart, calvings between these start dates were allocated the second breeding period start date. Other lactations were excluded from analyses. Breeding periods where arbitrary calving dates had been recorded (e.g., all calvings recorded as occurring on the first day of the calendar month) were also excluded from analyses, as were lactations with service or conception dates (or both) before breeding period start date. Breeding periods were considered to have adequate data for analyses only if they had been allocated more than 50 lactations, and for more than 80% of the ensuing lactations, the cow had at least one pregnancy diagnosis.

Four lactation-level binary reproductive performance measures were used as outcome (i.e., dependent) variables:

- submission (i.e., inseminated or served) by wk 3 of the breeding period,
- conception to first service (for lactations where the first service was by AI)
- pregnancy by wk 6 of the breeding period, and
- pregnancy by the end of the breeding period (considering only pregnancies up to the end of wk 21 of the breeding period).

For each reproductive measure, all selected lactations were included if the cow's status for that measure could be ascertained. For example, submitted by wk 3 of the breeding period could be ascertained only for cows not culled by that time, and pregnancy by wk 6 of the breeding period could be ascertained only for cows diagnosed pregnant or whose final pregnancy test was at least 70 d after the start of the breeding period.

Milk Protein Concentrations and Milk Yields

Milk protein concentrations and milk yields had been estimated by commercial milk recording services. Milk