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Components of the covariances between reproductive performance traits and milk protein concentration and milk yield in dairy cows

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ABSTRACT

Reproductive performance in dairy cows can be improved through genetic selection and herd management. Milk protein concentration is strongly associated with various measures of reproductive performance, but the relative importance of genetic and environmental components of these associations have not been defined. The primary objective of this study was to estimate the magnitudes of correlations and covariances between 9 reproductive performance traits in dairy cows and each of milk protein concentration and milk yield at 4 levels: genetic, permanent environmental effects of cow, herd-year-season, and residual levels. A retrospective single cohort study was conducted using data collected from seasonally and split calving dairy herds. We used animal models to partition covariances for the relationships between 9 fertility traits and each of milk protein concentration and milk yield at lactation level, with up to 80,203 lactations from 27,244 cows that were 780 herd-year-seasons in 65 herds. For the fertility traits, of the explained covariance with milk protein concentration, between 33 and 79% (median 53%) was genetic and 21 to 67% (median 47%) was nongenetic. We concluded that research should be conducted to identify management strategies that capture the nongenetic components of relationships between milk protein concentration and reproductive performance. Genetic correlations with milk protein concentration were generally similar to genetic correlations with milk yield, but the correlation with milk protein concentration was closer (i.e., the absolute value of the correlation coefficient was nearer to 1) for pregnant by wk 6, a key trait for seasonally and split calving dairy herds (correlation coefficient ± standard error = 0.28 ± 0.05 and −0.17 ± 0.07 for milk protein concentration and milk yield, respectively). As the associations also have substantial genetic components, it is possible that reliabilities of estimated breeding values for fertility may be improved by including milk protein concentration in multitrait genetic evaluation models for fertility traits. From our preliminary analyses, reliabilities were only slightly higher when pregnancy by wk 6 of the breeding period was analyzed with milk protein concentration rather than alone or with milk yield, but further research should be considered to assess this question. Importantly, the benefits of these strong relationships can only be fully harnessed through joint use of both management strategies and genetic strategies.
Key words: reproductive performance, seasonal milk production systems, genetic parameters

INTRODUCTION

Reproductive performance in dairy cows is important because delayed conception results in reduced annual milk yield (Auldist et al., 2007) and increased chance of culling (Rajala-Shultz and Grohn, 1999). Reproductive performance in dairy cows can be improved through genetic selection (Berry et al., 2014) and herd management changes. Milk protein concentration has been positively associated with reproductive performance in dairy cows phenotypically in numerous studies (e.g., Opsomer et al., 2000; Morton, 2004; Madouasse et al., 2010). This relationship has been attributed to energy balance during early lactation (Yang et al., 2009; Madouasse et al., 2010), but further research is required to allow the benefits of the association to be captured in dairy herd management. The current study is one of an ongoing series of studies with the ultimate aim of providing the necessary information to allow the benefits of the milk protein concentration-reproductive performance association to be captured (Fahey et al., 2008, 2017; Douglas et al., 2016; Morton et al., 2016a,b, 2017); the relationship is not due to confounding by milk yield, as positive associations are still present after adjusting for milk yield in multivariable regression models. Associations between milk protein concentra-

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tion and reproductive performance are weaker at higher early lactation milk yields, but positive associations are evident over a wide range of milk yields (Morton et al., 2016a). It is possible that both genetic and environmental factors affecting both milk protein concentration and reproductive performance contribute to these phenotypic associations. However, to our knowledge, the relationships between milk protein concentration and reproductive performance traits in dairy cows have not been separated into genetic and nongenetic components. A need exists to quantify the contributions of genetic effects, nongenetic cow effects, and herd effects to these relationships, as this would inform directions for future research. As indicator variables can improve the reliability of breeding values for fertility, if the relationships are predominantly genetic and explain a reasonable proportion of genetic variation in fertility traits, extending multitrait models for fertility genetic evaluation to include milk protein concentration should be considered. In contrast, if the relationships are predominantly nongenetic, research should focus on management changes that capture the nongenetic effects on reproductive performance.

The possibility of increasing the reliability of breeding values for fertility traits by using milk protein concentration is worth exploring. To our knowledge, milk protein concentration has not been used in this way in any country, but in some countries the effects of including milk yield in multitrait genetic evaluation models have been assessed (e.g., Olori et al., 2002; Harris et al., 2005; Sun et al., 2010). Accordingly, for comparison purposes, the covariance components between milk yield and reproductive performance were also of interest.

In Australia, where seasonally and split calving systems are the predominant calving systems, an important reproductive performance trait is whether the cow became pregnant in the first 6 wk of the breeding period (Morton, 2004). To derive this measure, pregnancy test data that allow accurate determination of conception dates over the whole breeding period are required. For accurate estimates of conception dates, pregnancy testing must be timed such that pregnant cows are examined relatively early in their pregnancy (Matthews and Morton, 2012; Brownlie et al., 2016). Availability of these high-quality data is currently limited (e.g., González-Recio et al., 2016); as a result, genetic evaluation of fertility in Australia currently relies on a multitrait model that uses calving interval, calving to first service interval, occurrence of pregnancy at any time in the breeding period, nonreturn to service, and lactation length. Results from this multitrait model are used to generate a fertility breeding value based on calving interval transformed into pregnancy by wk 6. This model was designed to capture as much of the genetic variation in fertility as possible using traits that were commonly available. Therefore, in addition to using the data on pregnancy by wk 6 to separate the relationship between milk protein concentration and fertility traits into different components, correlations between pregnancy by wk 6 and other fertility traits including some commonly available traits currently included in the multitrait model were of interest to assess how closely related they are with pregnancy by wk 6.

The primary objective of our study was to estimate the magnitudes of correlations and covariances for the relationships between 9 reproductive performance traits in dairy cows and each of milk protein concentration and milk yield at 4 levels: genetic, permanent environmental effects of cow, herd-year-season, and residual levels. We also estimated genetic and other correlations between a reproductive performance trait of primary interest in seasonally and split calving dairy herds, namely whether the cow become pregnant in the first 6 wk of the breeding period, and 8 other reproductive traits at these levels. We also performed preliminary analyses to quantify the advantage of analyzing milk protein concentration with pregnancy by wk 6 on the reliabilities of estimated breeding values of sires compared with the reliabilities when analyzing with milk yield and with neither.

MATERIALS AND METHODS

Study Overview

A retrospective single cohort study was conducted using data collected from 74 seasonally and split calving dairy herds. We assessed covariances for the relationships between 9 fertility traits and each of milk protein concentration and milk yield at lactation level. Full details of herd, lactation, and breeding period selection reproductive performance measures, as well as measurement of milk yields and milk protein and fat concentrations are provided in Morton et al. (2016b).

Herd Selection

In 2010, 58 commercial dairy herds with early rectal ultrasound or manual pregnancy diagnoses were selected from clients of each of 4 veterinary practices in Victoria and Tasmania, Australia. These herds were selected because their data had been entered into a database, those data were considered by the herd's veterinary practitioners to be relatively complete and accurate (based on their knowledge of the herd staff data-recording practices and frequency of discrepancies and missing data), and, in 2009, all cows were preg-