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Use of early lactation milk recording data to predict the calving to conception interval in dairy herds

J. G. Cook*[1] and M. J. Green†
*Yew Tree House, Carleton, Carlisle, CA1 3DP, United Kingdom
†School of Veterinary Medicine and Science, University of Nottingham, Sutton Bonington Campus, Sutton Bonington, LE12 5RD, United Kingdom

ABSTRACT

Economic success in dairy herds is heavily reliant on obtaining pregnancies at an early stage of lactation. Our objective in this study was to attempt to predict the likelihood of conception occurring by d 100 and 150 of lactation (days in milk, DIM) by Markov chain Monte Carlo analysis using test day milk recording data and reproductive records gathered retrospectively from 8,750 cows from 33 dairy herds located in the United Kingdom. Overall, 65% of cows recalved with 30, 46, and 65% of cows conceiving by 100 DIM, 150 DIM, and beyond 150 DIM, respectively. Overall conception rate (total cows pregnant/total number of inseminations) was 27.47%. Median and mean calving to conception intervals were 123 and 105 d, respectively. The probability of conception by both 100 DIM and 150 DIM was positively associated with the average daily milk weight produced during the fourth week of lactation (W4MK) and protein percentage for test day samples collected between 0 to 30 and 31 to 60 DIM. Butterfat percentage at 0 to 30 DIM was negatively associated with the probability of conception by 100 DIM but not at 150 DIM. High somatic cell count (SCC) at both 0 to 30 and 31 to 60 DIM was negatively associated with the probability of conception by 100 DIM, whereas high SCC at 31 to 60 DIM was associated with a reduced probability of conception by 150 DIM. Increasing parity was associated with a reduced odds of pregnancy. Posterior predictions of the likelihood of conception for cows categorized as having "good" (W4MK >30 kg and protein percentage at 0 to 30 and 31 to 60 DIM >3.2%) or "poor" (W4MK <25 kg and protein percentage at 0 to 30 and 31 to 60 DIM <3.0%) early lactation attributes with actual observed values indicated model fit was good. The predicted likelihood of a "good" cow conceiving by 100 and 150 DIM was 0.39 and 0.57, respectively (actual observed values 0.40 and 0.59). The corresponding values for a "poor" cow were 0.28 and 0.42 (actual observed values 0.26 and 0.37). Predictions of the future reproductive success of cows may be possible using a limited number of early lactation attributes.
Key words: dairy cow, pregnancy, early lactation, milk recording data

INTRODUCTION

Dairy herd profitability is highly dependent on reproductive performance (Louca and Legates, 1968; Oltenacu et al., 1981; Giordano et al., 2011, 2012) because optimizing the time cows spend in the most efficient part of the lactation curve has a significant effect on revenues obtained for milk sales (Ferguson and Galligan, 1999) as well as minimizing replacement costs due to reproductive failure. The timing at which pregnancy occurs during lactation is of utmost importance in sustaining profitability (Giordano et al., 2011); ideally this should occur between 90 and 130 DIM (Giordano et al., 2011).

In this context, the transition period has been recognized as a time when the dairy cow experiences an abrupt and severe change in demand for energy during the transition from the dry period to the onset of lactation (Bauman and Currie, 1980). At this time the cow's DMI may be limited and so the demand for energy cannot be met by DMI and most cows will experience a period of negative energy balance (**NEB**). The extent of NEB increases with energy output and increasing milk yield and has been linked to poor reproduction (Buckley et al., 2003; Patton et al., 2007).

Britt (1992) suggested that the biological environment in the relatively long period of follicular growth before ovulation is a major factor contributing to the syndrome of subfertility in dairy cows; however, to date the only long-term demonstrable adverse effect on fertility is the effect of heat stress (Chebel et al., 2004). Leroy et al. (2008a,b) have reviewed the mechanisms by which the biochemical environment of the cow and in

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[1]Corresponding author: john.cook14@btinternet.com

particular the metabolic changes associated with NEB may influence fertility, but many of these effects have been investigated only in the short term because in vitro studies examining long-term effects of metabolism are difficult to conduct (Leroy et al., 2008a).

Therefore, it would seem likely then that NEB in early lactation may at least in part be responsible for the creation of the biological environment that leads to sub fertility in dairy cows. Milk recording data from individual cows has been used in several studies to associate milk composition in early lactation with energy balance (Duffield et al., 1997; de Vries and Veerkamp, 2000; Heuer et al., 2001) and Madouasse et al. (2010) have associated milk components in early lactation with the probability of conception at certain intervals during lactation. In particular, Madouasse et al. (2010) identified an association between lower milk production on the second test day, higher percentage of protein on the second test day, and higher percentage of lactose on the first test day with increased probability of conception before 145 DIM, whereas positive associations of a smaller magnitude were identified for percentage of protein at the first test day and negative associations with first test butterfat and SCC on the first and second test days.

In cases of NEB, increases in milk fat percentage and decreases in milk protein percentage along with increases in milk fat to protein ratio have been a consistent finding (Duffield et al., 1997; de Vries and Veerkamp, 2000; Heuer et al., 2001). A consistent negative relationship between SCC and reproductive performance has also been found in more recent studies (Hudson et al., 2012, 2015; Bijker et al., 2015).

Milk protein yield, although tightly regulated (Jenness, 1979), has been shown to be associated with both nutritional and endocrine factors that influence protein metabolism in the mammary gland (DePeters and Cant, 1992; Mackle et al., 2000; Burgos et al., 2010). In particular, studies on animal and cell culture models have demonstrated that nutrient availability plays a role in regulating protein synthesis as both a substrate and via direct signaling to the protein synthetic machinery (Proud, 2007). Milk fat content is derived from both de novo synthesis of short- and medium-chain fatty acids by the mammary gland (Bauman et al., 2006) and long-chain fatty acids taken up from the bloodstream. Cows in NEB mobilize fat reserves and the milk percentage of C16:0 and C18:0 fatty acids increases (Stoop et al., 2009). The effects of changes in SCC may reflect the direct effect of subclinical mammary infection on reproductive function (Lavon et al., 2011b) or may simply be an indicator of metabolic issues (van Straten et al., 2009).

Shahinfar et al. (2015) successfully used milk yield data among 25 other explanatory variables including genetic information and health history to predict insemination outcome success using machine learning algorithm research, which also showed that the quality of data can have a significant effect on the accuracy of predictions particularly where recording of data is subjective such as in the recording of health traits.

Transition management success using early lactation milk yield data was also studied by Lukas et al. (2015); however, in this study transition management success was not linked to future reproductive outcomes.

Data from individual cow milk recordings is easily measured and readily accessible to both producers and consultants in the dairy industry globally and offers both a noninvasive and affordable method at both individual cow and herd level of assessing and monitoring energy status in early lactation as well as future reproductive potential. Readily accessible information that predicts an individual cow or herd's future reproductive performance would be of use to producers in managing reproductive programs as it affords the opportunity to alter management programs to potentially optimize the use of hormonal synchronization protocols, insemination methods (e.g., the use of sexed semen), or environmental management.

The objective of this research was to evaluate the usefulness of readily available production data to predict reproductive performance of dairy cows. Of particular interest was the difference between production characteristics to predict early pregnancy (by 100 DIM) or later pregnancy (by 150 DIM).

MATERIALS AND METHODS

Herd Selection and Reproductive Management

Herds were identified and selected to be included in this study if they had been referred to the technical services department of Genus ABS (Nantwich, UK) for consultation because of perceived poor reproductive performance reported in the period from September 1 to December 31, 2010; as such, they were part of the normal daily workload for that team.

Data were available for a total of 8,750 cows located in 33 herds. Mean and median herd sizes were 228 and 265 cows, respectively. Overall, 65% of cows (5,693) became pregnant and recalved. The percentages of cows that conceived by 100 DIM, 150 DIM, and beyond 150 DIM were 30, 46, and 65%, respectively. Overall conception rate (total cows becoming pregnant/total number of inseminations) for cows in this study was 27.47%. Mean and median calving to conception interval (days from