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Monitoring herd incidence of intramammary infection in lactating cows using repeated longitudinal somatic cell count measurements

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ABSTRACT

The objective of the study was to evaluate the ability of an estimate of the herd intramammary infection (IMI) incidence rate computed using repeated somatic cell count (SCC) measurements (quarter- and composite-SCC; hereafter, the SCC-derived herd IMI incidence, SCCI) to predict the incidence rate computed using repeated quarter-milk bacteriological culture (hereafter, bacteriological culture incidence, BCI) during the lactating period. A cohort of 91 Canadian dairy herds was followed in 2007 and 2008. In each herd and at each of 4 sampling periods, a series of 3 to 7 quarter-milk samples was collected from a sample of 15 cows. Routine milk bacteriological culture was conducted to identify IMI, SCC was measured on the quarter-milk samples, and composite-SCC of the preceding and following dairy herd improvement (DHI) tests were obtained. Mastitis pathogens were grouped in 3 categories: major, minor, and any pathogens. For each herd and for each period, BCI was computed for each group of organisms. Similarly, SCCI were computed using quarter- and DHI composite-SCC and using a threshold of 200,000 cells/mL to define infected quarters or cows. A linear regression model taking into account the structure of the data was used to compare the SCCI to the BCI. A similar model was used to compare fluctuations (i.e., changes from one sampling period to the next) over time of the SCCI and BCI. Measures of correlation between observed and predicted rates were computed and limits of agreement plots sketched to better explore the predictive ability of the SCCI. The quarter-milk SCC measurements that could be obtained—for instance, using on-line milking system measurements—appeared to be particularly valuable. Quarter-SCCI showed a positive and significant association with the BCI. However, limits of agreement plots indicated important disagreement for the small proportion of observations with very high BCI. Quarter-level SCCI and BCI fluctuations were also significantly associated, and a substantial correlation (Spearman rho ranging from 0.54 to 0.58) could be seen between observed and predicted rates. Conversely, the predictive value of composite-DHI SCC for monitoring IMI incidence during the lactation seemed to be quite limited. Composite SCCI was strictly associated with major IMI BCI, showed a relatively low correlation with the observed rate (Spearman rho: 0.14), and was of little help for longitudinal monitoring of the IMI incidence.
Key words: lactating period, intramammary infection, incidence, somatic cell count

INTRODUCTION

Mastitis is one of the most costly diseases for the dairy industry worldwide and most of the economic loss is actually due to subclinical mastitis, a nonclinical inflammation of the udder usually resulting from bacterial IMI (Halasa et al., 2007). The prevalence of subclinical mastitis in a herd is directly determined by the rate at which new IMI (**NIMI**) are acquired and eliminated (i.e., the incidence and elimination rates; Schukken et al., 2003). In 2 recent studies conducted in Canada, a given variation of the incidence rates of *Staphylococcus aureus* and CNS IMI—the 2 pathogens most frequently recovered from apparently normal milking quarters in the country—was found to have a greater effect on IMI prevalence than a comparable variation of their elimination rates (Dufour et al., 2012a,b). These results confirm that, as for many other infectious diseases, preventing new infections may be the key to long-term control of subclinical mastitis. Reducing the incidence of IMI should, therefore, be the main objective of a subclinical mastitis control program, and frequent monitoring of the herd IMI incidence rate should, consequently, be an essential component of routine udder health surveillance.

Obtaining a valid estimate of the herd IMI incidence rate is quite difficult, however, because of the repeated IMI measurements needed to identify NIMI occurrence. In research settings, IMI incidence measurements are

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often obtained using longitudinal study designs involving repeated cow or quarter bacteriological milk culture (Zadoks et al., 2001; Dufour et al., 2012a,b). Conducting repeated milk bacteriological cultures on a regular basis to monitor the herd IMI incidence rate, however, is certainly not very practical for routine udder health monitoring of commercial dairy herds. Conversely, monthly composite SCC measurements are available on most dairy farms and could potentially be used as a proxy for NIMI to estimate herd IMI incidence rate. Furthermore, novel milking systems that can measure quarter SCC at milking could be used to generate the data needed to estimate and monitor herd IMI incidence rate.

Several SCC thresholds and absolute or relative SCC increases have been evaluated for their ability to accurately detect the occurrence of NIMI at cow level. An SCC-derived NIMI definition, consisting of a composite SCC going from under to over 200,000 cells/mL over a 28-d interval, has also been suggested (Dohoo and Leslie, 1991). Even though the sensitivity of the proposed threshold to identify occurrence of NIMI at the cow level was fairly low (32%), it was, nonetheless, proposed as a useful criterion to compute herd-level incidence estimates and to monitor herd-level fluctuations in udder health status (Erskine, 2001). Today, the herd incidence rate derived from individual cow monthly DHI testing is reported by many DHI organizations and this measure is routinely monitored by dairy practitioners and extension agents to evaluate herd performances and to help decide on clinical investigations and interventions. Furthermore, such a measure of the herd IMI incidence has been used in research settings and variation of this parameter in large populations of dairy farms has been investigated to set targets for mastitis control programs (Lukas et al., 2005; Valde et al., 2005; Madouasse et al., 2010). Finally, some authors have recommended goals for SCC-derived herd IMI incidence (**SCCI**) and have suggested potential interpretations and course of investigation for herds exceeding these goals (Schukken et al., 2003; Bradley and Green, 2005).

Despite the widespread use of SCCI estimates, little is known about the relationship between these and bacteriological culture-derived herd IMI incidence (**BCI**) estimates. In the original study investigating the accuracy of different SCC-derived NIMI definitions, a strong correlation was found between SCCI and BCI rates (Dohoo and Leslie, 1991). In that study, however, the same data were used for selection of the criterion and for its subsequent evaluation, which may have biased the analysis presented, as acknowledged by the authors, and may have led to an inappropriately high correlation estimate. Likewise, little is known about the relationship between a given change over time in the SCCI rate and the behavior of its bacteriological culture counterpart. Consequently, despite all the proposed targets, little is known about the suitability of SCCI estimates when used as a proxy for BCI or as a tool for detecting undesirable fluctuations of herd IMI incidence over time. In both instances this may lead to inappropriate clinical investigations and interventions.

The main objective of this study was to evaluate the predictive value of herd IMI incidence density rate computed from repeated SCC measurements (quarter- and composite-SCC measurements) as a proxy for the herd IMI incidence density rate that would be obtained from repeated bacteriological quarter-milk cultures. A secondary objective was to evaluate the predictive value of SCCI density rate fluctuations over time as a surrogate to BCI density rate fluctuations for longitudinal monitoring of the herd IMI incidence rate.

MATERIALS AND METHODS

In 2006, 91 Canadian dairy herds were recruited to participate to the National Cohort of Dairy Farms (**NCDF**) of the Canadian Bovine Mastitis Research Network (**CBMRN**). A complete description of the herd selection process and of the general characteristics of these herds has been published elsewhere (Reyher et al., 2011). Briefly, herds were recruited in 4 regions of Canada based on willingness of the dairy producer to participate in a 2-yr (2007–2008) cohort study.

At the beginning of each of 4 intensive sampling periods (March–May 2007, June–August 2007, January–March 2008, and June–August 2008), a sample of 15 apparently normal milking cows were selected in each NCDF herd. Five of these cows were the most recently calved cows and the remaining 10 cows were randomly chosen within the lactating cows that were expected to remain in the milking herd for at least 2 mo. During the March–May 2007, January–March 2008, and June–August 2008 sampling periods, series of 3 single quarter-milk samples were collected from the selected cows at intervals of 3 wk. During the June–August 2007 sampling period, series of 7 single quarter-milk samples were collected at weekly intervals. The more intensive sampling period in summer 2007 was primarily carried out for another CBMRN study evaluating definitions of IMI (Dohoo et al., 2011), but was also used in the current study to maximize the quality of the data available.

Milk samples were frozen for storage and later thawed and cultured using a standardized protocol based on the National Mastitis Council guidelines for culture and species identification (Hogan et al., 1999). Briefly, 10 μL of milk was streaked on a Columbia agar + 5% sheep blood plate and incubated aerobically at