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Milk losses associated with somatic cell counts by parity and stage of lactation

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ABSTRACT

The reduction of milk production caused by subclinical mastitis in dairy cows was evaluated through the regression of test-day milk yield on log-transformed somatic cell counts (LnSCC). Official test-day records (n = 1,688,054) of Holstein cows (n = 87,695) were obtained from 719 herds from January 2010 to December 2015. Editing was performed to ensure both reliability and consistency for the statistical analysis, and the final data set comprised 232,937 test-day records from 31,692 Holstein cows in 243 herds. A segmented regression was fitted to estimate the cutoff point in the LnSCC scale where milk yield started to be affected by mastitis. The statistical model used to explain daily milk yield included the effect of herd as a random effect and days in milk and LnSCC as fixed effects regressions, and analyses were performed by parity and stage of lactation. The cutoff point where milk yield starts to be affected by changes in LnSCC was estimated to be around 2.52 (the average of all estimates of approximately 12,400 cells/mL) for Holsteins cows from Brazilian herds. For first-lactation cows, milk losses per unit increase of LnSCC had estimates around 0.68 kg/d in the beginning of the lactation [5 to 19 d in milk (DIM)], 0.55 kg/d in mid-lactation (110 to 124 DIM), and 0.97 kg/d at the end of the lactation (289 to 304 DIM). For second-lactation cows, milk losses per unit increase of LnSCC had estimates around 1.47 kg/d in the beginning of the lactation (5 to 19 DIM), 1.09 kg/d in mid-lactation (110 to 124 DIM), and 2.45 kg/d at the end of the lactation (289 to 304 DIM). For third-lactation cows, milk losses per unit increase of LnSCC had estimates around 2.22 kg/d in the beginning of the lactation (5 to 19 DIM), 1.13 kg/d in mid-lactation (140 to 154 DIM), and 2.65 kg/d at the end of the lactation (289 to 304 DIM). Daily milk losses caused by increased LnSCC were dependent on parity and stage of lactation, and these factors should be considered when estimating losses associated with subclinical mastitis.
Key words: subclinical, mastitis, test day record, milk loss

INTRODUCTION

Milk losses (**ML**) associated with high SCC at cow level are a consequence of the inflammatory response of the bovine mammary gland against infections caused by mastitis-causing pathogens (Hortet and Seegers, 1998; Seegers et al., 2003). Estimation of these losses have been systematically assessed (Halasa et al., 2007, 2009; Hogeveen et al., 2011; Huijps et al., 2008), providing the dairy industry with pivotal approximation on the costs incurred to keep high-SCC cows in the herd (Geary et al., 2012). The majority of these assessments were based on the assumption that a rise in the individual SCC above a threshold value of 200,000 cells/mL (Bradley and Green, 2005; IDF, 2013; Schukken et al., 2003) is an indication that an infection has occurred.

Not surprisingly, animals recording SCC >200,000 cells/mL at test day are prone to experience ML, the extent of which is dependent upon the parity and stage of lactation of the animal (Hagnestam-Nielsen et al., 2009; Hand et al., 2012). How much of this increase from individual SCC still kept below the 200,000 cells/mL threshold (IDF, 2013) is, in fact, reflected in ML from high-yielding cows is a key question yet not entirely addressed (Boland et al., 2013; Green et al., 2006); thus, animals potentially underperforming go unnoticed by the herd owner provided that the bulk tank SCC is ~200,000 cells/mL (van Asseldonk et al., 2010). This

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quantification requires a comprehensive understanding on the relationship held between the SCC and the milk yield at cow level (Hand et al., 2012).

Previous studies evaluated different SCC thresholds at which milk yield starts to be affected by changes in cell counts, taking parity and stage of lactation into consideration (Dürr et al., 2008). In Canada, Dürr et al. (2008) reported that losses were first observed when SCC of Holsteins and Ayrshires were >7,400 cells/mL. However, those associations (Dürr et al., 2008) may not be relatable to distinct populations of dairy cows, given the potential influence of geographic factors over different population of dairy cattle (Boland et al., 2013). Therefore, given that a direct relationship between SCC <200,000 cells/mL and ML exists (Dürr et al., 2008), and that this depends on both the cow's parity and the stage of lactation (Hand et al., 2012), our primary hypothesis was that the milk yield of Brazilian Holstein cows was not affected until the SCC level exceeded a certain level. However, after reaching a given hypothesized threshold, individual milk yield would be affected as SCC increases. Hence, the aims of our study were to estimate (1) the threshold at which the association between SCC and milk yield is observed; (2) the magnitude of the effect of SCC on milk yield from Holstein cows in Brazilian dairy herds using test-day records; and (3) whether the association between SCC and milk yield varies according to parity and stage of lactation of cows.

MATERIALS AND METHODS

Data

Test-day records were obtained from the Associação Paranaense de Criadores de Bovinos da Raça Holandesa (APCBRH), which is the official Holstein milk recording organization of State of Paraná, Curitiba, Brazil. The data set included information from lactating Holstein cows from January 2010 to December 2015. Editing was performed to ensure both reliability and consistency for the statistical analysis. To be included in the data set, test-day records were required to have fat content between 2.5 and 6.5%, protein content between 2.5 and 5.5%, lactose content between 3.5 and 6%, TS content between 8.5 and 14.5%, SCC between 0 and 1,000,000 cells/mL, and milk yield between 2 and 70 kg, as described by Dürr et al. (2008). Test-day recordings ≥305 d in milk were excluded from analysis. We also checked and imposed constraints on the ages at calving (by parity) to ensure that parities were consistent with sensible ages at calving. Twenty stages of lactation groups were defined (stage 1 = d 5 to 20, stage 2 = d 21 to 35, . . ., stage 20 = d 291 to 304). To allow the inclusion of a random herd–test-day (**HTD**) effect in the statistical model, we imposed a minimum of 100 records per herd and the constraint that within each parity-stage group the HTD needed ≥4 records to be kept for subsequent analyses. The number of test-day records excluded and retained at each step of the editing and the reasons for the exclusions are shown in Table 1. Initial analyses of records from parities greater than 3 (where there were low numbers of animals) gave parameter estimates that were unreliable (no SE of the parameter estimates, analyses did not converge, or the calculated parameters were nonsensical); consequently, only parities 1, 2, and 3 were retained for statistical analyses. The constraint of ≥4 records for each parity-stage-herd cluster removed a substantial number of records; however, it was necessary to have at least 4 records per cluster, as we were fitting random effects of a, b, and c to each cluster. After editing, the final data set comprised 232,937 test-day records from 31,692 Holstein cows in 243 herds from January 2010 to December 2015. Descriptive statistics of records used herein are presented in Table 2. Descriptive statistics of both kept and eliminated data sets showed that records used for analysis were representative of the Brazilian dairy cow population in the period studied (Cunha et al., 2008).

Statistical Analysis

To assess the aim of this study, statistical analyses were performed separately by parity and by stage of lactation. The majority of herds evaluated were monthly tested assisted by a milk recorder; hence, within one 15-d stage of lactation there was only 1 herd-test visit. Therefore, apart from any surprise spot-test retests of herds, only 1 record per cow per lactation stage was used to avoid any issues of repeated records per cow. To avoid problems of unlikely, occasional spot herd retest and the inclusion of individual repeated measurements within the same parity-stage interval, only the first record in a herd-parity-stage was kept for analysis.

To assess the SCC threshold at which a milk yield drop occurs, the approach adopted here was to estimate the threshold from the data by fitting a segmented regression (as per Dürr et al., 2008). As healthy cows maintain low cell counts in milk (Capuco et al., 2003), we hypothesized that milk yield was not affected by increasing SCC level up to some (unknown) level of SCC. After reaching this cutoff point, milk yield would be affected as SCC increases. This required the estimation of 3 parameters: the intercept (a), the cutoff (threshold) point where ML starts (c), and the regres-