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Investigating a dilution effect between somatic cell count and milk yield and estimating milk production losses in Irish dairy cattle

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ABSTRACT

Increased somatic cell counts (SCC) are associated with reduced milk yield. Additionally, it has been hypothesized that as milk yield increases, SCC is diluted in cattle without an intramammary infection (IMI). If the hypothesis is correct, estimates of SCC from high-yielding cattle without an IMI are likely to be lower than those from low-yielding cattle without an IMI. The objectives of this paper were to investigate the presence of a potential dilution effect between SCC and milk yield, overall and by parity, and to estimate lactation milk production losses with increasing SCC in Irish dairy cattle. The data consisted of 100 randomly selected herds from all milk recording herds between 2008 and 2010. The data set comprised 8,229 cows, of which approximately 90% were Holstein or Holstein crossbred animals. Various adjustments were used to investigate the presence of a potential dilution effect between SCC and milk yield; additionally, lactation milk production losses with increasing SCC and parity were estimated. The data had an inherent hierarchical structure, with lactations nested within cows and cows within herds; thus, a linear mixed model with 2 random effects was used. We found no evidence of a dilution effect of SCC with increasing milk yield in Irish dairy cattle. Average milk production losses were estimated, and they increased with increasing SCC compared with the referent of ≤50,000 cells/mL. Additionally, for all SCC values for parities 1 to 3, this production loss increased significantly with increasing parity. Estimated milk losses for parities 4 and 5 did not differ, and differences between parities 3 and 4 were significant only for SCC values <300,000 cells/mL. The estimated milk loss with increasing SCC varies greatly across studies, with the results from the current study exceeding most previously published results (except for results from the UK). Several factors could explain these differences, including geographic factors such as milk yield and predominant mastitis pathogens. The dilution effect warrants further work, as does the effect of prior duration of increased SCC on milk yield and the potential for compensation of milk yield losses over a lactation.
Key words: somatic cell count, dilution, parity, milk yield

INTRODUCTION

Increased SCC is associated with reduced milk yield (most recently demonstrated by Hand et al., 2012), and several studies have estimated the effect of subclinical mastitis on estimated milk production and on-farm economic loss (Seegers et al., 2003; Halasa et al., 2007). Estimates of milk yield loss with increased SCC have varied across studies, most likely because of differences in methodology (modeling approaches) and the animals under investigation (genotype and phenotype of the Holstein breed; Hand et al., 2012). Several factors are known to impact how increased SCC affects decreased milk yield, including mastitis incidence, pathogen involved, and management (Halasa et al., 2007). Further, higher producing cows exhibit greater milk loss with increased SCC than do lower producing cows (Hand et al., 2012).

One further consideration relates to the potential effect of dilution. Green et al. (2006) hypothesize that as milk yield increases, SCC is diluted in cattle without an IMI; the authors suggested, therefore, that estimates of SCC from high-yielding cattle without an IMI are likely to be lower than estimates of SCC from low-yielding cattle without an IMI. An inverse relationship between SCC and milk yield in quarters without infection has been noted in some studies (Emanuelson and Funke, 1991; Schepers et al., 1997), but not all (Laevens et al., 1997). Emanuelson and Funke (1991) and Schepers et al. (1997) attribute this to a possible dilution effect, although Schepers et al. (1997) does indicate that this effect could also be caused by false positives or by undetected clinical mastitis. A dilution effect was subsequently demonstrated in a single study (Green et al., 2006), using 2-level hierarchical models, based on data

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from approximately 850 Friesian/Holstein dairy cows on 5 farms in Gloucestershire, United Kingdom. The results suggested a decreased concentration of somatic cells with higher yields, particularly in low SCC categories, which led the authors to conclude that failing to account for a dilution in SCC with increasing yield would lead to an error in estimates of the effect of high SCC on milk yield, generally leading to an overestimate of the milk yield loss attributable to increased SCC. Given the small sample size, the authors recommended that "further work ... be done to refine approaches to the estimation of SCC dilution," including "analysis of quarter milk yields on a large number of cattle and farms ... to further investigate this phenomenon." No work on this dilution effect has subsequently been published to confirm the results of Green et al. (2006). Although the effect of dilution has been raised in subsequent publications, researchers have either not considered it further (Hand et al., 2012), suggesting that "to date, the dilution effect has not been quantified," or used the Green et al. (2006) estimates in their calculations (Halasa et al., 2009). Further, no work has yet reported any effect of parity on the dilution effect.

There are no published data on milk yield losses with increasing SCC in an Irish context; such data are required to estimate the on-farm costs of clinical and subclinical mastitis in the national herd. These estimates may differ from those published elsewhere, because Irish dairy farming is primarily spring-calving and pasture-based, with average milk production of approximately 4,700 kg per lactation (production of cow milk/number of dairy cows; International Dairy Federation, 2009). These yields are higher than those reported from New Zealand, but lower than in either the United States or the Netherlands (International Dairy Federation, 2009).

The objectives of this research were 2-fold: (1) to investigate the presence of a potential dilution effect between SCC and milk yield, overall and by parity, and (2) to estimate lactation milk production losses with increasing SCC in Irish dairy cattle, after taking into account a dilution effect, if present.

MATERIALS AND METHODS

The Data

Initially, all test-day records for 2008 to 2010 inclusive were extracted from the Irish Cattle Breeding Federation (ICBF, Bandon, Co. Cork, Ireland) database. Herds with fewer than 10 cows milk recorded in a year, cows that calved twice within 300 d, lactations >5, and test-days after 320 DIM were removed from the data set. A random sample of 100 herds was selected to reduce the size of the data set for modeling purposes. Simple random sampling was used to randomly select the herds, and all animals in the selected herds were included in the study.

Summary Statistics and Dilution Estimates

First, test-day SCC was divided into 7 categories (<51, 51 to <101, 101 to <201, 201 to <301, 301 to <401, 401 to <1,001, and ≥1,001; $\times 10^3$ cells/mL) and test-day milk yield into 4 categories (10 to <21, 21 to <31, 31 to <41, and ≥41 kg). For all parities, mean SCC for each milk yield category and mean milk yield for each SCC category were calculated and plotted.

Second, mean SCC values within parity for each milk yield and SCC category were calculated and used to calculate dilution estimates. As computed in Green et al. (2006), dilution estimates for each SCC category for all parities were calculated by dividing the mean SCC for each milk yield category by the mean SCC for the lowest milk yield category (i.e., 10 to <21 kg).

Statistical Modeling

First, the relationship between SCC (with no adjustment for dilution) and milk yield was investigated. Linear mixed models were used to analyze the data and to take into account the correlations between parities on the same cow and possible correlation between cows in the same herd. Two random effects were included in the model, herd (h) and cow within herd (a), to model these correlations. The random effects were assumed to have normal distributions with means 0 and variances σ_h^2 and σ_a^2, respectively. Together with the random effects, DIM, and exponential ($\text{DIM}^{-0.05}$) (Wilmink, 1987; Green et al., 2006), breed, parity, SCC category, and SCC category × parity were included in the model as fixed effects. The response was test-day milk yield.

Then, SCC test-day values were adjusted for dilution in 4 ways and the relationship between the adjusted SCC values and milk yield investigated. Adjustments 3 and 4 were investigated as a result of initial findings in this study (see Results section). The adjustments were as follows.

Adjustment 1. The dilution estimates calculated (described above) were used to adjust test-day SCC as follows: Adjusted SCC = SCC/corresponding SCC dilution estimate.

Adjustment 2. Only test-days with SCC <50,000 cells/mL (these animals were presumed uninfected) were modeled. Somatic cell count was set as the dependent variable, with herd and cow within herd as the random effects. Milk yield, parity, and milk yield × parity were included as fixed effects. The regression