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Association between somatic cell count early in the first lactation and the longevity of Irish dairy cows

S. C. Archer,*[1] F. Mc Coy,† W. Wapenaar,* and M. J. Green*
*University of Nottingham, School of Veterinary Medicine and Science, Sutton Bonington Campus, Sutton Bonington, Leicestershire, LE12 5RD, United Kingdom
†Animal and Grassland Research and Innovation Centre, Teagasc, Moorepark, Fermoy, Co. Cork, Ireland

ABSTRACT

Reduced longevity of cows is an important component of mastitis costs, and increased somatic cell count (SCC) early in the first lactation has been reported to increase culling risk throughout the first lactation. Generally, cows must survive beyond the first lactation to break even on their rearing costs. The aim of this research was to assess the association between SCC of primiparous cows at 5 to 30 days in milk (SCC1), and survival over a 5-y period for cows in Irish dairy herds. The data set used for model development was based on 147,458 test day records from 7,537 cows in 812 herds. Cows were censored at their last recording if identified at a later date in other herds or if recorded at the last available test date for their herd, otherwise, date of disposal was taken to be at the last test date for each cow. Survival time was calculated as the number of days between the dates of first calving and the last recording, which was split into 50-d intervals. Data were analyzed in discrete time logistic survival models that accounted for clustering of 50-d intervals within cows, and cows within herds. Models were fitted in a Bayesian framework using Markov chain Monte Carlo simulations. Model fit was assessed by comparison of posterior predictions to the observed disposal risk for cows aggregated by parameters in the model. Model usefulness was assessed by cross validation in a separate data set, which contained 144,113 records from 7,353 cows in 808 herds, and posterior predictions were compared with the observed disposal risk for cows aggregated by parameters of biological importance. Disposal odds increased by a factor of 5% per unit increase in ln SCC1. Despite this, posterior predictive distributions revealed that the probability of reducing replacement costs by >€10 per heifer calved, through decreasing the herd level prevalence of cows with SCC1 ≥400,000 cells/mL (from an initial prevalence of ≥20 to <10%) only exceeded 50% for less than 1 in 5 Irish herds. These results indicate that the effect of a reduction in the prevalence of cows with SCC1 ≥400,000 cells/mL on replacement costs alone for most Irish dairy herds is small, and future research should investigate other potential losses, such as the effect of SCC1 on lifetime milk yield.
Key words: dairy heifer, somatic cell count, early lactation, longevity

INTRODUCTION

Mastitis is well recognized as a costly disease in dairy cows, with losses accrued mainly from decreased milk production and discarded milk (Kossaibati and Esslemont, 1997). However, mastitis has also been associated with reduced longevity (Beaudeau et al., 1993; Seegers et al., 1998), and this has been estimated as the next biggest cost for dairy farmers (Huijps et al., 2008; Heikkilä et al., 2012). Further losses, such as the cost of drugs, veterinary services, diagnostic costs, labor, decreased milk quality, capital investments, and the adverse effects on other diseases (Halasa et al., 2007), are typically less, but may be important for particular herds (Huijps et al., 2008). Premature disposal is of particular relevance for heifers that develop mastitis (Heikkilä et al., 2012), as they must typically reach the second lactation to produce sufficient milk to break even on rearing costs. For example, under Irish conditions, the cost of rearing to the point of calving is approximately €1,451 per heifer (Kennedy et al., 2011). With an average margin over variable costs €0.17/kg (Hennessy et al., 2011), 8,535 kg of milk is required to break even, which would take >1 lactation. Increased longevity of cows reduces demand for replacement heifers and, in turn, provides economic benefits at the farm level, such as the opportunity costs of producing more beef calves, selling surplus heifers, increasing the size of the milking herd, or leasing resources. Alternatively, a surplus of replacement heifers creates the opportunity for increased voluntary culling and selective breeding to improve the genetic merit of the herd.

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[1]Corresponding author: svxsa@nottingham.ac.uk

Premature culling in the first lactation has been associated with IMI at calving in pasture-based herds in New Zealand (Compton et al., 2007). In Belgian herds, first lactation culling hazard increased by 11% per unit increase in ln SCC for primiparous cows at 5 to 14 DIM, and by 32% when only culling for udder health reasons were considered (De Vliegher et al., 2005). However, the effect of SCC early in the first lactation on lifetime survival has not been evaluated, this is important because the full repercussions of IMI in early life may not become evident until later in life, when maturity is reached and milk yield and financial return are maximized (Madouasse, 2009). As heifers now make up the largest parity group in many Irish herds (ICBF, 2011) following expansion (a trend that may continue in anticipation of the abolition of EU milk quotas in 2015), understanding the repercussions of heifer IMI is of particular importance.

The aim of this research was to assess the association between SCC of parity 1 cows at 5 to 30 DIM (**SCC1**) and survival over a 5-y period for cows in Irish dairy herds. A Bayesian approach was taken and posterior predictions were used to evaluate the magnitude and financial relevance of this effect, in the context of particular herd scenarios.

MATERIALS AND METHODS

Data Selection

To be eligible for inclusion in the study, cows were required to have at least 1 SCC recording between 5 and 30 DIM in parity 1 (**p1**). Cows were selected from a data set of Irish dairy herds based on recordings between 2005 and 2009 (Irish Cattle Breeding Federation, County Cork, Ireland), and 233,176 cows in 7,423 herds were included (p1_data).

Of the selected cows, 893 had more than 1 record between 5 and 30 DIM during parity 1, and SCC at the first of these was taken as SCC1. Two random samples of 1,000 herds were taken and all records for eligible cows were extracted using R (R Development Core Team, 2010). Not all herds sampled had dates of birth available for cows; for those that did, minimum age at first calving (**AFC**) was 371 d. Heifers with AFC <700 d were deemed at increased risk of culling independent of SCC1 because of dystocia (Berry and Cromie, 2009), and individual cows with AFC <700 d (6% of the total population) were discarded to remove this effect. Following selection, 147,458 records from 7,537 cows in 812 herds were included in the first sample data set (sample_1), used for model development, and 144,113 records from 7,353 cows in 808 herds in the second (sample_2), used for cross validation.

Definition of Disposal

Survival time was estimated as the number of days between the dates of first calving and the last recording and was aggregated into 50-d intervals. Disposal (death or culling) was assumed to occur in the last 50-d interval for each cow, in the absence of censoring. In survival analysis, censoring accounts for those cows in the data set for which disposal (the event of interest) may occur when not under observation. This allows them to contribute to the denominator population at risk during the study period (Dohoo et al., 2009). Three reasons were noted for censoring in this study. First, disposal could only occur in the last 50-d interval for each cow, and therefore censoring occurred in every interval survived until the last (this related to the data set structure). Second, cows were censored at the last 50-d interval if identified at a later time in other herds (assumed sold). Third, cows were censored at the last 50-d interval if they were present at the last available test date for the respective herd. Median and interquartile range (**IQR**) for variables in sample_1, and sample_2 were determined.

Model Development

Cow disposal was coded as a binary outcome. The discrete time logistic survival model used for analysis took the form

$$\text{Disposed}_{\text{ijk}} \sim \text{Bernoulli (probability} = \pi_{ijk}),$$

$$\text{logit}\ (\pi_{ijk}) = \alpha + \text{int}_{ijk} + \text{int}_{ijk}^{\ 2} + \text{int}_{ijk}^{\ 3} + \mathbf{X}_{ijk}\boldsymbol{\beta}_1 + \mathbf{X}_{jk}\boldsymbol{\beta}_2 + \mathbf{X}_{k}\boldsymbol{\beta}_3 + \text{v}_k + \text{u}_{jk},$$

$$v_k \sim \text{Normal}\left(0, \sigma_v^2\right),$$

$$u_{jk} \sim \text{Normal}\left(0, \sigma_u^2\right),$$

where the subscripts i, j, and k denote the ith 50-d interval, for jth cow, in the kth herd, respectively; α = intercept value; int = 50-d interval numbered from first calving (included on a ln scale centered on the mean interval number); $\mathbf{X}_{ijk}$ = matrix of exposure variables for each interval; $\boldsymbol{\beta}_1$ = vector of coefficients for $\mathbf{X}_{ijk}$; $\mathbf{X}_{jk}$ = matrix of exposure variables for each cow; $\boldsymbol{\beta}_2$ = vector of coefficients for $\mathbf{X}_{jk}$; $\mathbf{X}_k$ = matrix of exposure variables for each herd; $\boldsymbol{\beta}_3$ = vector of coefficients for $\mathbf{X}_k$; v_k = random effect to account for residual variation between herds (assumed to be a normal distribution with mean = 0 and variance = σ_v^2); u_{jk} = random effect to account for residual variation between cows (as-