The Veterinary Journal 196 (2013) 515–521

Contents lists available at SciVerse ScienceDirect

The Veterinary Journal

journal homepage: www.elsevier.com/locate/tvjl

Association of season and herd size with somatic cell count for cows in Irish, English, and Welsh dairy herds

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ARTICLE INFO

Article history:
Accepted 7 December 2012

Keywords:
Season
Herd size
Somatic cell count
Dairy cow
Modelling

ABSTRACT

The aims of this study were to describe associations of time of year, and herd size with cow somatic cell count (SCC) for Irish, English, and Welsh dairy herds. Random samples of 497 and 493 Irish herds, and two samples of 200 English and Welsh (UK) herds were selected. Random effects models for the natural logarithm of individual cow test day SCC were developed using data from herds in one sub-dataset from each country. Data from the second sub-datasets were used for cross validation.

Baseline model results showed that geometric mean cow SCC (GSCC) in Irish herds was highest from February to August, and ranged from 111,000 cells/mL in May to 61,000 cells/mL in October. For cows in UK herds, GSCC ranged from 84,000 cells/mL in February and June, to 66,000 cells/mL in October. The results highlight the importance of monitoring cow SCC during spring and summer despite low bulk milk SCC at this time for Irish herds. GSCC was lowest in Irish herds of up to 130 cows (63,000 cells/mL), and increased for larger herds, reaching 68,000 cells/mL in herds of up to 300 cows. GSCC in UK herds was lowest for herds of 130–180 cows (60,000 cells/mL) and increased to 63,000 cells/mL in herds of 30 cows, and 68,000 cells/mL in herds of 300 cows. Importantly, these results suggest expansion may be associated with increased cow SCC, highlighting the importance of appropriate management, to benefit from potential economies of scale, in terms of udder health.

Introduction

For individual dairy producers, treatment costs, production losses, and reduced sale value of high somatic cell count (SCC) milk are well known consequences of mastitis (Halasa et al., 2007). In the dairy processing industry, increased SCC is associated with both shortened shelf life of pasteurised milk (Santos et al., 2003), and reduced cheese yields (Barbano et al., 1991). Seasonal increase in bulk milk SCC (BMSCC) supplied to dairies has been reported from Ireland (Berry et al., 2006) and from England and Wales (Green et al., 2006b), reducing the ability of these countries to meet demand for high quality milk products.

In general BMSCC is highest in spring and summer in those countries where calving patterns are non-seasonal, such as England and Wales (Green et al., 2006b), Canada (Sargeant et al., 1998; Olde Riekerink et al., 2007) and Holland (Barkema et al., 1998; Lievaart et al., 2007), and is possibly related to the influence of higher temperature and humidity on intramammary infection (IMI) risk (Morse et al., 1988). In Ireland, however, BMSCC is generally lowest during April, and highest in November (Berry et al., 2006), because spring-calving predominates in this country. BMSCC in Ireland is therefore lowest when most milk is produced, but this may not reflect udder health, because cow level SCC dynamics associated with IMI may be masked by dilution (Green et al., 2006a). A key time for the occurrence of new infections in Irish dairy herds may therefore be overlooked if monitoring strategies use only BMSCC.

Increasing herd size is common throughout the developed dairy industry worldwide; producers hope to benefit from economies of scale accrued from lower investments per cow, lower variable costs per unit of production, and increased labour efficiency (Bailey et al., 1997). Larger herds in the US have been reported to have lower cow level average SCC compared to smaller herds (Oleggini et al., 2001), however, large Dutch herds have been reported to have higher BMSCC (Barkema et al., 1998). In general, Irish, English, and Welsh dairy herds are increasing in size (DairyCo, 2010; ICBF, 2010), and it is important for these industries to evaluate the effect on SCC.

The aims of this research were twofold. Firstly, we wished to investigate the association between time of year and cow SCC, particularly in Irish dairy herds after accounting for stage of lactation. Secondly, we evaluated the association between herd size and cow SCC in Irish, English, and Welsh dairy herds in order to assess the impact of herd expansion on SCC.

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1090-0233
http://dx.doi.org/10.1016/j.tvjl.2012.12.004

Table 1
Selection criteria for the Irish, and English and Welsh datasets.

Variable	Range before selection	Range after selection	Recordings removed (%)
Irish dataset			
Days in milk	−503 to 3548	5–304	10
Parity	1–87	<15	0.2
Test day milk yield (kg)	0.2–92.6	>1 and <71	0.003
Calving interval[a] (days)	−1046 to 2265	⩾300	0.4
English and Welsh dataset			
Days in milk	1–1794	5–304	17
Parity	1–19	<15	0.001
Test day milk yield (kg)	0.2–99.8	>1 and <71	0.003
Calving interval (days)	36–1647	⩾300	0.3

[a] For cows with more than 1 recorded calving date from subsequent parities.

Table 2
Descriptive results for the selected Irish dataset (Ire_dat), and the selected English and Welsh dataset (UK_dat).

Variable	Lower quartile	Median	Upper quartile
Irish dataset			
Test day milk yield (kg)	17	22	28
Test day fat proportion	0.034	0.038	0.043
Test day protein proportion	0.032	0.034	0.036
Test day somatic cell count (cells/mL)	55,000	110,000	243,000
Mean herd size (cows)	46	71	81
English and Welsh dataset			
Test day milk yield (kg)	21	27	33
Test day fat proportion	0.034	0.039	0.043
Test day protein proportion	0.030	0.032	0.034
Test day somatic cell count (cells/mL)	37,000	74,000	173,000
Mean herd size (cows)	101	139	189

Materials and methods

Data

Data from 2005 to 2009, comprising 11,619,287 records from 964,612 cows in 8095 Irish herds, were provided by Irish Cattle Breeders Federation, and restricted to remove impossible values (Table 1). For each herd year, the mean number of cows present per test day was determined (herd size); herds with a mean of ⩽10 cows were excluded. The minimum proportion of cows present per test day in each herd year had a distribution with distinct modes at 0.05 and 0.65. It was deemed that there were differences between recordings with a low minimum proportion of the herd present at a test date, compared to the majority (possibly associated with purchased cows), and 0.7% of recordings were excluded in which <10% of the mean annual number of cows were present. For inclusion, ⩾4 herd test day recordings per year were required; 5% of herd years not meeting this criterion were excluded. The cleaned dataset (Ire_dat) contained 10,181,545 recordings from 1,938,359 lactations in 860,563 cows, in 7551 herds.

A second dataset was available for English and Welsh (UK) herds from 2004 to 2006, provided by National Milk Records. Selection criteria for this dataset have been described in detail (Madouasse, 2009). Briefly, herd years with at least 10 test dates based on ⩾20 cows were included, and those with factored data were removed. At least 80% of cows were Holstein or Friesian breeds. The data were limited (Table 1) and the final dataset (UK_dat) contained 6,772,182 records from 953,242 lactations in 474,669 cows in 2128 herds.

Descriptive statistics

Since not all variables were normally distributed, median and interquartile ranges (IQRs) were evaluated for each variable. The numbers of cows (parity 1 and >1) calving in each calendar month were determined. Herd level geometric means of test day SCC were calculated for cows by lactation month (1–10), and parity (1 and >1), because lactation curve shape differed mostly between these groups.

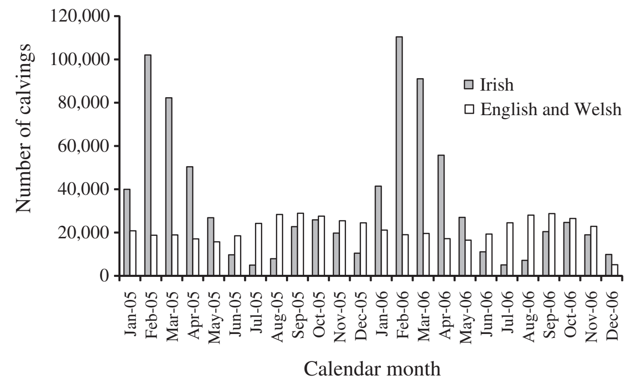

Fig. 1. Number of cows calving per month during 2005 and 2006 for 7551 Irish (Ire_dat) and 2128 English and Welsh dairy herds (UK_dat).

Table 3
Geometric mean cow level somatic cell count (cells/mL) for the median herd by month of lactation in the selected Irish (Ire_dat) and English and Welsh (UK_dat) datasets.

Month of lactation	Irish dataset		English and Welsh dataset	
	Parity 1	Parity > 1	Parity 1	Parity > 1
1	104,000	101,000	75,000	75,000
2	75,000	93,000	50,000	60,000
3	77,000	106,000	50,000	67,000
4	83,000	121,000	54,000	76,000
5	89,000	137,000	57,000	86,000
6	96,000	154,000	59,000	96,000
7	102,000	173,000	61,000	107,000
8	112,000	196,000	65,000	121,000
9	122,000	224,000	69,000	137,000
10	127,000	245,000	74,000	158,000

Random samples of 497 Irish, and 200 UK herds were selected from Ire_dat, and UK_dat respectively, and the corresponding records extracted. Sample sizes were selected to give the largest sub-datasets of Irish ($\text{Ire\_dat}^{\text{SUB1}}$), and UK ($\text{UK\_dat}^{\text{SUB1}}$) herds, with similar numbers of lines in each, that could be handled with the available computing power. $\text{Ire\_dat}^{\text{SUB1}}$ contained 633,751 records from 122,707 lactations in 56,899 cows, and $\text{UK\_dat}^{\text{SUB1}}$ contained 635,346 records from 88,798 lactations in 43,943 cows. Actual BMSCC was not available for the herds of interest; therefore BMSCC over the study period was estimated from individual cow records using $\text{Ire\_dat}^{\text{SUB1}}$ and $\text{UK\_dat}^{\text{SUB1}}$.

For each calendar month *j*, in each herd *k*, BMSCC was approximated by the arithmetic mean of the yield corrected SCC from test day records *i* as:

$$\text{BMSCC}_{jk} \approx \sum(\text{SCC}_{ijk}\ (\text{cells/mL}) \times \text{TDY}_{ijk}\ (\text{mL}))/\sum \text{TDY}_{ijk}\ (\text{mL}),$$

where $\sum$ = sum of, and TDY = test day milk yield.

Estimated BMSCC was compared with the cow level data, both before and after adjustment for the confounding influence of stage of lactation, and milk yield in the following models.

Model development

Random effects models that include random effects in addition to fixed effects were used to account for a lack of independence due to clustering in the data. Models were constructed using $\text{Ire\_dat}^{\text{SUB1}}$ and $\text{UK\_dat}^{\text{SUB1}}$; natural logarithm (ln) SCC at the test day level for individual cows was the outcome variable used to ensure normality of residuals. The models took the form;

$$Y_{ijkl} = \alpha + X_{ijkl}\beta_1 + X_{jkl}\beta_2 + X_{kl}\beta_3 + X_l\beta_4 + f_l + v_{kl} + u_{jkl} + e_{ijkl}$$

$$f_l \sim \text{MVN}\left(0, \sum_f\right)$$

$$v_{kl} \sim N(0, \sigma_v^2)$$

$$u_{jkl} \sim N(0, \sigma_u^2)$$

$$e_{ijkl} \sim N(0, \sigma_e^2)$$

where y_{ijkl} = lnSCC at test day *i*, in parity *j*, for cow *k*, in herd *l*, α = intercept value, X_{ijkl} = matrix of test day variables, β_1 = vector of coefficients for X_{ijkl}, X_{jkl} = matrix of parity variables, β_2 = vector of coefficients for X_{jkl}, X_{kl} = matrix of cow variables, β_3