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Effect of increased somatic cell count on lactation yields of milk, fat and protein

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ABSTRACT

The purpose of this study was to estimate the effect of increased SCC on production in New Zealand dairy farms. Herd test data from lactations one through six were used in the study. Herd test milk, fat and protein yields were modelled as a function of days in milk at the time of the herd test and the logarithm (base 2) of SCC. The model estimates were used to obtain the predicted value for each observation using the actual log SCC and again where the log SCC was increased by one (*i.e.* doubling the SCC level). For first-lactation cows, the reduction in a 270-day lactation yield from a doubling of the SCC was estimated to be 78 litres, 2.39 kilograms and 2.04 kilograms for milk, fat and protein yield, respectively. Herd SCC level also influenced the extent to which a doubling of SCC decreased production. For first-lactation cows every doubling of SCC was predicted to result in an average loss of 67 and 90 litres in the lowest and highest quartiles, respectively.

Keywords: somatic cell count; milk production; dairy cows.

INTRODUCTION

The somatic cell count (SCC) of a cow's milk is an indication of her udder health. Very high levels of SCC are indicative of clinical mastitis, while cows with a moderately elevated SCC are said to have subclinical mastitis. One effect of subclinical mastitis is a reduction in milk production. Several studies have found that an increase in SCC is associated with a reduction in milk production (Reichmuth, 1975; Duirs & Macmillan, 1979; Eberhart *et al.*, 1982; Bartlett *et al.*, 1990; Koldeweij *et al.*, 1999; Seegers, *et al.*, 2003). Dairy farm management practices in NZ differ from many overseas practices potentially resulting in different production levels and SCCs. Hence, the losses reported in overseas literature may not be indicative of the NZ situation. The purpose of this study was to quantify the reduction in the yield of milk production traits arising from an increased SCC.

MATERIALS AND METHODS

Data

Data for the analyses were obtained from herd-test data of cows that had their first lactation in Livestock Improvement's Sire Proving Scheme (SPS) herds in years 1995 to 2004. Where available, data from subsequent lactations of these cows, up to lactation six, were included in the analyses. Herd tests for SCC (measured in 1000 cells/ml of milk) and milk, fat and protein yields collected from days in milk (DIM) 3 to 270 were included in the analyses. A total of 165,871 cows had first lactation records. These cows were the progeny of 2427 sires. The first-lactation cows had an average of 3.8 herd tests per cow. The breed composition of the first-lactation cows was 1% Ayrshires, 57% Friesians, 22% Jerseys, and 20% crosses of these breeds. Table 1 contains the summary statistics of the herd-test data by lactation number. The lower number of cows in the later lactations reflects the culling of cows and

Table 1: Summary statistics for herd-test data by lactation.

Lactation	n_{cows}	$n_{records}$	Milk (l)	Fat (kg)	Protein (kg)	SCC(1000s/ml)	Log_2(SCC)
1	165,871	632,376	12.8	0.607	0.462	117	5.92
2	111,067	411,242	15.1	0.719	0.555	128	6.06
3	83,168	302,720	16.6	0.792	0.613	157	6.28
4	61,188	219,935	17.3	0.825	0.640	189	6.47
5	42,313	150,626	17.8	0.845	0.656	234	6.67
6	26,485	92,905	17.9	0.846	0.656	284	6.86

also the fact that cows first calving in year 1999 or later did not have the opportunity to produce six lactations by 2004.

Statistical Analyses

The lactation curves for milk, fat and protein yields were modelled using the regression equation outlined by Wood (1967) as follows:

$$\log_e(y_{ij}) = \mu + \beta_1 d_j + \beta_2 \log_e(d_j) + \beta_3 \log_2(scc_j) + htd_i + e_{ij} \quad [1]$$

where;

y_{ij} is the j[th] test-day observation of milk, fat or protein yield in herd-year-test-day contemporary group i,

μ is the overall mean,

β_1 is the linear regression coefficient of test-day yield on DIM, *d*,

β_2 is the linear regression coefficient of test-day yield on $\log_e$(DIM),

β_3 is the linear regression coefficient of test-day yield on $\log_2$ of test-day yield SCC,

htd_i is the fixed effect of the i[th] herd-year-test-day contemporary group,

e_{ij} is the random error.

All regressions were estimated within lactation. For each trait (milk, fat or protein yield), predicted values from model [1] were obtained for each observation using the actual test-day $\log_2$(SCC) and when the $\log_2$(SCC) was increased by 1 (effectively a doubling of the SCC). The predicted values were averaged over each DIM (3 to 270) and summed to create a 270-day yield. The difference between the predicted 270-day yields based on the actual SCC and when the $\log_2$(SCC) was increased by 1 was used to quantify the loss in production from a doubling of the SCC.

Additional analyses were done using first-lactation data to investigate whether the effect of increasing the SCC was influenced by herd-level production or herd-level SCC. For each cow, a lactation yield milk, fat or protein yield was calculated using the test interval method (see, for example, Anonymous (2005)). The calculated lactation yield was averaged over all cows within a herd year. Herds-years were categorised as being in one of four quartiles for production. Because SCC is a concentration measure, a lactation average of $\log_2$(SCC), as opposed to yield, was calculated for each cow. These averages were averaged over the cows within each herd year. As with lactation yields, herd-years were categorised by the quartile of their average herd $\log_2$(SCC). The effect of herd level production on SCC was assessed using the regression analysis as outlined in Equation [1] except that the $\log_2$(SCC) term was replaced by the interaction between $\log_2$(SCC) and the quartile of herd level production or SCC, respectively. As above, the effect of doubling the SCC on production was calculated using the predicted values based on the actual $\log_2$(SCC) and again using $\log_2$(SCC) + 1 in the prediction. Analyses were done using ASREML (Gilmour *et al*., 2002).

RESULTS

The coefficients of determination (R^2) for model [1] ranged from 0.69 to 0.76 for milk and protein yield and were slightly lower for fat yield, ranging from 0.62 to 0.65. Table 2 contains the predicted losses in 270-day lactation yields for milk, fat or protein given a doubling of the SCC. The magnitude of the losses increased with increasing lactation number up to lactation 4 after which they decreased. Table 3 shows the effect of herd-level production on the production losses for a doubling of SCC in lactation 1. For milk production, the loss in production increased with increasing herd level for the first three quartiles. Similar trends were not evident for fat or protein yields. Table 4 shows the effect of herd-average $\log_2$(SCC) on the production losses for a doubling of SCC in lactation 1. For all traits, the magnitude of the loss was higher in the high SCC herds than in the low SCC herds.

Table 2: Predicted reduction in 270-day lactation yields of milk, fat and protein from a doubling of SCC.

Lactation	Milk (L)	Fat (kg)	Protein (kg)
1	78	2.39	2.04
2	87	2.87	2.29
3	99	3.35	2.68
4	99	3.64	2.72
5	94	3.58	2.60
6	85	3.63	2.36

Table 3: Predicted reduction in first-lactation 270-day yields of milk, fat and protein from a doubling of SCC by quartile of herd-level production.

	Milk (L)		Fat (kg)		Protein (kg)	
Quartile	Mean	Redn	Mean	Redn	Mean	Redn
1	2586	66	127.5	2.33	95.7	1.90
2	3097	70	149.0	2.26	112.1	1.80
3	3480	78	164.0	2.01	124.2	1.82
4	4038	79	186.8	2.22	143.9	2.04

Table 4: Predicted reduction in first-lactation 270-day yields of milk, fat and protein from a doubling of SCC by quartile of herd-average SCC.

Quartile	SCC Mean	Milk (L)	Fat (kg)	Protein (kg)
1	69	67	1.77	1.61
2	98	72	2.12	1.85
3	122	76	2.36	2.01
4	184	90	3.04	2.47

DISCUSSION

The results of this study are in agreement with overseas work in that an increase in SCC is associated with a reduction in production. However, the magnitudes of the reported reductions are not directly comparable across the studies because of the production level of the cow and the choice of log transformation and model used for the analyses. Koldeweij *et al*. (1999) reported a milk yield loss of 1.29 kg/day for each unit increase in $\log_{10}$(SCC) for first-lactation cows and 2.04 kg/day for older cows. A unit increase in a $\log_{10}$(SCC) is a ten-fold increase in SCC. The current study used a unit increase in $\log_2$(SCC) which is a two-fold increase in SCC. If a linear association between SCC increase and a reduction in production is assumed, changing a ten-fold increase to a two-fold increase and multiplying by 268 to obtain the 270-day lactation (3 to 270 DIM), would result in reductions of 69 kg for first-lactation cows and 109 kg for older cows. These figures are of similar magnitudes as those found in the present study although relatively lower considering the average daily production. Bartlett *et al*. (1990) reported a reduction of 1.17 kg of milk per day for an increase in SCC. This reduction was calculated as the difference in predicted production assuming a SCC of 427 and a SCC of zero. Again, considering and that the average test-day production level of cows used in the study of Bartlett *et al*. (1990) was 50% higher than that of this study, and the difference in the SCC levels at which the two predictions were made was more than double of that considered here, the results of the two studies are similar.

The comparisons of overseas results to those of the present study assumed a linear association between change in SCC level and reduction in production and thus should be regarded as rough approximations. The results obtained from the first-lactation data showed that the effect of doubling SCC has a greater impact on milk production in higher yielding herds than in lower yielding herds (although the result was not consistent for fat and protein yields). However, the effect of doubling the SCC is most marked in the highest herd quartile of SCC for all traits. Dividing the cows into herd quartiles was simply a method of conveniently examining the relationship between herd-level SCC and production and doesn't imply that there is a threshold after which increasing the SCC will have a marked effect. A more likely situation is that the impact of increasing the SCC on production increases gradually as the level of SCC increases.

This study estimated the association between increased cow SCC and production. Losses in production for a doubling of SCC were quantified. This study did not directly address the issue how a reduction in SCC affects production. Because of nonlinearity, the calculated increase in production from halving the SCC would not be identical to the loss in production from doubling SCC. However, comparisons between the two approaches showed that the calculated increases in production from halving SCC are almost the same as the calculated losses from doubling SCC, with the results differing by less than two percent. Therefore, the results shown here can be used to determine the expected production improvements from lowering the SCC within a herd. Farmers and veterinarians can use this information to determine the production improvements that can be expected from implementing a SCC control program. This study dealt only with the association between SCC and production and did not consider the association between clinical mastitis and SCC or the association between clinical mastitis and production.

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