The School of Veterinary Medicine and Science

A multiphase model to estimate lactation milk losses associated with an elevated somatic cell count in early lactation

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Introduction

A significant number of mastitis cases occurring in early lactation have been shown to originate from the dry period. While numerous studies have investigated the impact of mastitis on milk production, there exists no estimate of lactation milk losses associated with mastitis in early lactation. Movements across a somatic cell count (**SCC**) of 200,000 cells/mL between the last milk recording in a lactation and the first milk recording in the subsequent one have been associated with significantly different risks of mastitis and can be used as a proxy for mastitis. The aim of this study was to **model the association between 4 categories of SCC level defined by a threshold of 200,000 cells/mL recorded on the last milk recording of a lactation and the first milk recording in the following lactation on the shape of the lactation curve.**

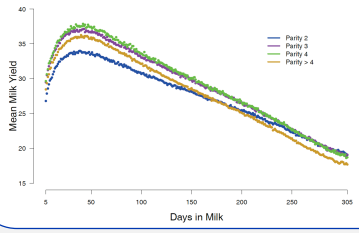
Study

Data

- Monthly collected milk recording data
- England and Wales
- January 2004 to December 2006

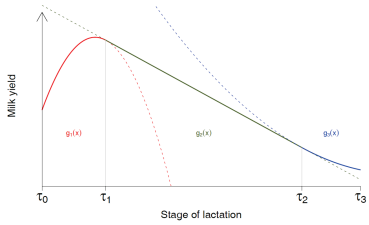
8 million individual cow recordings
1 million lactations
0.5 million cows
2,128 herds

Mean milk production per day in milk



- **Milk production exhibits multiple phases**:
  - Ascending phase: calving to ~ 50 days
  - Descending linear phase: 50 to 250 days
  - Non linear after 250 days

A multiphase model for lactation curves



Lactation curves can be modelled using piecewise functions

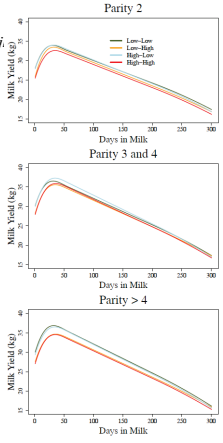
- Cubic function for the ascending phase
- Linear decrease after the peak
- Quadratic function for the end of lactation

$$f(x)=\begin{cases} g_1(x)=\alpha_0+\alpha_1 x+\alpha_2 x^2+\alpha_3 x^3 \\ g_2(x)=\delta_0+\delta_1 x \\ g_3(x)=\gamma_0+\gamma_1 x+\gamma_2 x^2 \end{cases}$$

This is equivalent to fitting the following multilevel model:

$$Y_{ijk}=\beta_0+\beta_1 x_{ijk}+I_1(\beta_2 x_{ijk}^2+\beta_3 x_{ijk}^3)+I_3\beta_4(\tau_2^2-2\tau_2 x_{ijk}+x_{ijk}^2)+\varepsilon_{ijk}$$

- ***Y*** : milk yield
- ***x*** : days in milk
- ***i*** : recording level
- ***j*** : lactation level
- ***k*** : herd level
- τ_2 : second change point
- ε : error term. The error was split between herd, lactation and residual levels
- I_1 : indicator variable 1 in interval 1 ; 0 otherwise
- I_3 : indicator variable 1 in interval 3 ; 0 otherwise
- Days in milk were centred on τ_1 = 60 days in milk
- Models were fitted on a random sample of 19,799 lactations from 1,000 herds



- **Curves fitted for 4 SCC categories and 3 parity categories**
  - Low or High: below or above 200,000 cells/mL
  - On the **Last milk recording of previous lactation** – **First milk recording of the lactation modelled** (e.g. **Low-Low**)
- **Difference in milk production between categories predicted by the model:**

	Parity 2	Parity 3 and 4	Parity > 4
Low-Low (Ref)	8032	8477	8380
Low-High	-198	-177	-400
High-Low	-23	120	-86
High-High	-366	-162	-493

Main findings

A multilevel multiphase model was found to fit lactation curves accurately when looking at the mean of multilevel residuals per day in milk (not shown – submitted for publication and available on request). The intercept (β_0) of this model corresponds to the milk production at 60 days in milk and the coefficient for days in milk (β_1) to the persistency. The model predicted a milk production between 162 and 493 kg lower in cows with a SCC > 200,000 cells/mL during the first month after calving as compared to cows with a SCC < 200,000 cells/mL on both the last milk recording of the previous lactation and the first milk recording in the current lactation.

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