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The influence of breed and parity on milk yield, and milk yield acceleration curves

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Abstract

This study had two aims. Firstly, we wanted to quantify the effects of breed and parity on lactation curves. A parametric model for describing milk yield for cows [Friggens, N., Emmans, G., Veerkamp, R., 1999. On the use of simple ratios between lactation curve coefficients to describe parity effects on milk production. Livest. Prod. Sci. 62, 1–13] was used. The data contained 155,051 daily records of milk yield from 318 cows of three different breeds; Danish Red, Danish Holstein and Jersey. There were 276, 230, and 98 lactation curves for parities 1, 2 and 3 respectively. For every cow lactation, the parameters of the model were estimated using a least squares procedure for non-linear models. The resulting parameters were analysed in a mixed linear model. Significant effects of parity were observed on the same two parameters as in Friggens et al. [Friggens, N., Emmans, G., Veerkamp, R., 1999. On the use of simple ratios between lactation curve coefficients to describe parity effects on milk production. Livest. Prod. Sci. 62, 1–13]. Breed was also found to have a significant effect on some of the parameters. However, there was no significant interaction between breed and parity. The second aim of the study was to evaluate the properties of acceleration in milk yield in the context of providing an indicator for physiological stress and subsequent health problems. Milk yield acceleration was highest around calving and also reflected trends for higher stress/risk for higher yielding cows.

Keywords: Milk yield; Lactation; Parity; Breed; Cows

1. Introduction

Being able to predict the potential milk production of a cow through lactation period is an important prerequisite for designing feed rations that will allow this potential to be expressed and feed efficiency maxi-

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mized. In this context, lactation curve models that can predict potential milk yield using limited information are of relevance. Under commercial conditions the available information is frequently limited to factors such as breed, parity and composite estimates of previous yield. Both breed and parity effects have been shown to exist on lactation curves (e.g. Wood, 1980; Collins-Lusweti, 1991; Friggens et al., 1999; Rekaya et al., 2001) and can now easily be included as fixed factors in test-day models and other linear models that incorporate time trends (Van der Werf et al., 1998; Macciotta et al., 2005). However, in such models it is not usually possible to relate the breed or parity effects to the underlying biological processes (see Vetharaniam et al., 2003). This makes it difficult to build these effects into prediction models that allow the consequences of different potential yields to be evaluated.

An alternative approach is to estimate breed and parity effects in biologically derived lactation curve models (e.g. Dijkstra et al., 1997; Friggens et al., 1999; Pollott, 2000). These are usually non-linear. In this context, Friggens et al. (1999) provided estimates of parity effects on the different phases of lactation. However, this study was based on data from only one herd and did not estimate how parity effects were affected by breed. The first aim of the present study was to quantify parity effects on lactation curves in different breeds.

It has been suggested that the degree of physiological stress experienced by cows in early lactation can be indexed by the acceleration in milk yield, which is the daily rate of change in yield, during this period (Ingvartsen et al., 2003). Formally, denoting the daily milk yield at time t by $\mu(t)$ the acceleration in milk yield at that same time point is the derivative $\mu'(t)$. The characteristics that acceleration in milk yield must have if it is to be an indicator of stress, and thus of susceptibility to metabolic diseases, can be deduced from literature pertaining to production factors affecting disease incidences in early lactation. The highest incidences of diseases occur immediately after calving, substantially before peak yield (Ingvartsen et al., 1999, 2003). Higher yielding cows have also been found to be more likely to have health problems (Pryce et al., 1999; Hansen, 2000). Thus, for milk yield acceleration to provide a suitable indicator of physiological stress it should reflect these findings; being highest immediately post calving and, at a given time point in lactation, higher for higher producing animals. To our knowledge there is no published information concerning the properties of milk yield acceleration curves in real datasets. Thus the second aim of this study was to characterise the properties of milk yield acceleration curves.

2. Materials and methods

2.1. Data material

The data set used consisted of daily recordings of milk yield for 604 cow lactations. The cows were of three breeds; Danish red (106 cows), Danish Holstein (129 cows), and Jersey (83 cows). The total number of lactations in first, second and third parities were 276, 230 and 98 respectively. Breed and parity are the factors studied here to determine the effects on the parameters and quantities derived from these parameters. The data were collected between January 1996 and October 2001 at the Danish Cattle Breeders Organisation research farm, Ammitsbøl Skovgård, as a part of a long-term ongoing genetic evaluation programme. The design and methods for the production aspects of the experiment has been described in detail in Nielsen et al. (2003). The experiment was focused on genetic evaluation and therefore environmental conditions including feeding conditions were kept as constant as possible. Cows received one standard total mixed ration, fed ad libitum, throughout lactation containing either 12.88 MJ/kg dry matter or 13.55 MJ/kg dry matter. In Fig. 1 some typical examples of the development in milk yield through a lactation period are shown. Observations where *days from calving* was greater than 180 were discarded to exclude the depressing effects of pregnancy on milk yields at the end of lactation. Those lactation periods with no more than 140 daily milk yield recordings (in those first 180 days) and those with no measurement made before the fifth day after calving were also excluded. These exclusions reduced the number of lactation periods from 604 to 409.

2.2. Lactation curve coefficients

Several models with different functional forms have been proposed in the literature to model yield data (Rook