J. Dairy Sci. 99:1–13
http://dx.doi.org/10.3168/jds.2015-9583

Effect of calving interval and parity on milk yield per feeding day in Danish commercial dairy herds

J. O. Lehmann,*[1] J. G. Fadel,† L. Mogensen,* T. Kristensen,* C. Gaillard,‡ and E. Kebreab†
*Department of Agroecology, Aarhus University-Foulum, Blichers Allé 20, DK-8830 Tjele, Denmark
†Department of Animal Science, University of California-Davis, One Shields Avenue, Davis 95616
‡Department of Animal Science, Aarhus University-Foulum, Blichers Allé 20, DK-8830 Tjele, Denmark

ABSTRACT

The idea of managing cows for extended lactations rather than lactations of the traditional length of 1 yr primarily arose from observations of increasing problems with infertility and cows being dried off with high milk yields. However, it is vital for the success of extended lactation practices that cows are able to maintain milk yield per feeding day when the length of the calving interval (CInt) is increased. Milk yield per feeding day is defined as the cumulated lactation milk yield divided by the sum of days between 2 consecutive calvings. The main objective of this study was to investigate the milk production of cows managed for lactations of different lengths, and the primary aim was to investigate the relationship between CInt, parity, and milk yield. Five measurements of milk yield were used: energy-corrected milk (ECM) yield per feeding day, ECM yield per lactating day, cumulative ECM yield during the first 305 d of lactation, as well as ECM yield per day during early and late lactation. The analyses were based on a total of 1,379 completed lactations from cows calving between January 2007 and May 2013 in 4 Danish commercial dairy herds managed for extended lactation for several years. Herd-average CInt length ranged from 414 to 521 d. The herds had Holstein, Jersey, or crosses between Holstein, Jersey, and Red Danish cows with average milk yields ranging from 7,644 to 11,286 kg of ECM per cow per year. A significant effect of the CInt was noted on all 5 measurements of milk yield, and this effect interacted with parity for ECM per feeding day, ECM per lactating day and ECM per day during late lactation. The results showed that cows were at least able to produce equivalent ECM per feeding day with increasing CInt, and that first- and second-parity cows maintained ECM per lactating day. Cows with a CInt between 17 and 19 mo produced 476 kg of ECM more during the first 305 d compared with cows with a CInt of less than 13 mo. Furthermore, early-lactation ECM yield was greater for all cows and late-lactation ECM yield was less for second-parity and older cows when undergoing an extended compared with a shorter lactation. Increasing CInt increased the dry period length with 3 to 5 d. In conclusion, the group of cows with longer CInt were able to produce at least equivalent amounts of ECM per feeding day when the CInt was up to 17 to 19 mo on these 4 commercial dairy farms.
Key words: extended lactation, dairy cow, milk yield, lactation curve

INTRODUCTION

Dairy production is characterized by cycles of calving, lactation including gestation, and a dry period followed by the next calving. Originally, these cycles were driven solely by annual changes in daylight and feed availability, but, in modern intensive dairy systems, these cycles are mostly driven by decisions of the farmer. Seasonality may still play a major role in modern dairy systems, such as the grassland-based production in New Zealand, where the average calving interval (**CInt**) is 368 d (LIC and DairyNZ, 2013). In contrast, the average CInt in the confinement systems in Denmark has increased to around 395 d (Danish Cattle, 2014a). The dry period length is likely unchanged, and therefore the extended CInt results in an extended lactation. Both planned and unplanned effects such as reduced fertility may have contributed to this increase in CInt.

Reduced fertility in intensive dairy systems has been linked to the continued genetic selection for increased milk yield through a more severe negative energy balance around the time of calving (Ancker et al., 2006). Managing cows for extended lactation means that cows are likely inseminated after the cows have passed the most severe negative energy balance. Hence, extended lactation may be a way of alleviating this issue as well as reduce the number of cows being dried off with high milk yields (Knight, 2008). Also, extended lactation

Received March 17, 2015.
Accepted September 21, 2015.
[1]Corresponding author: JesperO.Lehmann@agro.au.dk

reduces the required supply of replacement heifers per year.

Furthermore, extended lactation could potentially reduce greenhouse gas (**GHG**) emission per kilogram of milk produced through a reduction in herd feed use per kilogram of milk produced and, thereby, also improve farm profitability in commercial herds (Knight, 2008; Eckard et al., 2010; Lehmann et al., 2014). However, total meat production will be reduced in a system with extended lactation as a result of fewer calvings and hence fewer culled cows and bull calves for sale. In addition, genetic progress may slow down as a result of longer generation intervals.

The success of using extended lactation as a management system is highly dependent on the ability of a cow to maintain milk yield per feeding day. This yield measure encompasses the whole lactation and the length of the dry period, which is in contrast to traditional figures such as 305-d lactation yield.

Milk yield per feeding day was shown to be maintained during extended lactations in experimental herds in Sweden (Österman and Bertilsson, 2003) and Denmark (Christiansen et al., 2005), as well as commercial herds in Israel (Arbel et al., 2001). On the other hand, Auldist et al. (2007) showed a small negative effect and Kolver et al. (2007) showed some gains and some losses in milk yield of cows, which had their lactations extended to up to 2 yr in a pastoral system. Furthermore, 2 studies have indicated a potential negative influence of a previous extended lactation on the dry period length and milk yield of the following lactation (Arbel et al., 2001; Österman and Bertilsson, 2003).

We hypothesized that dairy cows undergoing an extended lactation should be able to produce the same amount of milk per feeding day as cows undergoing lactations of traditional length. Partly because the number of days lactating relative to the number of days dry will be increased, and partly because the potential negative effect of pregnancy on milk yield (Bormann et al., 2002; Roche, 2003) may be delayed when breeding is postponed.

Estimating daily milk production from commercial milk yield recordings is often challenged by data frequency, as farmers typically only conduct monthly or even bimonthly recordings. A lactation curve can be fitted with either empirical (e.g., Wood, 1967; Wilmink, 1987) or mechanistic (e.g., Dijkstra et al., 1997) mathematical functions. The ability of the model to describe the asymptotic phase occurring mid to late lactation is important to estimate daily yield during extended lactations (Macciotta et al., 2011; Steri et al., 2012). Legendre polynomials are useful because they can represent a greater number of lactation curvatures, and their mathematical properties cause them to have less correlation among parameters (Macciotta et al., 2005).

The main objective of our study was to investigate the milk production of cows undergoing lactations of different lengths on commercial farms in Denmark known to deliberately delay insemination. Furthermore, the aims were to (1) estimate daily milk yield by fitting a Legendre polynomial model to milk yield recordings, (2) investigate the relationship between CInt length, parity, and milk yield, and (3) investigate the influence of previous CInt length on current milk yield.

MATERIALS AND METHODS

Data

The data came from 4 commercial Danish dairy farms known to deliberately delay insemination of selected cows and, hence, manage the herd for extended lactations. The 4 farms (Table 1) varied in herd size, breed, milk production and composition, annual cull rate, CInt length, and milk recording scheme (6 or 11 recordings per year). The farms were selected based on work by van Vliet (2012), who identified 6 farmers practicing extended lactation through contacting dairy cattle advisors. The 4 farms were chosen because they had the longest lactations and were willing to participate in the project.

For completed lactations, the average DIM at first insemination increased consistently as the average CInt length increased for herds 2, 3, and 4 with increasing CInt (Figure 1). This illustrates that the voluntary waiting period increased, but, in these herds, some cows either failed to conceive at first or second insemination or did not express mating behavior. This was particularly pronounced in herd 1, although only 9% of lactations had a CInt greater than 17 mo (Figure 1).

Data consisted of milk yield recordings and dates for inseminations, pregnancy tests, drying off, calving, and culling. Energy-corrected milk yield was calculated using the equation of Sjaunja et al. (1991):

$$\text{ECM} = \text{milk (kg)} \times [0.383 \times \text{fat (\%)} + 0.242 \times \text{protein (\%)} + 0.7832]/3.14.$$

Data were obtained from cows that calved between January 1, 2007, and May 1, 2013, in the 4 herds, and data from 176 lactations with less than a total of 3 milk recordings were removed. Twenty-six lactations (from 15 cows) with no information on date of next calving, drying off date, or culling date and no records during the last 3 mo before May 1, 2013, were removed. Herd 1 purchased 11 cows, of which 5 were purchased after