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Association of milking interval and milk production rate in an automatic milking system

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ABSTRACT

The primary aim of this research was to describe the association between milking interval (MI) and milk production rate (MPR) at the quarter level in a large commercial farm using an automatic milking system. A secondary aim was to determine whether a 2-h decrease in MI would increase MPR at the cow level in midlactation multiparous cows. Six months of data from 1,280 cows were used to assess the association between MI (h) and quarter MPR (kg/h). Increasing MI was associated with decreased MPR for early, mid, and late lactation, both primiparous and multiparous cows, and all 4 quarter positions and across time. The decrease in MPR is approximately 2%/h of increasing MI for multiparous cows and 1.5%/h for primiparous cows. Regardless of quarter, multiparous cows had a greater MPR than primiparous cows, and rear quarters had greater MPR than front quarters. An experiment to test the causal relationship between changing MI and cow-level MPR was conducted using 26 animal pairs matched on MI, days in milk, and milk yield. During the 21-d treatment period, the average MI of treatment cows was decreased by 2.4 h compared with control cows. In both the 21-d treatment and 42-d posttreatment periods, no significant difference was found in cow-level MPR between the treatment and control groups. Despite the negative association between increasing MI and MPR being consistent across all assessed days in milk windows and all quarters, results from this experiment suggest that intervention to decrease MI might require an MI change greater than 2 h or be applied in early lactation to significantly increase MPR.

Key words: voluntary milking system, milking frequency, milk production rate

INTRODUCTION

Research on the association between milking frequency and milk production has appeared in the literature over several decades. Although they are related measures, milking frequency has usually been used to describe a fixed number of milkings per day (e.g., twice daily, 3 times daily), whereas milking interval (**MI**) is more commonly applied to define the time (h) between milkings for voluntary milking systems in which the milking frequency and MI may vary from day to day. Early research by Elliott (1961), using a half-udder design, demonstrated a 12% increase in milk yield when 3-times-daily milking was compared with twice-daily milking—a 4-h decrease in MI. The increase in yield was noted after 1 d and persisted during the entire period that the 3-times-daily treatment was applied. Nørgaard et al. (2005) milked cows 3 times per day or twice daily for 8 wk and found an increase in milk yield of 11% in the 3-times-daily group but no persistency of response from wk 11 to 16. In an experiment conducted with mid-lactation cows comparing 3-times-daily with once-daily milking, after 8 wk of comparison, the yield of milk harvested once daily was 40% that of milk harvested 3 times per day (Bernier-Dodier et al., 2010). Four-times-daily milking has also been compared with twice-daily milking in an experiment conducted on 4 commercial farms; the average daily increase in milk yield associated with the 4-times-daily treatment was 2.2 kg/cow per day, or 6.8%, across the 7 mo of treatment (Soberon et al., 2011). Six-times-daily milking during the first 6 wk of lactation has been compared with 3-times-daily milking, with a significant increase in milk yield observed for the 6-times-daily treatment in addition to a carryover effect through wk 7 to 18 of lactation after the treatment had ceased (Bar-Peled et al., 1995). Hale et al. (2003) noted results similar to those of previous milking frequency experiments in an experiment comparing 4-times-daily and twice-daily milking using uneven MI. A review by Wall and McFadden (2012) concluded that a 4-h decrease in MI (twice-daily to 3-times-daily milking) results in a 15 to 20% increase in milk yield, whereas a further 2-h

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decrease in MI (3-times-daily to 4-times-daily milking) results in a further 7% increase in milk yield.

The studies mentioned thus far have all been based around conventional milking systems with regimented MI. The automatic milking system (**AMS**), or milking robot, was first introduced commercially in 1992, and there are now approximately 38,000 individual AMS units worldwide (Hallén-Sandgren and Emanuelson, 2017). Irrespective of the animal traffic design, AMS systems rely to some degree on voluntary cow movement, and MI is influenced by individual cow behavior. As such, AMS has offered new research opportunities in terms of how MI is associated with milk yield. Increasing MI in AMS has been associated with decreasing milk production per hour, with the effect of MI being greatest at higher production levels (Ouweltjes, 1998; Hogeveen et al., 2001). Daily or weekly milk yield was reported to have decreased linearly as MI increased (Bach and Busto, 2005; André et al., 2010), whereas daily milk yield was found to be negatively correlated with MI and correlated in both positive and negative directions, depending on days to peak production, with DIM (Helmreich et al., 2014). Pettersson et al. (2011) determined that high milking frequency (low MI) in early lactation was associated with an increased peak milk yield, and high milking frequency across the entire lactation was associated with an increased peak milk yield in multiparous cows milked using AMS. In addition, there was improved persistency of lactation.

Little experimental work has been conducted using AMS stocking rates typical of commercial farms (Jacobs and Siegford, 2012), and research has predominantly reported milk yield results at the udder rather than quarter level. No experiments to establish a cause–effect relationship between changes in MI and resulting production response in mid-lactation cows in AMS have been reported. The primary aim of this research was to describe the association between MI and milk production rate (**MPR**; kg of milk produced/h of MI) at the quarter level in a large commercial AMS (5 or more units in a single commercial farm). A secondary aim was to determine whether a 2- to 3-h decrease in MI would increase cow-level MPR in mid-lactation multiparous cows. Satisfying both aims, conceivably, can lead to useful information for the configuration of milking permission settings and milking strategies in AMS.

MATERIALS AND METHODS

An observational study and a planned experiment were conducted on a commercial dairy farm (n = 1,280 Holstein Friesian cows) using 20 AMS units (De Laval VMS, DeLaval, Tumba, Sweden) located in the northeastern United States. This farm has used an AMS for more than 10 yr. The average lactation number of cows in the study herd was 2.3 (SD = 1.1), with an average production level of 34.6 (SD = 11.4) kg/cow per day. Cows are housed year-round and fed using a partial mixed ration system with concentrate feeding in the AMS stall. Concentrate feeding is not adjusted according to individual cow production levels. Each AMS services a pen of 55 cows, with 6 pens of primiparous cows (**L1**) and 14 pens of multiparous cows (**L2+**). As animals freshen, they are allocated to evenly distribute cow DIM between pens. Less than 10% of the animals are moved to different pens in any 12-mo period. Milking permission is granted to L1 cows if they had not been successfully milked in the previous 5 h, whereas L2+ cows are granted milking permission if they have not been successfully milked in the previous 6 h. No milk production parameters are used to determine milking permission. Under normal farm protocol, cows are fetched only if they have not recorded a successful milking within 24 h of the previous milking. Milking configuration of the AMS (system vacuum and pulsation settings) was not altered during the study period. Teat cup removal was based on a threshold of 0.2 kg/min applied at the quarter level.

Observational Study

Pen ID, cow ID, milking start time (date, hour, minute, second), milking duration (minute, second), incomplete milkings, quarter-level milk yield (kg), average flow rate (kg/min), peak flow rate (kg/min), and conductivity (mS/cm) were recorded for each cow milking (Delpro, DeLaval). Days in milk were calculated for each milking based on calving date contained in a separate database. Quarter-level MPR was calculated by dividing the individual quarter milk yield by the time since the last milking (or MI) and is reported as kilograms per hour. Quarter MPR was averaged over 10-DIM periods. Two pens used a semiguided traffic system in which animals had to pass through the AMS to gain access to the partial mixed ration feeding area. Eighteen pens used a guided traffic system in which a presorting gate directed cows to either the feeding area or the AMS holding area. Pen design was uniform for all 20 pens with the exception of this single presorting gate in each of the guided traffic pens. Milking data from January to June 2015 comprising 539,548 individual cow milking records was available for observational study.

Statistical Analysis for Observational Study

All data manipulation and statistical analysis were performed using SAS 9.4 (SAS Institute Inc., Cary,