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Cow-level associations of lameness, behavior, and milk yield of cows milked in automated systems

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ABSTRACT

This study evaluated differences in behavior and productivity between lame and nonlame cows in herds with automated milking systems (AMS). We monitored 30 cows per herd on 41 farms with AMS in Canada (26 herds in Ontario and 15 herds in Alberta). During a 6-d period, milking data (n = 1,184) and lying behavior data (n = 1,209) were collected from cows on 41 farms. Rumination behavior (n = 569) and activity (n = 615) data were available for cows at 22 farms. Locomotion was scored using a numerical rating system (NRS; 1 = sound; 5 = extremely lame). Cows were defined as clinically lame with NRS $\geq$ 3 (n = 353, 29%) and nonlame with NRS < 3 (n = 865, 71%). Greater parity, lower body condition, and lower environmental temperature were factors associated with lameness. When accounting for other factors, lame cows produced 1.6 kg/d less milk in 0.3 fewer milkings/d. Lame cows were 2.2 times more likely to be fetched more than 1 time during the 6-d period and spent 38 min/d more time lying down in bouts that were 3.5 min longer in comparison with nonlame cows. As the number of cows per AMS unit increased, the frequency of milkings and refusals per cow per day decreased and cow activity increased. For each 13.3 percentage point increase in freestall stocking density (cows per stall), daily lying time decreased by 13 min/d and cows were 1.6 times more likely to be fetched more than 1 time during the 6-d period. There was no difference in daily rumination or activity between lame and nonlame cows or in night:day rumination time, but lame cows had greater night:day activity ratios. This study supports the growing knowledge that lameness has negative effects on milk production, voluntary milking behavior, and lying behavior of cows in herds with AMS. These results may help dairy producers gain a better appreciation of the negative effects of even moderate cases of lameness and may help motivate them to improve their lameness monitoring and treatment protocols.
Key words: robotic milking, behavior, lameness, management

INTRODUCTION

The expanding use of automated milking systems (**AMS**) provides many challenges and opportunities to dairy producers. In addition to reduced labor costs and greater time flexibility, producers can manage supplemental feed for each cow and the permission for cows to access the AMS for milking and a feed reward. Individual milking of cows at various frequencies creates the opportunity to (1) milk early-lactation cows more often and provide more supplement (including additives) to maximize peak milk yield and (2) taper off milking frequency for late-lactation cows to reduce the stress of sudden dry-off (Bertulat et al., 2013). The use of AMS also has the advantage of monitoring cow-level milking frequency and quarter-level production and milk quality, which can be helpful tools for illness detection (Jacobs and Siegford, 2012). Nonetheless, not all health disorders can be detected electronically, and producers must still physically assess cows as well as fetch cows for milking if their milking interval is too long. The number of cows needing to be fetched in Canadian herds was recently estimated to be 8% of the herd/d (King et al., 2016).

Lameness is a major health and welfare concern in the dairy industry. Producers strongly agree that lameness is a painful condition, and they are willing to implement proven control measures even if such measures are inconvenient; however, they still greatly underestimate the prevalence of lameness in their herd (Bennett et al., 2014). Many cases go untreated for several weeks, and those that are treated often develop repeat cases requiring further treatment (Leach et al., 2012; Green et al., 2014). Recent studies have reported prevalence estimates of lameness in North America to be 21 to 55% in conventional freestall herds (von Keyserlingk et

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al., 2012; Solano et al., 2015) and 15 to 26% in AMS freestall herds (King et al., 2016; Westin et al., 2016b). For any herd, lameness has negative implications for productivity and behavior (Huxley, 2013), but this may be heightened in AMS due to the (ideally) voluntary nature of cows visiting the milking unit.

Demonstrating the negative changes associated with lameness, especially when accounting for other factors, would help dairy producers gain a better appreciation of the negative effects of even moderate cases of lameness and would likely motivate them to improve their lameness monitoring and treatment protocols. To date, no researchers have examined associations of lameness with both productivity and behavior at the cow level in AMS while also evaluating and controlling for many other cow-level factors. Cow-level studies of lameness in AMS herds have reported reduced milk yield, reduced total and voluntary milking frequency, and greater daily lying time for lame cows (Bach et al., 2007; Deming et al., 2013a; Westin et al., 2016a). Other factors influencing milking and lying behavior include parity, social status, DIM, and stocking density. For example, multiparous cows in AMS are milked less often yet produce more milk than primiparous individuals (Borderas et al., 2008; Deming et al., 2013b), and subordinate cows may achieve milking frequencies that are similar to those of dominant individuals but spend more time standing, perching in stalls (Galindo and Broom, 2000), and waiting to access the AMS (Ketelaar-de Lauwere et al., 1996). At a herd level, milking frequency and yield per cow also decline with greater stocking density at the AMS (Deming et al., 2013b; King et al., 2016) and with increasing DIM (Deming et al., 2013a,b).

Our objective was to compare the behavior and productivity of lame and nonlame cows while accounting for body condition, parity, DIM, and other environmental factors. Comparisons were made regarding daily milk yield, milking and refusal frequencies, lying behavior, rumination behavior, and a measure of activity.

MATERIALS AND METHODS

Farm Selection

From October 2014 to June 2015, we visited 41 commercial dairy farms with AMS (26 herds in Ontario and 15 herds in Alberta). Farms visited were those used in a herd-level analysis by King et al. (2016). They were contacted using information from Ontario AMS dealers and Alberta Milk (Edmonton, AB, Canada). Selection criteria and herd descriptions are reported in King et al. (2016). Study herds milked 105 ± 56 lactating cows with 2.2 ± 1.3 AMS units, and more than 80% of herds used free cow traffic. The study design was approved by the University of Guelph Animal Care Committee and Research Ethics Board, and animal use complied with the guidelines of the Canadian Council on Animal Care (CCAC, 2009).

Data Collection

Farms were visited twice, 7 d apart, to collect 1 period of 6 complete days (each representing a 24-h period between 0000 and 2359 h) of behavior data for focal cows. At each farm, 30 focal cows were randomly selected for this analysis to accurately represent lying behavior of herds of similar size to the current study (Ito et al., 2009). If all lactating cows were housed in 1 large group, all 30 focal cows were selected from that group. In cases of farms housing lactating cows in more than 1 pen, we selected a proportionate number of cows per pen based on the number of cows per pen. Therefore, we also included a proportionate number of cows separated into smaller treatment or separation pens with AMS access. We used systematic random sampling to select focal cows by including only every *n*th cow based on the number of cows needed per pen. This ensured that cows were selected proportionately from all parts within a pen (i.e., lying stalls, feed bunks, and all alleyways). This ensured that a representative and random sample was achieved, which is evident by similar means of DIM, parity, milking data, and lying behavior variables at the cow level, in comparison with the herd-level means reported by King et al. (2016). As the stocking density of lactating cows relative to AMS units and lying stalls has previously been associated with behavior and production in AMS herds (King et al., 2016), the number of cows in every pen was recorded at both visits. Stocking density (%) in stalls was calculated as the average number of cows per pen relative to the number of lying stalls × 100%. Cows per AMS unit was calculated as the average number of cows relative to the number of AMS units per group. Cow parity and DIM details were collected from the AMS computer at each farm.

Assessment of Gait and Body Condition

On the first visit to all farms, locomotion was scored for the 30 focal cows per farm by 1 observer using a 5-point numerical rating system (**NRS**) at increments of 1.0 (Flower and Weary, 2006). Locomotion scoring was performed from a clear posterior side angle while cows took at least 6 steps on flat flooring while walking and not when stumbling, falling, defecating, urinating, or restricted from free movement by a nearby cow (Flower and Weary, 2006). A total of 12 cows were excluded either because of missing locomotion scores or