Effects of sawdust bedding dry matter on lying behavior of dairy cows: A dose-dependent response

L. J. Reich,* D. M. Weary,* D. M. Veira,† and M. A. G. von Keyserlingk*¹

*Animal Welfare Program, Faculty of Land and Food Systems, University of British Columbia, 2357 Main Mall, Vancouver, British Columbia, V6T 1Z4, Canada

†Agriculture and Agri-Food Canada, PO Box 1000, Agassiz, British Columbia, V0M 1A0, Canada

ABSTRACT

The objective was to determine the effect of sawdust bedding dry matter on the lying behavior of Holstein cows. Dry matter (DM) was varied systematically over 5 treatment levels to test how cows respond to damp bedding. This experiment was repeated during summer and winter to test if the effects of damp bedding varied with season. The 5 bedding treatments averaged ($\pm$ SD) 89.8 ± 3.7 , 74.2 ± 6.4 , 62.2 ± 6.3 , 43.9 ± 4.0 , and $34.7 \pm 3.8\%$ DM. Over the course of the trial, minimum and maximum temperatures in the barn were 2.6 ± 2.0 and $6.8 \pm 2.2^\circ\text{C}$ in the winter and 13.3 ± 2.5 and $22.6 \pm 4.1^\circ\text{C}$ in the summer. In both seasons, 5 groups of 3 nonlactating cows were housed in free stalls bedded with sawdust. Following a 5-d acclimation period on dry bedding, groups were exposed to the 5 bedding treatments in a 5×5 Latin square. Each treatment lasted 4 d, followed by 1 d when the cows were provided with dry bedding. Stall usage was assessed by 24-h video scanned at 5-min intervals. Responses were analyzed within group ($n = 5$) as the observational unit. Bedding DM affected lying time, averaging 10.4 ± 0.4 h/d on the wettest treatment and increasing to 11.5 ± 0.4 h/d on the driest bedding. Lying time varied with season, averaging 12.1 ± 0.4 h/d across treatments during the winter and 9.9 ± 0.6 h/d during the summer, but season and bedding DM did not interact. These results indicate that access to dry bedding is important for dairy cows.

Key words: bedding quality, cow comfort, season, lying behavior

INTRODUCTION

The lying surface provided for dairy cows can affect lying behavior. The type (Keys et al., 1976; Tucker et al., 2003), amount (Tucker and Weary, 2004; Drissler et al., 2005), and dryness (% DM; Fregonesi et al., 2007b)

of bedding can affect how much time cows spend lying down.

Bedding becomes wet when cows urinate and defecate, leak milk, and enter the lying area with dirty, wet hooves. Rain can enter the barn from the sides or through the open doors, and feed-line soakers can add moisture to bedding. Wet bedding can reduce the amount of time cows spend lying in free stalls. Fregonesi et al. (2007b) found that dairy cows show a strong preference for dry bedding; cows spent 5 h/d less time lying down when they only had access to stalls with wet bedding compared with when they had access to stalls with dry bedding. In the same study, cows spent more time standing outside the stall when restricted to wet bedding compared with when they had access to dry bedding. However, Fregonesi et al. (2007b) compared 2 extremes of moisture content (86.4 vs. 26.5% DM), and it is unknown how cows respond to intermediate moisture levels more typically found on commercial farms.

Several studies have examined the effect of season on lying behavior, and for the most part, these studies focused on the obvious difference in temperature between seasons. Lactating dairy cows spend less time lying down when the temperature is high (Keys et al., 1976; Shultz, 1984; Cook et al., 2007), perhaps because standing improves their ability to use evaporative cooling. Cows might use conductive cooling by lying down on wet surfaces, but to our knowledge this idea has not been tested. There may be other differences between seasons that cause changes in behavior. For example, photoperiod affected milk production (Dahl et al., 1997) and may affect lying behavior as well.

The objectives were to determine 1) the effects of a range of moisture levels in sawdust bedding, and 2) the interaction between season and bedding moisture on the lying behavior of Holstein dairy cows.

MATERIALS AND METHODS

Animals, Housing, and Diet

The study was conducted at the University of British Columbia's Dairy Education and Research Centre

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¹Corresponding author: marina.vonkeyserlingk@ubc.ca

(Agassiz, British Columbia, Canada) during August and September 2008 (summer) and replicated in January and February 2009 (winter). For each of the 2 replicates, 15 pregnant, nonlactating Holstein dairy cows were randomly assigned to 5 groups of 3 animals. Cows entered the experiment at the beginning of a target 60-d dry period. For the summer experiment, groups were balanced for mean ($\pm$ SD) parity (2.2 ± 1.1), days to expected date of calving (56.1 ± 9.3 d), BW (723 ± 67 kg), and BCS (3.3 ± 0.4 ; scored from 1 to 5 following Edmonson et al., 1989). For the winter experiment, groups were balanced for mean parity (2.3 ± 1.4), days to expected date of calving (59.1 ± 15.7 d), BW (727 ± 116 kg), and BCS (3.3 ± 0.3).

Lameness affected standing behavior, especially for cows housed on mattresses (Cook et al., 2004), so cows were only included in the experiment if they were not clinically lame (i.e., gait score <3 ; Flower and Weary, 2006). Any cow that became lame over the course of the experiment was removed. Cows were cared for according to the guidelines of the Canadian Council on Animal Care (1993).

The experiments were carried out in a naturally ventilated wooden frame barn (width = 38 m, length = 156 m) with a north-south orientation and curtained sidewalls. Each experimental pen measured 9.5 m wide by 12.3 m long with 12 stalls configured in 2 rows tail-to-tail. Nine stalls were blocked with chains to prevent cows from entering them and so that each pen had 3 stalls available for the 3 cows. The bed of each stall was 2.6 m long. Stalls were separated (1.2 m center-to-center) with Y2K free-stall partitions (Artex, Langley, British Columbia, Canada). The neck rail was positioned 1.2 m above the stall surface and 1.5 m from the rear curb of the stall. The brisket board (Poly Pillow, Promat Ltd., Seaforth, Ontario, Canada) was positioned 1.7 m from the rear curb of the stall. The stall was covered with a geotextile mattress and bedded with 0.1 m of kiln-dried sawdust (approximately 7.5 kg/stall). The rest of the flooring in the pen was covered with textured rubber. The alleys were 3.5 m wide at the feed bunk and 3.0 m wide between the 2 rows of stalls. Alleys were scraped 6 times/d with an automatic scraper.

Each pen had headlocks positioned 60 cm center-to-center at the feed bunk with a total of 9.5 m of bunk space/pen. Cows were given *ad libitum* access to a TMR consisting of 44.4% grass silage, 19.1% corn silage, 27.8% ryegrass seed straw, and 8.7% concentrate mix on a DM basis. The composition of the TMR was 46.6% DM and contained (on a DM basis) 13.4% CP, 35.9% ADF, and 55.6% NDF. Fresh feed was provided once daily at 0800 h and feed was pushed up twice

daily. A self-filling trough was used to provide water *ad libitum*.

Treatments and Experimental Design

Five moisture levels were tested for both experiments: 4 were prepared by mixing 1.7, 4.0, 9.0, and 15.5 L of water with 7.5 kg of sawdust in a cement mixer, and the fifth consisted of kiln-dried sawdust without any added water. Bedding was replaced twice daily at 0800 and 1800 h, and samples were collected before and after the bedding treatments were placed in the stalls. Samples were taken from each stall, pooled within treatments, and frozen in plastic bags until they were oven-dried at 55°C for 2 d. Bedding samples from the 5 treatments were ($\pm$ SD) 34.7 ± 3.8 , 43.9 ± 4.0 , 62.2 ± 6.3 , 74.2 ± 6.4 , and $89.8 \pm 3.7\%$ DM. To correspond with the earlier literature on bedding moisture, bedding treatments will hereafter be referred to in terms of bedding DM.

Groups were acclimated to the test pens for 5 d on kiln-dried sawdust and were then exposed to each of the 5 treatments using a 5×5 Latin square design. Groups remained in the same pen throughout the course of the experiments and treatments changed within each pen. Each group was tested on each treatment for 4 d, with 1 d between each treatment on kiln-dried sawdust.

Behavior

Behavior was recorded 24 h/d using 2 cameras (Panasonic WV-BP334 24V; Panasonic, Mississauga, Ontario, Canada) placed above the feed bunk and above the stalls for each pen. The cameras were attached to a video multiplexer (Panasonic WJ FS616C) and time-lapse recorder (Panasonic AG 6540). Red lights (100 W) were hung adjacent to the cameras to facilitate video recording at night. Cows were marked with unique symbols using hair dye to identify individuals within each group if necessary. Video recordings were scanned at 5-min intervals; each scan recorded if the cow was lying in the stall, lying in the alley, perching (standing with 2 hooves in the stall), standing with 4 hooves in the stall, standing elsewhere in the pen, or feeding (when the cow's head was in the headlock and ears were past the feed barrier). Behavior was recorded for 2 of the 4 d during each treatment period. During the summer experiment, behavior was recorded on d 1 and 4 of each treatment period. Because of difficulties with recording during the winter experiment, behavior was recorded for 2 d chosen at random for each experimental period. Results were compared between different days of the experimental period for each season,

and days within each experimental period did not have an effect on behavior.

Temperature

A data logger (Hobo Temperature/Relative Humidity Data Logger, Onset Computer Corporation, Pocasset, MA) that recorded temperatures every 3 min was placed in the center of the barn to record daily minimum and maximum temperatures.

Statistical Analysis

The UNIVARIATE procedure of SAS (version 9.1, SAS Institute, 2003) was used to screen the data for outliers and normality. One cow, treated for lameness and identified as an extreme outlier for time spent standing fully in the stall, was removed from the data set. The remaining data were averaged by group (the experimental unit) and treatment, such that each group contributed one observation for each treatment level in the statistical analysis.

The MIXED procedure (version 9.1, SAS Institute, 2003) was used to test the fixed effect of season (1 df), DM treatment (continuous, 1 df), and the season by DM interaction (1 df), with group specified as a random effect. The interaction between season and DM treatment was never significant and will not be discussed further.

The REG procedure (version 9.1, SAS Institute, 2003) was used to calculate the coefficients of determination between lying time and temperature and day length, separately for each season. Temperature and day length are two obvious sources of variation within and between seasons.

RESULTS

Bedding DM

Cows spent more time lying in the stall when sawdust bedding was drier (Figure 1A; $P = 0.011$). Cows spent 10.4 ± 0.4 h/d lying in the stall on the wettest bedding (34.7% DM) versus 11.5 ± 0.4 h/d on the driest treatment (89.8% DM). When bedding was wet, cows appeared to compensate for reduced lying time by spending more time standing idle in the alley (not including feeding time). With drier treatments, time spent standing in the alley decreased by about 13% (Figure 1B; $P = 0.015$) because cows spent more time lying in the stalls. No other behaviors varied with bedding DM. Cows averaged 1.5 ± 0.1 h/d perching in the stall, 0.2 ± 0.1 h/d standing in the stall, and 5.5 ± 0.1 h/d feeding.

During the summer experiment, 3 of the cows occasionally lay down in the alley, but none of the cows in the winter experiment ever exhibited this behavior. Because only a few cows showed this behavior and it occurred on a variety of treatments during different treatment periods, lying in the alley was attributed to differences among cows, rather than bedding DM or season, and will not be discussed further.

Season

The average ($\pm$ SD) minimum and maximum temperatures were $2.6 \pm 2.0^\circ\text{C}$ and $6.8 \pm 2.2^\circ\text{C}$, respectively, for the winter experiment and $13.3 \pm 2.5^\circ\text{C}$ and $22.6 \pm 4.1^\circ\text{C}$, respectively, for the summer experiment. There were seasonal effects on lying in the stall and standing in the alley. The time cows spent lying in stalls was 2.2 h/d greater in the winter than in the summer ($P = 0.0003$; Figure 1A), and cows spent 1.4 h/d less time standing outside of the stall in the winter months ($P = 0.0146$; Figure 1B). There were no seasonal effects on perching or standing in the stall, but cows averaged 5.0 ± 0.2 h/d feeding in the winter versus 5.8 ± 0.2 h/d in the summer months ($P < 0.0001$; Figure 1C).

There was no effect of temperature on lying time within either winter or summer and no effect of day length on lying time during the winter. As day length increased during the summer, cows tended to spend less time lying down ($R^2 = 0.12$, $P < 0.09$).

DISCUSSION

Bedding DM

The results confirmed that wet sawdust bedding reduces the amount of time cows spend lying down in the stall and support previous studies (Keys et al., 1976; Fregonesi et al., 2007b). Cows spent 1.1 h/d less time lying on the wettest treatment compared with the driest. These results support other studies examining stall design and cow comfort.

Changes in stall design and management typically increase or reduce lying times by 0 to 3 h/d; examples include changes in bedding materials (Tucker et al., 2003), stall width and length (Tucker et al., 2004), amount of bedding material (Tucker and Weary, 2004), neck-rail placement (Tucker et al., 2005), stall surface and depth of bedding material (Drissler et al., 2005), brisket board (Tucker et al., 2006), and stocking density (Fregonesi et al., 2007a). Yet, in a study comparing moisture levels, Fregonesi et al. (2007b) reported a decrease of 5 h/d in lying time on wet bedding (26.5% DM) compared with dry bedding (86.4% DM). The smaller difference between treatments in the current

Figure 1. Time (h/d) spent A) lying in the stall, B) standing in the alley, and C) feeding, shown separately for summer and winter experiments. Data were averaged from 5 groups for 2 d on each treatment using a Latin square design.

study may be partially due to differences in the moisture levels used. The lowest DM ($34.7 \pm 3.8\%$ DM) was still about 8 percentage units drier than the “wet” treatment (26.5% DM) in Fregonesi et al. (2007b).

Bedding materials containing low percentages of DM (29% DM in dewatered manure solids; Keys et al., 1976, and 26.5% DM in sawdust bedding; Fregonesi et al., 2007b) reduced lying times relative to bedding materials containing high percentages of DM (81% DM in sawdust and 90% DM in dehydrated manure solids; Keys et al., 1976, and 86.4% DM in sawdust; Fregonesi et al., 2007b). The current study examined the effects of intermediate levels of DM in sawdust bedding and showed a decrease in the amount of time cows spend lying in the stall as the DM of sawdust decreases. Yet, this decrease in lying time was modest until DM decreased below approximately 60% DM, suggesting that cows may not have a strong preference for drier bedding when all options are relatively dry (i.e., between 60 and 90% DM).

Effect of Season

Lying time was lower in the summer than the winter. Dairy cattle are known to spend less time lying down when heat stressed (Shultz, 1984), or mildly heat stressed (i.e., temperature-humidity index >68 ; Cook et al., 2007). There was no relationship between temperature and lying time within either season, suggesting that some other seasonal factor was involved. There was no relationship between lying time and day length during the winter.

Dry matter intake decreases as a result of heat stress (West, 2003). Dry matter intake was not measured, but the time spent feeding was lower in the winter than summer. If cows had been heat stressed during the summer, the opposite result would have been expected (i.e., decreased feeding time during the summer).

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