Effects of Bedding Quality on Lying Behavior of Dairy Cows

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ABSTRACT

Cows prefer to spend more time lying down in free stalls with more bedding, but no research to date has addressed the effects of bedding quality. Bedding in stalls often becomes wet either from exposure to the elements or from feces and urine. The aim of this study was to test the effect of wet bedding on stall preference and use. Four groups of 6 nonlactating Holstein cows were housed in free stalls bedded daily with approximately 0.1 m of fresh sawdust. Following a 5-d adaptation period, each group of cows was tested sequentially with access to stalls with either dry or wet sawdust bedding (86.4 ± 2.1 vs. $26.5 \pm 2.1\%$ dry matter), each for 2 d. These no-choice phases were followed by a 2-d free-choice phase during which cows had simultaneous access to stalls containing either wet or dry bedding. Stall usage was assessed by using 24-h video recordings scanned at 10-min intervals, and responses were analyzed by using a mixed model, with group ($n = 4$) as the observational unit. The minimum and maximum environmental temperatures during the experiment were 3.4 ± 2.2 and $6.8 \pm 2.5^\circ\text{C}$, respectively. When cows had access only to stalls with wet bedding, they spent 8.8 ± 0.8 h/d lying down, which increased to 13.8 ± 0.8 h/d when stalls with dry bedding were provided. Cows spent more time standing with their front 2 hooves in the stall when provided with wet vs. dry bedding (92 ± 10 vs. 32 ± 10 min/d). During the free-choice phase, all cows spent more time lying down in the dry stalls, spending 12.5 ± 0.3 h/d in the dry stalls vs. 0.9 ± 0.3 h/d in stalls with wet bedding. In conclusion, dairy cows show a clear preference for a dry lying surface, and they spend much more time standing outside the stall when only wet bedding is available.

Key words: dairy cattle, preference test, cow comfort, welfare

INTRODUCTION

A growing body of research has now demonstrated that the surface we provide for cows is one of the most important factors in designing a suitable lying area. Cows clearly prefer lying surfaces with more bedding, and they spend more time lying down in well-bedded stalls than in those with little or no bedding (Tucker et al., 2003; Wagner-Storch et al., 2003; Tucker and Weary, 2004), likely because this provides a softer lying surface (Fulwider and Palmer, 2004). Problems with stall comfort are related to health risks. For example, cows housed in deep-bedded sand stalls have a lower prevalence of lameness than cows housed on mattresses with little or no bedding (Cook et al., 2004).

Making the decision to provide a well-bedded surface is just the first step in achieving a reasonable level of cow comfort; this surface must be properly maintained. Drissler et al. (2005) documented how bedding levels decline in deep-bedded stalls that are not maintained, and how these declines can have a dramatic effect on stall usage. The study showed that lying time declined by approximately 10 min/d for every 1 cm of reduction in sand bedding.

In addition to this decline in bedding quantity, it is likely that bedding declines in quality as it becomes wet, either from exposure to the elements or from feces and urine entering the stall. Sawdust, for example, has a high water-holding capacity (Ward et al., 2000). Dry matter decreases rapidly with use by cows, resulting in increased bacterial counts on both the bedding and the teats (Zdanowicz et al., 2004). A previous study reported that cows preferred bedding that contained less moisture (dry sawdust and dehydrated manure) than a high-moisture bedding (dewatered manure) in both the winter and summer seasons (Keys et al., 1976). Unfortunately, no published scientific research has examined the effect of declining bedding quality on cow comfort. Two established methods of assessing the effects of stall design and management on cow comfort are tests of cow preferences when given a choice among different options, and tests of stall usage (especially lying times) when cows are provided access to only a single option. Thus, the aim of the current experiment

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was to determine how access to dry and wet bedding affects stall preference and usage by dairy cows.

MATERIALS AND METHODS

The experiment was conducted at the University of British Columbia's Dairy Education and Research Center in Agassiz, British Columbia, during January and February 2007. Twenty-four pregnant and nonlactating Holstein cows were randomly assigned to 4 groups of 6 animals that were balanced for mean ($\pm$ SD) parity (2.1 ± 1.4), days before predicted calving date (48.3 ± 8.5 d), BW (764 ± 73 kg), and BCS (3.4 ± 0.3 ; scored from 1 to 5 following Edmonson et al., 1989).

The experiment was 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 (width = 9.5 m, length = 12.3 m) contained 12 free stalls configured in 2 rows. The stalls had a bed length of 2.6 m and were separated by Dutch-style partitions, measuring 1.2 m wide center to center, with a neck rail 1.2 m high and 1.5 m from the rear curb, and the brisket board 1.7 m from the rear curb. The stall base was a geotextile mattress bedded with 0.1 m of kiln-dried soft-wood sawdust (approximately 7.5 kg/stall). Flooring elsewhere in the pen was covered with textured rubber. The alleys closest to the feed bunk and between the 2 rows of stalls measured 3.5 m and 3.0 m in width, respectively. Alleys were cleaned 6 times/d with automatic scrapers.

Each pen had 9.5 m of feed bunk space available through a headlock barrier. Animals were fed *ad libitum* a forage-based diet containing corn silage, grass silage, and alfalfa hay. Fresh feed was provided daily (0800 h) and feed was pushed up 2 times/d. Water was available *ad libitum* from a trough.

The wet treatment was created by soaking 45 kg (i.e., 7.5 kg for each of 6 stalls per pen) of kiln-dried sawdust per stall in a 0.6 m³ water-filled tub. Bedding was replaced twice daily (0800 and 1800 h), and samples were collected at the beginning and end of each experimental phase. Samples from each stall were stored in plastic bags and kept in a freezer until oven-dried at 55°C for 2 d. Samples averaged ($\pm$ SD) $86.4 \pm 2.1\%$ DM for the dry condition and $26.5 \pm 2.1\%$ DM for the wet condition.

Cows were acclimatized to the test pen for 5 d and then tested sequentially (each for 2 d, with order alternated between groups) with access to stalls containing either kiln-dried or wet sawdust bedding. These no-choice phases were followed by a 2-d free-choice phase when cows had access to stalls containing either wet or dry bedding. During this free-choice phase, treatments were alternated among adjacent stalls, and treatment

conditions were reversed after 24 h so that each stall was tested with each treatment.

Behavior was recorded for 24 h during each experimental phase by using 3 cameras (Panasonic WV 330; Panasonic, Mississauga, Ontario, Canada) positioned 10 m above the experimental pen. The cameras were attached to a video multiplexer (Panasonic WJ FS416) and a time-lapse recorder (Panasonic AG 6540). Red lights (100 W) were hung 10 m above the pen to facilitate video recording at night. Cows were marked with unique symbols by using hair dye to identify individuals, and stalls were numbered for identification. Video recordings were scanned at 10-min intervals, and for each scan, cow position [lying, standing with 2 hooves in the stall (perching), standing with 4 hooves in the stall, lying or standing elsewhere in the pen, feeding, and drinking], cow number, and, where appropriate, stall number were recorded.

Two thermometers of minimum and maximum temperatures were used to record daily temperatures inside the experimental pen for each experimental group, and these were $3.4 \pm 2.3^\circ\text{C}$ and $6.8 \pm 2.6^\circ\text{C}$, respectively.

Statistical Analysis

Animal responses were analyzed by using a mixed model, with group ($n = 4$) as the observational unit during the no-choice phases and cow ($n = 24$) as the observational unit during the free-choice phase. Body condition score and BW were included as covariates in preliminary analyses, but were never significant and were not reported further.

RESULTS

During the no-choice phases of the experiment, cows were restricted to free stalls with either wet or dry bedding. When provided access to the stalls with dry bedding, cows spent 13.8 ± 0.8 h/d lying down, but this figure declined to 8.8 ± 0.8 h/d when cows were restricted to stalls with wet bedding (Figure 1A; $F_{1,5} = 21.2$, $P = 0.006$). All cows spent more time lying down when provided access to stalls with dry bedding, but the magnitude of this difference varied from just 40 min/d for one cow to more than 11 h/d for another.

Cows compensated for this reduced lying time by tending to spend more time standing with just the front 2 hooves in the stall (Figure 1B; $F_{1,5} = 4.0$, $P = 0.1$), by spending more time standing fully in the stall (Figure 1C; $F_{1,5} = 6.6$, $P = 0.05$), and by spending more time standing inactive in the alley outside the stall (Figure 1D; $F_{1,5} = 25.0$, $P = 0.004$). Cows spent a little more than 5 h/d feeding, with no difference between treatments (5.3 ± 0.3 h/d on the dry bedding vs. 5.7 ± 0.3 h/d on the wet bedding; $F_{1,5} = 1.1$, $P = 0.32$).

Figure 1. Time (h/d) spent (A) lying down, (B) standing in the stall with the front hooves (perching), (C) standing with all 4 hooves in the stall, and (D) standing in the alley outside the stall. Least squares means ($\pm$ SE) are reported separately for periods when groups ($n = 4$, each of 6 cows) had access to stalls with only wet or dry sawdust bedding during the no-choice phases of the experiment.

Cows showed a clear preference for the dry stalls during the free-choice phase of the experiment; cows spent 12.5 ± 0.3 h/d lying down in the stalls with dry bedding and 0.9 ± 0.3 h/d in the stalls with wet bedding (Figure 2A; $F_{1,23} = 640.7$, $P = 0.0001$). All cows spent most of their lying time in the dry stalls, and 50% of the cows did not lie down at all in the stalls with wet bedding. During this free-choice phase, cows also spent more time standing in stalls with dry bedding. This was true both for standing with just the front 2 hooves in the stall (Figure 2B; $F_{1,23} = 23.9$, $P < 0.0001$) and for standing fully in the stall (Figure 2C; $F_{1,23} = 13.4$, $P = 0.001$). For this phase, cows stood and fed from a common alley, so these behaviors cannot be shown by treatment.

DISCUSSION

No-Choice Phases

Maintaining lying times is a key priority for dairy cattle; cattle will work (i.e., press repeatedly on a panel; Jensen et al., 2004) and forgo eating (Munksgaard et al., 2005) to increase lying times. When cows had access only to stalls freshly bedded with kiln-dried sawdust, lying times averaged almost 14 h/d. This value is simi-

lar to that observed in previous studies on dry cows with access to well-bedded free stalls (Tucker and Weary, 2004). In contrast, when cows had access only to stalls with wet bedding, lying time decreased to <9 h/d. This 5 h/d treatment difference compares with the 0 to 3 h/d treatment differences in studies on stall surface (Tucker et al., 2003), bedding depth (Tucker and Weary, 2004; Drissler et al., 2005), stall width (Tucker et al., 2004), neck rail placement (Tucker et al., 2005), brisket board position (Tucker et al., 2006), and stocking density (Fregonesi et al., 2007). The reduction in lying times observed in the current study is consistent with a study that found 8 h/d longer lying times when cows were kept indoors vs. in a wet environment outdoors (Tucker et al., 2007). The only other study to report this great a difference in lying times was by Manninen et al. (2002), who found 5 to 9 h/d less lying time when cows were provided stalls with unfamiliar sand bedding compared with familiar straw-bedded stalls.

Reduced lying times are likely aversive to the cows (Munksgaard and Simonsen, 1996; Fisher et al., 2002). In previous studies in our facilities, changes in stall design or management never resulted in cows lying down outside the stall, but in the current experiment, 2 cows were observed lying down on the rubber flooring outside the stall. Cows can cope with some restriction in lying times by changing body posture to alleviate strain on the legs and hooves while standing (Cooper et al., 2007), but motivation to lie down increases after only a few hours of deprivation (Metz, 1985). Recently, Tucker et al. (2007), and in earlier work, Fisher et al. (2002), demonstrated that cows with similarly restricted lying times have elevated levels of plasma cortisol and other indicators of physiological stress.

If cows spend less time lying down, then they must spend more time standing, and cows in the current experiment had increased standing times in most areas monitored. Where cows spend this standing time likely varies with the importance of the activity and the comfort of the standing area. For example, feeding time appears as a high-priority behavior and was not reduced, even when cows spent much more time lying down in the dry stalls. Other studies that have monitored behavior in relation to comfort of the stalls (Haley et al., 2000, 2001) and comfort of the standing area in front of the feeder (Fregonesi et al., 2004) have found little effect on time spent feeding. Yet after a period during which both feeding and lying were prevented, cows compensated by increasing the proportion of time spent lying, indicating that maintaining lying times was especially important (Munksgaard et al., 2005).

Time spent standing fully or partially in the stall is known to be affected by several factors, including neck rail placement, stall width, and cow size (Tucker et

Figure 2. Time (h/d) spent (A) lying down, (B) standing in the stall with the front hooves (perching), and (C) standing with all 4 hooves in the stall. Least squares means ($\pm$ SE) are reported separately for periods when cows ($n = 24$) had access to stalls with either wet or dry sawdust bedding during the free-choice phase of the experiment.

al., 2004, 2005). Cows also stand in the stall to escape uncomfortable standing surfaces outside the stall (Stefanowska et al., 2001; Tucker et al., 2006), and perhaps to use the stall as a refuge from more dominant herd mates (Galindo and Broom, 2000). In our work, cows spent more time standing in the wet stalls, likely because they were reluctant to lie down.

Free-Choice Phase

The results from the free-choice phase agree with earlier work by Keys et al. (1976) showing that cattle avoid lying on surfaces with a high moisture content. One explanation for the aversion to wet bedding is that cows avoid the chilling effects of contact with a surface that conducts body heat, and their preferences for stall surfaces are known to be affected by temperature (Wagner-Storch et al., 2003). This trial was carried out during the winter, and temperatures within the barn were mild (averaging 3 to 7°C). Cattle were more tolerant of low than high temperatures (Knizková et al., 2002), but nonlactating cows like those used in the current study likely have less tolerance for low environmental temperatures than do lactating cows (Purwanto et al., 1990). Conductive heat loss caused by contact with wet bedding should be a problem only in cold condi-

tions, but Keys et al. (1976) found that cows avoided wet bedding when tested in both winter and summer conditions, indicating that the preference for dry bedding was related not only to thermoregulation.

The ability to tolerate heat loss will vary with cow size and body condition; Tucker et al. (2007) found that New Zealand Holsteins with a low BCS were particularly affected by wet conditions. We did not find an interaction between treatment and BW or BCS in the current study. Tucker et al. (2007) found that cows varied their lying position on wet surfaces, likely in an attempt to avoid conductive heat loss. We did not record body position while lying, but encourage future research on this topic to do so.

Before the experiment, cows had been housed in a barn with sand-bedded stalls, but all the cows had had previous experience with sawdust bedding as heifers. In addition, before the free-choice phase, all the cows had had at least some experience with both the dry and wet sawdust during the no-choice phase. Previous work has shown that when cows have experience with both sand and sawdust bedding, they show good acceptance of both (Tucker et al., 2003). That said, the animals would have had much less previous experience with wet sawdust bedding prior to the study, so it is possible that the strong avoidance of wet bedding may have become tempered with more exposure.

In the free-choice phase, cows spent more time standing fully and with 2 hooves in the stalls with dry bedding. This difference likely reflects the fact that cows often stand for a period of time before they lie down and after they get up. The increased standing times in the dry stalls during the free-choice phase contrasts with the increased standing times in wet stalls during the no-choice phase. This difference can be explained by the available alternatives in the 2 cases. During the free-choice phase, cows could stand in the alley, in dry stalls, or in wet stalls, and they largely avoided the latter option. In the no-choice phase (wet bedding), cows had a choice only between standing in the alley and in wet stalls, and they likely chose the wet stalls in preference to the alley. It should be noted that the sampling method used (10-min scan sampling) is well suited for behaviors that are reasonably common (such as lying and perching) but is less well suited for behaviors that are infrequent or short in duration (such as standing fully in the stall). Although the 10-min scans were sufficient to detect treatment differences, we suggest the use of shorter scanning intervals in future work.

In conclusion, dairy cows showed a clear preference for a dry lying surface, and they spent much more time standing outside the stall when only a wet lying surface was available. This effect of bedding quality was greater than for any other effect of stall design or management

we have documented in previous work, and suggests that maintaining a dry lying surface is important to cows. Future research should document how cows respond to a range of bedding moisture levels. Future studies should examine how this effect varies in relation to varying cow condition and environmental temperatures, and should document cow lying postures in addition to time budgets.

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