11-2009

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Recommended Citation

Fregonesi, J. A., Von Keyserlingk, M. A. G., & Weary, D. M. (2009). Cow preference and usage of free stalls compared with an open pack area. Journal of dairy science, 92(11), 5497-5502. doi: 10.3168/jds.2009-2331

J. Dairy Sci. 92:5497–5502
doi:10.3168/jds.2009-2331

Cow preference and usage of free stalls compared with an open pack area

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ABSTRACT

Free-stall housing systems are designed to provide a comfortable and hygienic lying area, but some aspects of stall design may restrict usage by cows. The aim of this study was to compare free-stall housing with a comparable lying area (open pack) without stall partitions. We predicted that cows would spend more time lying down and standing in the bedded area when provided access to an open pack than when in free stalls. We also predicted that cows would spend less time standing outside of the lying area and less time perching with the front 2 hooves in the lying area when using the open pack. Groups (n = 8) of 12 cows each were provided access to either the open pack or stalls. After a 7-d adaptation period, each group was tested sequentially in the 2 treatments for 3 d each. This no-choice phase was followed by an 8-d choice phase during which cows had simultaneous access to both treatments. During the no-choice phase, cows spent more time lying down (13.03 ± 0.24 vs. 12.48 ± 0.24 h/d) and standing with all 4 hooves in the bedded area (0.96 ± 0.12 vs. 0.41 ± 0.12 h/d) of the open pack than in the stalls. During the choice phase, cows spent more time lying down (7.20 ± 0.29 vs. 5.86 ± 0.29 h/d) and standing with all 4 hooves in the bedded area (0.58 ± 0.07 vs. 0.12 ± 0.07 h/d) of the open pack than in the stalls. In both the no-choice (1.66 ± 0.24 vs. 0.55 ± 0.24 h/d) and choice (0.55 ± 0.07 vs. 0.29 ± 0.07 h/d) phases, cows spent more time standing with just 2 hooves in the stalls than in the open pack. In conclusion, cows spent more time lying and standing with all 4 hooves in the bedded open pack than in the stalls. Additionally, cows spent more time standing in the alley and standing with just the front 2 hooves on the bedding in the stalls than in the bedded open pack; increased standing time on wet concrete is a known risk factor for lameness.

Key words: dairy cattle, cow comfort, free-stall design, open pack

INTRODUCTION

Free-stall housing systems are designed to provide a comfortable and hygienic lying area, but some aspects of stall design may restrict usage by cows. Measures of stall usage, including time spent lying and standing, and measures of preference can provide insight into aspects of housing design that are important to cows. Housed dairy cattle spend approximately 8 to 16 h/d lying down (Dechamps et al., 1989; Tucker and Weary, 2004) and 0.5 to 3 h/d standing in stalls (Stefanowska et al., 2001; Fregonesi et al., 2009).

Cows prefer lying surfaces with more bedding and spend more time lying down in heavily bedded mattress stalls. For example, in a study by Tucker and Weary (2004), cows spent approximately1.5 h/d more lying in heavily bedded stalls than in ones with little or no bedding. The effects of the type and size of the lying space are less well-understood. In one study, heifers were housed in straw-bedded pens with 1.8, 2.7, or 3.6 m^2 of lying space (Mogensen et al., 1997) and, in another study, cows were housed with either 9 or 4.5 m^2 of bedded area per cow (Fregonesi and Leaver, 2002); in neither study did lying time vary with space allowance.

A series of experiments has tested how the hardware used to configure free stalls affects stall usage. The results of these studies are consistent: all show decreased stall usage when stall hardware is used or positioned in such a way that it is more likely to contact the cow. For example, cows spend less time lying and standing in stalls when their partitions are closer together (Tucker et al., 2004) and spend less time standing in stalls when the neck rail is positioned closer to the stall entrance (Tucker et al., 2005). More restrictive positioning of the neck rail and stall partitions restrain forward movements in the stall while the cow is standing, thus reducing soiling of the stall surface with urine and feces (Fregonesi et al., 2009). The brisket board achieves the same function of restricting where cows lie down, but cows also spend less time lying down when stalls have a 20-cm-high brisket board than when stalls did not have this barrier (Tucker et al., 2006a). Given the individual effects of these stall attributes on stall use, bedded ar-

Received April 27, 2009.
Accepted July 20, 2009.
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eas without any such hardware are predicted to be used more for both lying and standing.

Comparing different housing systems is difficult; previous attempts to compare free-stall housing with open packs have been marred by confounded comparisons (e.g., comparing pens or barns with housing conditions that differ in respects other than the treatment of interest) or by inadequate replication (e.g., testing each treatment in only a single pen or barn).

The aim of the current experiment was to provide the first fully controlled and replicated comparison of free-stall housing versus an open lying area (open pack) by testing stable groups of cows in identically configured pens, one in which stall hardware (including stall partitions, neck rails, and so on) was installed and one in which hardware was removed to create an open pack. We measured lying and standing behavior both when cows were restricted to each of the treatments in turn and when they were provided free access to both treatments.

MATERIALS AND METHODS

The experiment was conducted at the University of British Columbia's Dairy Education and Research Centre in Agassiz, British Columbia, Canada, from October to December 2006. Ninety-six mid-lactation Holstein cows were randomly assigned to 8 groups of 12 animals each. Average (mean ± SD) parity was 2.6 ± 1.60 lactations, DIM 198 ± 58 d, milk yield 35.5 ± 6.48 L/d, body height 140 ± 5 cm (measured at third thoracic vertebra), body length 142 ± 5 cm (measured between the first cervical vertebra and the most caudal vertebra at the base of the tail), BW 675 ± 72 kg, and BCS 3 ± 0.4 [scored from 1 to 5 following Edmonson et al. (1989)]. Cows were gait scored [scored from 1 to 5 following Flower and Weary (2006)] before being assigned to the experiment; all cows with a gait score >3.0 were excluded. The remaining cows had gait scores of 2.0, 2.5, and 3.0. The groups were balanced such that each included an equal number of cows of each score.

The experiment was carried out in a naturally ventilated wood-frame barn (width = 38 m, length = 156 m) with a north–south orientation and curtained sidewalls. Average minimum and maximum temperatures inside the barn were 5 ± 5.6°C and 12 ± 7.0°C, respectively. Each experimental pen (118 m^2) had a lying area (37.5 m^2) with a geotextile base and was bedded with 0.1 m of washed river sand. The lying area was either configured to contain 12 stalls (arranged in 2 rows of 6) or left as an open pack.

The stalls were separated by Dutch-style partitions, had a bed length of 2.6 m, and were 1.2 m wide when measured center-to-center. The neck rail was positioned 1.2 m above the stall surface and 1.5 m from the inside of the rear curb, as measured on the horizontal axis. A rounded brisket locator (Polly Pillow, Promat Inc., Woodstock, Ontario, Canada; height = 0.18 m) was positioned 1.70 m from the inside of the rear curb (height = 0.20 m). The open pack was created by removing all of the stall hardware with the exception of the brisket board. This created an open, 37.5 m^2 lying area with mattresses that were covered with 0.1 m sand, which was an identical surface to that available in the stalls.

The bedding surface was raked clean during every milking and fresh sand was added every 2 to 4 d as needed. Flooring in the alleys was textured rubber and was cleaned 6 times/d with automatic scrapers. Each pen had 9.5 m of accessible feed bunk space. Animals were fed a TMR containing, on a DM basis, 6.0 kg of corn silage, 2.8 kg of grass silage, 2.5 kg of grass hay, and 11.2 kg of concentrate per cow per day. Fresh feed was provided twice daily (at 0600 and 1500 h) and was pushed up 4 times/d. Water was freely available from a self-filling trough. Cows were milked twice daily (at 0800 and 1700 h) in a double-12 parallel milking parlor.

Experimental Design

Cows were acclimated to the test pen (configured with stalls) for 7 d before the experiment began. In the no-choice phase of the experiment, groups of 12 cows were then split into 2 subgroups of 6; each subgroup was tested in 1 of 2 adjacent pens containing the different housing treatments. After 3 d, the subgroups were switched to the alternate treatment in the adjacent pen and behavior was recorded for an additional 3 d. During the choice phase, the subgroups were merged and provided free access to the 2 pens (and 2 treatments) for 4 d. The placement of the 2 treatments was then reversed (i.e., the pen containing stalls was converted to an open pack and vice versa) and cows were provided an additional 4 d of free access to the 2 treatments. The starting placement of the housing treatments was switched for each of the 8 replicates.

Behavior

Behavior was recorded 24 h/d throughout the experiment using 3 cameras (Panasonic WV-BP334 24V) per pen. The cameras were positioned 10 m above the pen and were attached to a video multiplexer (Panasonic WJ FS416) and time-lapse recorder (Panasonic AG 6540; Panasonic, Mississauga, Ontario, Canada). Red lights (100 W) were hung 10 m above the pen to facilitate video recording at night. Cows were marked with unique symbols using hair dye to identify individuals.

Instantaneous scan sampling at 10-min intervals was used to identify location and behavior in the pens (lying, standing with either 2 or 4 hooves in the bedded area, standing outside of the bedded area, and feeding). Cows were scored as feeding when the cow's neck collar was visible from above on the feed alley side of the tombstone separating the cows from the feed alley. The total time per day spent on each of these activities was calculated for each cow.

Statistical Analysis

Observations on the total duration for each activity per cow per day (3 d in the no-choice and 4 d in the choice phases) were averaged to form a mean value per cow for each treatment condition. For the choice phase, these cow values were then averaged to form one mean per group (n = 8) per treatment (open pack or stall) for a total of 16 observations. The effect of housing on these data was tested using a mixed model, with the group specified as a random effect (7 df) and the effect of housing (1 df) tested against the residual error (7 df).

For the no-choice phase of the study, behavioral data were recorded only during the last 4 test groups. For this analysis, the cow values were averaged for each of the subgroups (n = 8), again yielding a total of 16 observations across the 2 treatments. The effect of housing on these data was tested using a mixed model identical to that described above.

We expected that larger cows would be the most affected by the stall architecture. To test the effect of cow size we subtracted choice phase treatment means for the open pack from those for the stalls; this was done separately for each cow (n = 96). These differences were then correlated (Pearson correlation; SAS, version 9.1.3; SAS Institute Inc., Cary, NC) with measures of cow height and length.

RESULTS

No-Choice Phase

When cows were restricted to stalls, they spent less time lying down; lying time was 13.03 ± 0.24 h/d in the open pack compared with 12.48 ± 0.24 h/d in the stalls ($F_{1,7} = 6.7$; $P < 0.037$). Cows also spent more time standing with all 4 hooves in the bedded area of the open pack than in the free stall ($F_{1,7} = 22.7$; $P < 0.002$). In contrast, cows spent more time standing with just the front 2 hooves in the bedded area ($F_{1,7} = 12.6$; $P < 0.009$) and standing in the alley ($F_{1,7} = 93.5$; $P < 0.001$) when housed in stalls than when housed in the open pack (Figure 1). Cows spent 5.04 ± 0.19 h/d

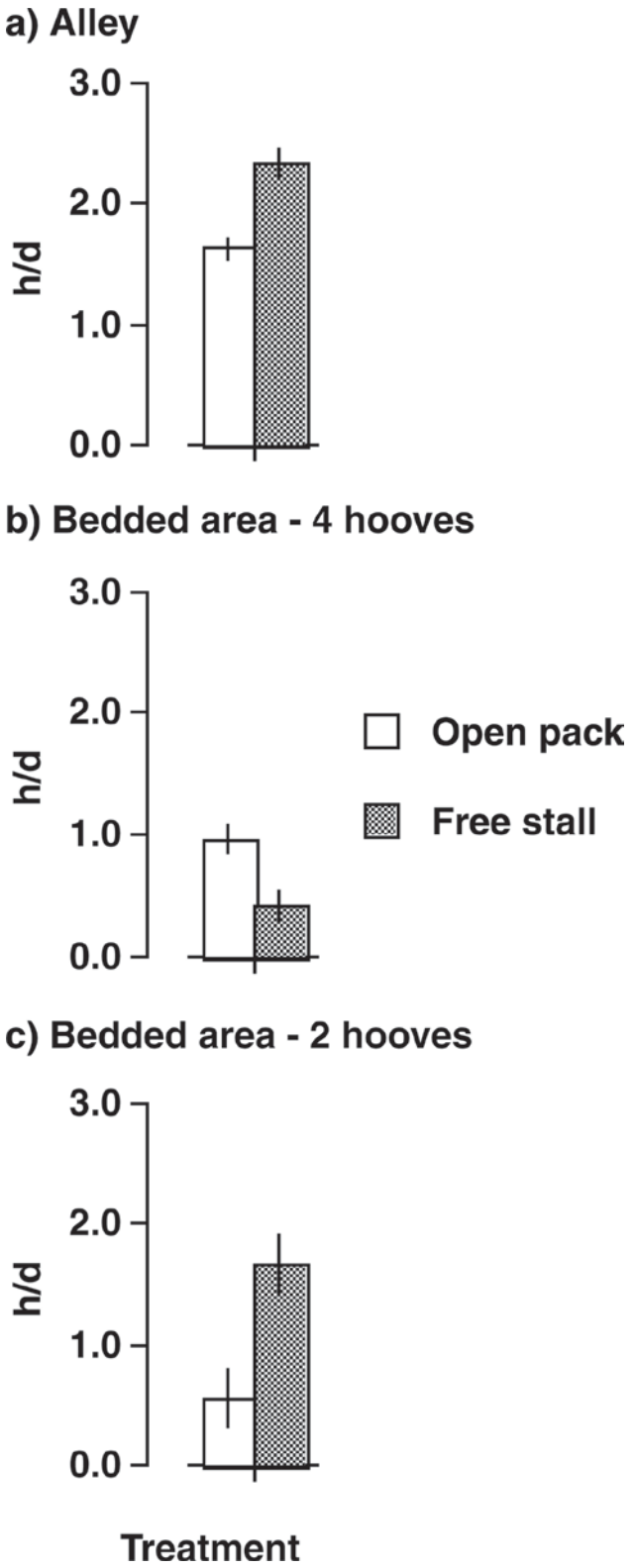

Figure 1. Results from the no-choice phase of the experiment. Mean (±least squares SEM) time (h/d) that dairy cows spent standing in the alley (a) and on the bedding surface with 4 (b) or 2 (c) hooves in the open pack or the free stall ($F_{1,7} \geq 12$, $P < 0.01$ for all 3 comparisons).

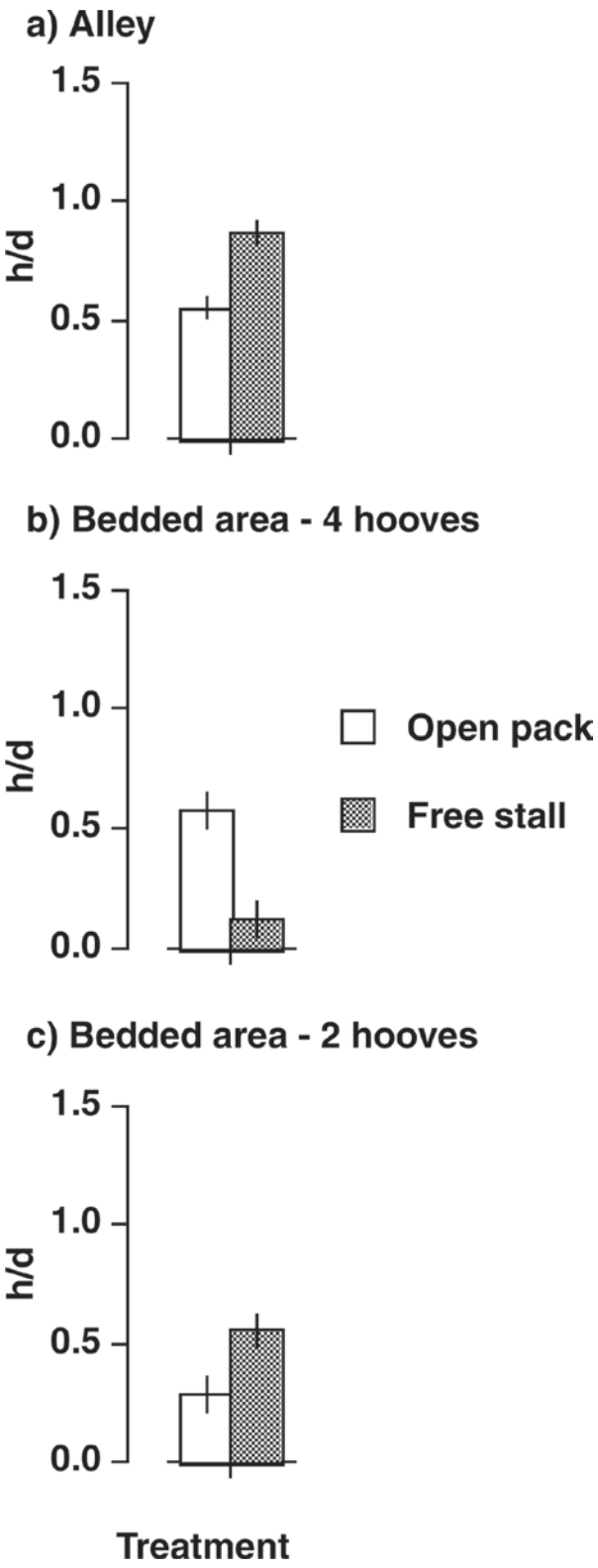

Figure 2. Results from the choice phase of the experiment. Mean (±least squares SEM) time (h/d) that dairy cows spent standing in the alley (a) and on the bedding surface with 4 (b) or 2 (c) hooves in the open pack or the free stall ($F_{1,7} \geq 22$, $P < 0.002$ for all 3 comparisons).

(mean ± SD) feeding, with no effect of treatment ($F_{1,7} = 0.95$, NS). There was no interaction between cow size and treatment for any measure.

Choice Phase

When offered the choice, cows spent more time in the open pack than in an equivalent free stall. During this phase, cows spent 7.20 ± 0.29 h/d lying in the open pack compared with 5.86 ± 0.29 h/d lying in the stalls ($F_{1,7} = 10.9$; $P < 0.013$). Cows spent more time standing with all 4 hooves in the bedded area of the open pack than in stalls ($F_{1,7} = 22.0$; $P < 0.002$), but spent more time standing with 2 hooves in the bedded area ($F_{1,7} = 36.1$; $P < 0.001$) and standing in the alley ($F_{1,7} = 38.3$; $P < 0.001$) in the free stall area than in the open pack (Figure 2). Feeding time averaged 2.54 ± 0.07 h/d in both pens, with no effect of treatment ($F_{1,7} = 0.00$, NS). As in the no-choice phase of the experiment, there was no interaction between cow size and treatment for any measure.

Cows were not unanimous in their preferences. Of the 96 cows tested, 53 spent more time lying down in the open pack than in the free stalls. Preferences were clearer in standing behavior; 92 of the 96 cows spent more time standing fully on the open lying surface and only 4 cows spent more time standing in the stalls. In contrast, 74 of the 96 cows spent more time perching with just their front 2 hooves on the bedded area in the stalls compared with the open pack.

DISCUSSION

No-Choice Phase

One method of establishing appropriate features of areas for lying and standing is to examine the amount of time cows spend using the areas available to them. When cows were housed in free stalls, lying times were within the ranges reported previously for this herd (Fregonesi et al., 2007). Providing the cows with an identical lying area, but without the stall partitions, had a significant but numerically modest effect: 13.03 h/d lying in the open pack compared with 12.48 h/d lying in free stalls. The comparison by Fregonesi and Leaver (2001) of an open straw lying area with multiple free stalls also showed a relatively modest difference in total lying times (13.20 vs. 11.76 h/d lying down). However, all studies to date have shown increased lying times when cows were provided access to more open areas such as straw yards in comparison with free stalls (Schmisseur et al., 1966; Phillips and Schofield, 1994; Fregonesi and Leaver, 2001). It is important to note that lying times are highly variable among farms and

among cows within a farm, such that the range of lying times that can be found within a system is greater than that among systems (Ito et al., 2009). For example, total time spent lying has been reported from as low as 9.36 h/d for one study in which cows were provided an open pack bedded with sawdust (Endres and Barberg, 2007) to as high as 13.92 h/d when cows were provided free stalls (Tucker and Weary, 2004).

The differences in lying time may have been caused, in part, by the stall partitions, neck rail, and associated hardware hindering the cows from freely getting up and lying down in the stall. We found no evidence that larger cows showed a stronger preference for the open pack, suggesting either that contact with stall hardware is not important or that even the smaller cows were affected by the stall hardware as configured in this study. The difference in lying time may have been greater had we used stalls that were narrower and less well-maintained; both factors are known to affect lying time (h/d) (Tucker et al., 2004; Drissler et al., 2005; Fregonesi et al., 2007).

When cows were restricted to the free stalls, they spent between 1.5 and 2 h/d standing with the 2 front hooves in the stall. This value is similar to that reported by Fregonesi et al. (2009) for similarly configured free stalls in the same research facility. To our knowledge, this study is the first to compare standing behavior in free stalls with standing behavior in open packs. The increased time cows spent perching with the front 2 hooves in the lying area of the stalls compared with time spent perching in the open pack is not surprising. A series of experiments has now shown more perching in more restrictive stalls, including stalls with neck rails positioned closer to the stall surface and entrance (Tucker et al., 2005; Bernardi et al., 2009; Fregonesi et al., 2009) and with less space between stall partitions (Tucker et al., 2004). These same studies also showed that providing larger stalls increases the time cows spend standing fully within the stall. Cows may stand on the lying surface to escape uncomfortable standing surfaces outside the stall (Stefanowska et al., 2001; Tucker et al., 2006). Interestingly, perching behavior was not eliminated in the current study when cows were housed in the open pack; cows still spent approximately 15 min/d standing in this position.

The cows in the current study had some experience with the open pack during the no-choice phase, but most of their previous experience was with the free stalls. Previous experience can affect cow preferences and behavior, and we suggest that previous experience may be an especially important factor in perching behavior. Cows may learn to perch when first introduced to stalls, particularly in situations in which the neck rail is restrictive; to our knowledge, no work to date has tested this idea.

Providing cows an opportunity to escape from hard, wet standing surfaces in the alley reduces the risk of lameness (Hernandez-Mendo et al., 2007; Bernardi et al., 2009). We suggest that open-pack systems, such as the one used in this study, may provide a useful option for producers interested in reducing the risk of new cases of lameness or helping lame cows recover.

Choice Phase

Preference tests can be especially useful as a first step in identifying features of housing systems that are important to animals and can be a powerful source of insight into how cattle perceive aspects of their environment and how they rank the various options provided (Fraser et al., 1993). In the present study, cows showed a relatively small and variable preference for the open pack as a place to lie down but showed a strong and consistent preference for the open pack as a place to stand with all 4 hooves. The total bedded area was identical in the 2 treatments, but the stall hardware limited where cows could stand and lie down. Previous work has reported that cows showed no preferences for lying in wider stalls (Tucker et al., 2004) or in stalls with different neck rail height positions (Tucker et al., 2005), but did show a strong preference for lying on softer (Tucker et al., 2003) and drier (Fregonesi et al., 2007) stall surfaces. These previous findings provide evidence that cattle appear to rarely consider spatial constraints when making decisions regarding where to lie down but that the nature of the lying surface is important (Tucker et al., 2005). Although both lying options in our experiment may have offered a suitable lying surface for the cows, it was clear that the cows preferred the open area for standing. These results provide further evidence that cows seek a comfortable, dry place to stand (Stefanowska et al., 2001; Tucker et al., 2004; Tucker et al., 2005; Bernardi et al., 2009).

The sand pack may have also allowed for increased social interactions. Galindo and Broom (2000) suggested that stall partitions have the advantage of protecting subordinate animals from aggression and displacement from the lying surface. The results of Fregonesi and Leaver (2001) were consistent with this idea; cows housed in an open straw pack showed more aggression and displacements than did cows housed in free stalls. Displacements were not monitored in the current study, but the almost uniform preference for standing in the open pack suggests that these negative social interactions were not a problem. Future studies should monitor these social interactions and displace-

ments in the 2 treatments, particularly when cows are overstocked.

The current study was designed to compare housing options in terms of cow preferences and the time cows spent lying and standing on the different surfaces. Given the strong preference for an open pack, at least as a place for cows to stand, more study is need on how to best manage pack-based systems. Open lying areas typically require more bed maintenance in order to maintain a clean, dry lying surface.

CONCLUSIONS

Cows spent more time lying and standing fully in an open pack than in stalls. When provided access to the open area, cows spent less time standing outside of the lying area and perching with the front 2 hooves in the lying area, both of which are behaviors associated with increased risk of lameness.

ACKNOWLEDGMENTS

We thank the faculty, staff, and students at University of British Columbia's Dairy Education and Research Centre and the University's Animal Welfare Program. Special thanks to Wiolene Montanaro, a student from Universidade Federal do Parana (UFP, Curitiba, Brazil). The Animal Welfare Program is funded by Canada's Natural Sciences and Engineering Research Council (Ottawa, Ontario) Industrial Research Chair Program with industry contributions from the Dairy Farmers of Canada (Ottawa, Ontario), Westgen Endowment Fund (Milner, British Columbia, Canada), Pfizer Animal Health (Kirkland, Québec, Canada), BC Cattle Industry Development Fund (Kamloops, British Columbia), the BC Milk Producers (Burnaby, British Columbia), BC Dairy Foundation (Burnaby, British Columbia), BC Dairy Education and Research Association (Abbotsford, British Columbia), Alberta Milk (Edmonton, Alberta, Canada), and others listed at www.ubc.ca/animal welfare. The first author also thanks Universidade Estadual de Londrina (UEL, Londrina, Brazil) and Coordenação de Pessoal de Nivel Superior (CAPES, Brasilia, Brazil).

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