Dairy cow preference for different types of outdoor access

Anne-Marieke C. Smid, Daniel M. Weary, Joao H. C. Costa,¹ and Marina A. G. von Keyserlingk²

Animal Welfare Program, Faculty of Land and Food Systems, University of British Columbia, Vancouver, BC, V6T 1Z6 Canada

ABSTRACT

Dairy cows display a partial preference for being outside, but little is known about what aspects of the outdoor environment are important to cows. The primary aim of this study was to test the preference of lactating dairy cattle for pasture versus an outdoor sand pack during the night. A secondary aim was to determine whether feeding and perching behavior changed when cows were provided outdoor access. A third objective was to investigate how the lying behavior of cows changed when given access to different outdoor areas. Ninety-six lactating pregnant cows were assigned to 8 groups of 12 animals each. After a baseline phase of 2 d in which cows were kept inside the freestall barn, cows were habituated to the outdoor areas by providing them access to each of the 2 options for 24 h. Cows were then given access, in random order by group, to either the pasture (pasture phase) or the sand pack (sand phase). As we tested the 2 outdoor options using space allowances consistent with what would be practical on commercial dairy farms, the space provided on pasture was larger (21,000 m²) than that provided on the sand pack (144 m²). Cows were tested at night (for 2 nights in each condition), from 2000 h until morning milking at approximately 0800 h, as preference to be outdoors is strongest at this time. During the next 3 nights cows were given access to both outside options simultaneously (choice phase). Feeding and perching behaviors were recorded when cows were indoors during the day and night periods. Lying behavior was automatically recorded by HOBO data loggers (Onset, Bourne, MA). Cows spent more time outside in the pasture phase (90.0 ± 5.9%) compared with the sand phase (44.4 ± 6.3%). When provided simultaneous access to both options, cows spent more time on pasture than on the sand pack (90.5 ± 2.6% vs. 0.8 ± 0.5%, respectively). Time spent feeding indoors during the day did not change regardless of what type of outdoor access was provided, but

there was a decline in perching during the day when cows were provided access to either outdoor option at night. Lying time in the pasture phase was lower than in the baseline or sand phase. During the nighttime, lying time outside was not different between the sand (55.4 ± 7.9%) and pasture (52.0 ± 7.4%) phases. In summary, cows spent a considerable amount of time outside during the night when given the opportunity and showed a preference for a large pasture versus a small sand pack as an outdoor area.

Key words: sand pack, pasture, animal welfare, free range, exercise

INTRODUCTION

Pasture access provides certain benefits to dairy cows (reviewed by Charlton and Rutter, 2017), including increased opportunities to express natural behaviors such as grazing and exploring. Providing cows access to pasture can also be positive for udder (Washburn et al., 2002), foot, and leg health (Haskell et al., 2006; Olmos et al., 2009).

Freestall-housed cows spend different portions of their time outside when given access to pasture, with the percentage of time spent outside varying across studies from 72% (Krohn et al., 1992) to 10% (Charlton et al., 2011b). One reason for this variation may be that cows in different studies varied in their experience with pasture. Experience can influence preference (Kirkden and Pajor, 2006), with animals often preferring environments with which they are familiar (Fraser and Matthews, 1997). This may help explain why in the study of Charlton et al. (2011b) the cows, which had limited pasture experience, spent more time indoors.

Preferences of animals can be complex (Fraser and Matthews, 1997). For example, cows may prefer different environments for engaging in different behaviors. They may prefer one environment for feeding but another for socializing. Many factors influence the preference of dairy cows for pasture access. An important factor that influences preference for pasture is the weather (e.g., Legrand et al., 2009; Charlton et al., 2011a, b). Cows spend more time on pasture at night (Charlton et al., 2011a, 2013; Motupalli et al., 2014), especially when ambient temperatures during the day are high

Received June 6, 2017.

Accepted September 17, 2017.

¹Present address: Department of Animal and Food Sciences, University of Kentucky, Lexington, KY 40546.

²Corresponding author: nina@mail.ubc.ca

(Legrand et al., 2009). It has also been shown that distance to pasture affects its use during the day but not during the night, which is consistent with a higher motivation of cows to access pasture during the night (Charlton et al., 2013; Motupalli et al., 2014).

Despite the clear benefits of pasture access for dairy cattle, it is often difficult to implement pasture access on dairy farms. Outdoor areas other than a pasture may be more practical to implement on some farms because the space requirements are normally lower than for pasture. However, little is known about what aspects of outdoor access are important to dairy cattle (Charlton and Rutter, 2017). For instance, are cows motivated specifically to graze? Or is their preference driven by preferences for alternate lying and standing surfaces not available indoors?

To our knowledge, no work has attempted to test whether freestall-housed cows prefer to access a pasture versus some other outdoor area, particularly during the night when cows show the strongest motivation for outdoor access (von Keyserlingk et al., 2017). In addition, although some work has shown welfare benefits of exercise in an outdoor pack (Loberg et al., 2004; Regula et al., 2004), no work has investigated whether the behavior of cows while in the barn changes when the cows have access to the outdoors. As changes in flooring (Fregonesi et al., 2004) and cubicle design (Bernardi et al., 2009) can influence the standing, lying, and perching behavior (standing with the 2 front hooves in the stall) of cows, the provision of outdoor access may also lead to changes in behavior of cows when inside their normal freestall housing.

Cows prefer to lie on pasture as opposed to in freestalls when environmental conditions are favorable (Legrand et al., 2009; Falk et al., 2012), probably because pasture provides cows with a less restricted environment than any type of loose housing environment (Krohn and Munksgaard, 1993; Charlton and Rutter, 2017). A soft outdoor pack can provide cows with some of the same benefits as pasture, as it allows cows to stand, walk, and lie down without having to navigate the confines of a freestall. Indeed, when given a choice between freestalls and an open sand pack indoors, cows spent more time lying and standing with 4 feet in the pack than in the freestalls (Fregonesi et al., 2009b). In addition, cows spent more time standing outside of the stall (typically on wet concrete surfaces) and more time perching with their front legs on the bedded surface when in freestalls versus the open pack (Fregonesi et al., 2009b); such behaviors increase the risk of lameness (Bernardi et al., 2009).

The primary objective of this experiment was to determine the preference of lactating dairy cows for pasture versus an outdoor sand pack during the night.

Our second objective was to determine whether feeding and perching behavior inside the barn changed when cows were provided outdoor access. A third objective was to investigate how lying behavior was affected by providing cows access to different outdoor areas.

MATERIALS AND METHODS

Cows and Treatment

This experiment was carried out at the University of British Columbia Dairy Education and Research Centre (Agassiz, BC, Canada) and took place between August and October 2015. This experiment and all procedures were approved by the University of British Columbia Animal Care Committee (protocol A15-0082).

We used 96 pregnant Holstein cows that were assigned to 8 groups (12 cows/group). Cows had (mean $\pm$ SD) a parity of 2.5 ± 0.2 , DIM of 243 ± 17 , a projected 305-d milk production of $10,937 \pm 448$ kg, a BCS of 3.4 ± 0.1 (range: 2.5–4.5), and a gait score of 2.0 ± 0.1 (range: 1–3). Two experienced observers assessed the BCS and gait scores of each cow. The BCS was assessed using a 5-point scale (1 = severely under condition, 5 = severely over condition) with quarter-point increments following Edmonson et al. (1989). Gait scoring was done using a 5-point scale (1 = healthy, 5 = severely lame) following Flower and Weary (2006). Severely lame cows (gait score 4 and 5) were not included in the experiment. The majority of cows had previously been kept on pasture for varying periods as heifers, and some had also been kept on pasture during previous dry periods.

Two groups were tested simultaneously. Each group was housed in 1 of 2 experimental pens for at least 14 d. After regrouping, animals were given at least 3 d to allow for the social behavior to stabilize (see von Keyserlingk et al., 2008). Groups were kept in the freestall barn for 2 additional days to allow for baseline observations (baseline phase). All animals had previous experience with sand bedding because they were kept on sand-bedded freestalls. Animals were given access to the sand pack and the pasture on alternate days for approximately 24 h each (i.e., from 1100 h until morning milking the following day) before data collection began. To ensure that cows were familiar with both outdoor areas during this habituation period, they were moved outside during these experience days at 1500, 2000, 2200, and 0600 h, if not already outdoors.

The data collection during which cows were provided free access to the outdoors consisted of 2 parts. The first followed immediately after the habituation phase. Cows were provided access to either the pasture (pasture phase) or the sand pack (sand phase) for 2 nights each. Nights were defined as the time between 2000 h

Figure 1. Schematic of experimental areas used to test the preferences of lactating dairy cows for different types of outdoor access.

and the next morning milking; from morning milking until 2000 h the cows were confined to the freestall barn. The order of access to the different outdoor areas was balanced among the groups. On the first day of both the pasture phase and the sand phase, all animals were forced outside. For the final part of the experiment, groups were given access to both outdoor areas for 3 successive nights (choice phase). The third day of the choice phase consisted of the nighttime only.

Housing, Management, and Diet

The 2 experimental pens (Figure 1) were located in a mechanically ventilated (72-in. Artex Storm fan, Artex Barn Solutions, Abbotsford, BC, Canada) wooden-frame freestall barn (42 × 93 m) with a north-south orientation and curtained sidewalls. Each pen (7.3 × 13.5 m) consisted of 12 lying stalls (2.4 × 1.2 m), configured in 3 rows of 4 stalls filled with ±40 cm of washed river sand. Stalls were divided by Dutch-style partitions spaced 1.2 m wide center to center, with the neck rail

placed 1.3 m above the stall surface and 1.4 m from the inside of the rear curb. The 0.2-m-high brisket board was placed 1.8 m from the inside of the rear curb that measured 0.2 m high from the alley floor. The concrete alleys were cleaned 6 times daily with an automated scraper; crossover alleys were manually cleaned twice per day. Each pen had a headlock feed barrier with 12 headlocks per pen (60 cm wide center to center).

Cows were fed a TMR formulated following NRC (2001) guidelines to meet or exceed the requirements of a 659-kg Holstein producing 34 kg of milk/d. The TMR consisting of 33% corn silage, 48% concentrate mash, 14% grass silage, and 5% alfalfa hay on a DM basis was fed inside during the complete experimental period and was available ad libitum. Fresh feed delivery took place between 0530 and 0630 h and between 1500 and 1600 h for one group and between 0630 and 0730 h and between 1600 and 1700 h for the other group. Feed was pushed up at approximately 1100, 1830, and 2230 h, and orts were taken away at approximately 0530 h. Animals had ad libitum access to fresh water provided

from a self-filling water trough located on the crossover alley. Each outdoor area also contained 1 self-filling water trough.

Animals were milked twice daily in a double-12 parallel milking parlor between 0730 and 0830 h and between 1730 and 1830 h. If animals were outside at the time of morning milking, they were moved directly to the parlor.

Outdoor Areas

Both the pasture and sand pack (Figure 1) were lined with electric fencing. Outdoor paths were covered with rubber mats. The sand pack was covered with approximately 15 cm of washed river sand and measured 144 m² (12 × 12 m). Each pasture plot was 21,000 m² (350 × 60 m). The pasture, planted in April 2015, consisted of 10% orchard grass (*Dactylis glomerata* L.), 43% tall fescue (*Festuca arundinacea*), 43% festulolium (*Festulolium pabulare*), and 4% annual ryegrass (*Lolium multiflorum*). Samples of the pasture were taken at the beginning of October (n = 5) and November (n = 8) to determine pasture quality. Approximately 40% of the field farthest from the barn was mowed at the end of September to allow regrowth and harvest of the grass. As the pasture plot was large, providing 1,750 m²/cow, it is unlikely that this would have affected pasture use. All feed samples were dried at 60°C for a total of 48 h to determine DM content. Dried samples were ground and sent for nutritional analysis (A&L Laboratories Inc., London, ON, Canada). During the experiment, pasture mass averaged (±SD) 1.11 ± 0.5 kg/m² of fresh matter; 17.8 ± 3.0% DM; and (expressed as % of DM) 22.5 ± 2.3% CP, 57.3 ± 1.9% NDF, and 33.2 ± 3.7% ADF.

Behavioral Measures

The behavior of the cows was recorded using video. Cameras (Panasonic WV-CW504SP outdoor video camera, Sandpiper Technologies Inc., Manteca, CA) were placed 6 m above the entrance of the barn, 8 m above the indoor alley that connected the outdoor areas with the experimental pens, and 8 m above each pen to provide an overview of the lying area. Above each experimental pen another camera (Panasonic WVCP-470, Panasonic Corporation of North America, Newark, NJ) was placed 6 m above the feed bunk. All recordings were stored using a GeoVision 1480 digital recorder (USA Vision Systems, Irvine, CA). Infrared lights (BR38 red incandescent flood light, 100 W; Globe Electric Co. Inc., Montréal, QC, Canada) were placed adjacent to each camera to facilitate the observation of the cows during the night. Each cow received a unique

symbol on its back made with hair dye to facilitate individual recognition of animals. Cows were scored as feeding and perching using 5-min scan sampling. Feeding was defined as the cow having its head completely through the headlock, and perching was defined as the cow standing only with the 2 front feet in the lying stall. Location of the animals (i.e., in the pen, pasture, or sand pack or in the indoor or outdoor alley) was scored using 5-min scan sampling.

Lying times were quantified using HOBO data loggers (HOBO Pendant G, Onset, Bourne, MA; UBC AWP, 2013). The data loggers were programmed to record the posture of the cow (i.e., lying or standing) in 1-min intervals. The logger was attached to 1 of the cow's rear legs before the beginning of the baseline phase and was removed after the experimental period. Loggers were attached and removed in the milking parlor.

Climatic Measures

For each experimental day, hourly mean air temperature, maximum relative humidity, mean wind speed, and total precipitation were recorded by the Environment Canada weather station in Agassiz, located 400 m from the UBC Dairy Education and Research Centre. Temperature, relative humidity, and wind speed during the nighttime (i.e., from 2000 until 0800 h) averaged (±SD) 12.6 ± 3.0°C (range: 3.8–20.5°C), 81.7 ± 15.4% (range: 41.8–98.1%), and 1.6 ± 1.6 m/s (range: 0–8.8 m/s). It rained on 9 out of 28 experimental days. Rainfall averaged 0.11 ± 0.33 mm (range: 0–2.4 mm) on days that it rained. Temperature-humidity index (THI), calculated as $THI = (1.8 T + 32) - [(0.55 - 0.0055 RH) \times (1.8 T - 26)]$ with T = air temperature (°C) and RH = relative humidity (%; Ravagnolo et al., 2000), averaged (±SD) 55.1 ± 4.8 (range: 40.0–66.8).

Statistical Analyses

During the experiment, 1 cow was identified as lame and was removed from the group, 2 others were diagnosed with an udder injury; all 3 were excluded from all data analyses. Two other cows came into heat; data collected on the days of estrus were discarded from all cows in the pen. Only 1 of these cows was removed from the group, as the cow showed signs of estrus on the day that data collection took place. The second cow showed signs of estrus during the baseline phase and was therefore retained in the experiment. One group was excluded from the analysis of feeding behavior because of a malfunction of the headlocks. Of this group, 1 animal was excluded from all analysis and 3 others were excluded for 1 d (2 animals) and 2 d (1 animal) because they were locked in the headlocks on these days

for >3 consecutive hours. For 2 groups, the last 24 h of data collection was excluded from all analysis because cows were accidentally given access to the outdoor areas during part of the day.

Data were summarized by group and phase. All analyses were performed considering group ($n = 8$) as the experimental unit, and all results are reported as a percentage of time available for observation (i.e., not in the inside or outside alley or away for milking or health checks). Data were scrutinized using PROC UNIVARIATE in SAS for normality and homogeneity (version 9.4, SAS Institute Inc., Cary, NC). Data were separated into day (return from morning milking until 2000 h) and night (2000 h until morning milking) periods. Analyses were performed using PROC MIXED in SAS. To test preference for the various locations (i.e., pen, pasture, or sand pack), the MIXED model included phase as fixed effect and group as random effect. All P -values were corrected using a Bonferroni correction.

Weather conditions (relative humidity, air temperature, wind speed, precipitation, and THI) never had a significant effect on the amount of time cows spent outside, and were thus excluded from the final model. However, when plotted, it appeared that high hourly rainfall (i.e., ≥ 1.4 mm/h) reduced the time spent outside. Therefore, the 2 d with ≥ 1.4 mm of rainfall per hour were removed from all analyses.

Treatment differences in feeding and perching were analyzed separately for daytime observations only (i.e., ~0800 to 2000 h, when animals never had outdoor access), and for day and night observations combined (to assess the effect of treatment on the total time budget). Lying behavior was only analyzed for day and night observations combined and for the time during which animals were outside. The MIXED model included phase as a fixed effect and group as a random effect, and used a contrast statement to test (1) whether behaviors differed between the pasture phase and sand phase and, if this was not significant, (2) whether the pasture and sand phases combined differed from the baseline phase. All models were run with a Bonferroni correction. Significance was declared when $P < 0.05$.

RESULTS

Preference

When freestall-housed cows were provided access to only pasture (pasture phase), they spent $90.0 \pm 5.9\%$ (range: 75.6–100%) of the available time outside; in contrast, cows spent about $44.4 \pm 6.3\%$ (range: 9.8–72.4%) of their time outside when provided access to only the sand pack (sand phase; Figure 2; $F_{1,6} = 29.03$, $P <$

Figure 2. Mean $\pm$ SEM percentage of time groups of lactating dairy cows ($n = 8$) spent outside (gray bar) and inside the freestall barn (white bar) during the night (2000 to ~0800 h) when provided free choice between the freestall barn and pasture and between the freestall barn and a sand pack.

0.01). When the cows were provided simultaneous access to both pasture and the outdoor sand pack (choice phase), they spent $90.5 \pm 2.6\%$ (range: 80.0–99.4%) of the time available on pasture and $0.8 \pm 0.5\%$ (range: 0–4.5%) of the time on the sand pack.

Behavior in the Freestall Barn

Time spent feeding indoors during the day (i.e., from morning milking until 2000 h) did not change when comparing baseline, pasture, and sand phases ($F_{2,11} = 0.25$, $P = 0.7812$; Table 1). Cows spent less time perching in the stall during the day during both the pasture and sand phases compared with the baseline phase ($F_{2,13} = 18.06$, $P < 0.001$). During the time available, time spent feeding indoors was highest during the baseline phase, intermediate in the sand phase, and lowest in the pasture phase ($F_{2,11} = 92.13$, $P < 0.001$). The same pattern was found for perching behavior ($F_{2,13} = 83.35$, $P < 0.001$).

Lying Behavior

Over the time available, lying time varied between the baseline, sand, and pasture phases ($F_{2,13} = 11.52$, $P < 0.01$; Table 1); this was driven by lower lying times during the pasture phase compared with the sand and baseline phases. The lying time in the baseline phase did not differ from that in the sand phase. The percentage of time cows spent lying when outside was not different in the sand phase ($55.4 \pm 7.9\%$) compared with the pasture phase ($52.0 \pm 7.4\%$; $F_{1,6} = 0.14$, $P = 0.718$).

DISCUSSION

When allowed free access to pasture during the night in this study, cows spent around 90% of their time outside. Other authors (Krohn et al., 1992; Charlton et al., 2011a; Motupalli et al., 2014) found that cows spent around 70% of their total time outside when given a choice between pasture and a freestall barn, but this number is a combination for day and night, and in the latter 2 studies pasture use was highest at night. Previous work (Legrand et al., 2009; Falk et al., 2012) found that cows spent about 80 to 90% of their time outside at night and tended to stay indoors during the day. Cattle are sensitive to heat stress (Blackshaw and Blackshaw, 1994), partially explaining why cows spend more time outside during the night. In addition, it appears that cows are specifically motivated to avoid solar radiation, an important feature in the design of shade for dairy cows (Schütz et al., 2009). Thus, avoiding direct sunlight and the consequences in terms of radiant heat may be a reason why outdoor access is especially preferred at night, at least during the summer months. Cattle also avoid rain (Legrand et al., 2009; Charlton et al., 2011b, 2013), and the results of the current study indicate that heavy rain kept cows indoors. We found no effect of other climatic variables on time spent outside, but readers should consider that the weather conditions under which this study was conducted were typical for the lower Fraser Valley region of British Columbia. During this study, the outside air temperature during the night ranged from 3.8 to 20.5°C, a range of temperatures that falls well within the lower (Hamada, 1971) and upper (Berman et al., 1985) critical temperature range for dairy cattle.

Cows that were provided access to an outdoor sand pack used this option but spent only about 44% of their time outdoors. When allowed access to both outdoor options, cows showed a preference to access pasture over the sand pack. This preference may have been due

to the greater available outdoor space on pasture versus the sand pack. By design, the space provided was different between the 2 outdoor options as we tested the sand pack and pasture options using space allowances consistent with what would be practical on commercial dairy farms. Future experimental work could examine the role of space independent of surface. In addition, future studies should investigate how much space is required per cow on an outdoor open pack.

The fact that cows could graze while on the pasture may also explain the preference for this option compared with the sand pack, particularly if grazing is a rewarding activity for dairy cows. Little is known about the motivation of cattle to graze (Charlton and Rutter, 2017), and we encourage work in this area, as the inability to graze may be an important constraint in the development of alternative forms of outdoor access for cattle.

The cows used in this experiment had varying degrees of previous experience with pasture, but the outdoor sand pack was novel. Cows were provided a habituation period for both options, but this period may have been inadequate for the sand pack. Previous work has shown that cows may require long adaptation periods to overcome initial preferences (Tucker et al., 2003). Therefore, the amount of time cows spend in the sand pack may have been higher if a longer habituation period was given.

Feeding time inside the barn during the day was not affected when cows had the choice to be outdoors during the night in either a pasture or a sand pack. This result is in line with the findings of Chapinal et al. (2010), who showed that overnight pasture housing did not decrease TMR intake. However, when considering day and night observations combined, feeding time was lowest in the pasture phase, intermediate in the sand phase, and highest in the baseline phase. It is possible that cows increased their feeding rate, as was observed by Legrand et al. (2009), to maximize the time spent outdoors, especially when pasture was available.

Table 1. Mean $\pm$ SEM time groups ($n = 8$) of cows spent performing different behaviors, expressed as a percentage of the time available for observation (i.e., not away from the pen for milking, and so on)¹

Behavior	Phase		
	Baseline	Pasture	Sand
Feeding, % day	23.8 $\pm$ 1.0	23.4 $\pm$ 1.0	24.1 $\pm$ 1.0
Perching, % day	5.0 ^a $\pm$ 0.4	3.3 ^b $\pm$ 0.4	3.7 ^b $\pm$ 0.4
Feeding, % day and night	18.2 ^a $\pm$ 0.4	12.8 ^c $\pm$ 0.4	16.3 ^b $\pm$ 0.4
Perching, % day and night	6.11 ^a $\pm$ 0.4	1.72 ^c $\pm$ 0.4	2.88 ^b $\pm$ 0.4
Lying, % day and night	57.2 ^b $\pm$ 1.3	52.3 ^a $\pm$ 1.3	59.0 ^b $\pm$ 1.3

^{a-c}Means within a row with a different superscript differ significantly ($P < 0.05$).

¹The results are shown separately for feeding and perching (i.e., standing with the 2 front feet in the lying stall) during the daytime observations (day, ~0800 to 2000 h), and for feeding, perching and lying during day and night combined.

In line with previous work (Hernandez-Mendo et al., 2007; Legrand et al., 2009; Charlton et al., 2013), our study found the lowest lying times when cows were given access to pasture. Legrand et al. (2009) suggested that lower lying times on pasture might be due to time spent grazing. Given that the lowest feeding times also occurred during the pasture phase, we speculate that cows spent a considerable amount of time grazing during this phase. However, as we did not take any observations when the cows were on pasture, we are unable to confirm this. Future work of this nature should consider equipping the animals with automated grazing monitors to investigate whether the lower lying times come from time spent grazing.

Cows spent around 54% of their time lying down when outside, and this figure did not differ between the pasture and sand phases. This result suggests that cows found the 2 surfaces equally comfortable for lying down. We thus speculate that the preference for pasture versus the sand pack in total time spent outside was driven by factors others than the comfort of the lying surface.

Cows spent less time perching during the day and over the total time available when they were provided outdoor access at night. This lower time spent perching may be beneficial to the cows' health, as perching is linked to lameness in dairy cattle (Bernardi et al., 2009; Fregonesi et al., 2009a, b). To our knowledge, this study is the first to show how outdoor access during the night affects the behavior of cows during the day. Lobeck et al. (2011) showed that cows housed on a compost bedded pack had improved foot and leg health, resulting in lower lameness rates compared with cows housed in freestall barns. Boyle et al. (2008) reported that heifers housed on an outdoor woodchip pad showed more social behavior, play, stretching, and scratching a part of their body while standing with 1 leg raised compared with heifers housed in a freestall barn. In combination, these results indicate that cows can benefit from access to an outdoor bedded pack.

CONCLUSIONS

Cows exhibited a preference to spend much of the night outside when provided the opportunity under the relatively mild weather conditions encountered in the current study. The preference to be outdoors was greater for a large pasture than for a small outdoor sand pack.

ACKNOWLEDGMENTS

We thank the staff of the University of British Columbia's Dairy Education and Research Centre (Agas-

siz, BC, Canada) for their help with the experiment. We also thank members of the University of British Columbia's Animal Welfare Program, in particular Marta Leal and Jensine Wilm, for their help with the video analysis. In addition, we thank Agriculture and Agri-Food Canada (Agassiz, BC, Canada) for providing us access to the hourly weather data. A. M. C. Smid was supported in part by the Irving K. Barber Victory in Europe scholarship. J. H. C. Costa was supported in part by a scholarship from CNPq (Brasília, Brazil). M. A. G. von Keyserlingk and D. M. Weary are supported by Canada's Natural Sciences and Engineering Research Council (NSERC; Ottawa, ON, Canada) via the Industrial Research Chair Program with industry contributions from the Dairy Farmers of Canada (Ottawa, ON, Canada), British Columbia Dairy Association (Burnaby, BC, Canada), Westgen Endowment Fund (Milner, BC, Canada), Intervet Canada Corporation (Kirkland, QC, Canada), Zoetis (Kirkland, QC, Canada), Novus International Inc. (Oakville, ON, Canada), BC Cattle Industry Development Fund (Kamloops, BC, Canada), Alberta Milk (Edmonton, AB, Canada), Valacta (St. Anne-de-Bellevue, QC, Canada), and CanWest DHI (Guelph, ON, Canada).

REFERENCES

- Berman, A., Y. Folman, M. Kaim, M. Mamen, Z. Herz, D. Wolfenson, A. Arieli, and Y. Graber. 1985. Upper critical temperatures and forced ventilation effects for high-yielding dairy cows in a subtropical climate. *J. Dairy Sci.* 68:1488–1495. [https://doi.org/10.3168/jds.S0022-0302\(85\)80987-5](https://doi.org/10.3168/jds.S0022-0302(85)80987-5).
- Bernardi, F., J. Fregonesi, C. Winckler, D. M. Veira, M. A. G. von Keyserlingk, and D. M. Weary. 2009. The stall-design paradox: Neck rails increase lameness but improve udder and stall hygiene. *J. Dairy Sci.* 92:3074–3080. <https://doi.org/10.3168/jds.2008-1166>.
- Blackshaw, J., and A. Blackshaw. 1994. Heat stress in cattle and the effect of shade on production and behaviour: A review. *Aust. J. Exp. Agric.* 34:285. <https://doi.org/10.1071/EA9940285>.
- Boyle, L. A., R. M. Boyle, and P. French. 2008. Welfare and performance of yearling dairy heifers out-wintered on a woodchip pad or housed indoors on two levels of nutrition. *Animal* 2:769–778. <https://doi.org/10.1017/S1751731108001870>.
- Chapinal, N., C. Goldhawk, A. M. de Passillé, M. A. G. von Keyserlingk, D. M. Weary, and J. Rushen. 2010. Overnight access to pasture does not reduce milk production or feed intake in dairy cattle. *Livest. Sci.* 129:104–110. <https://doi.org/10.1016/j.livsci.2010.01.011>.
- Charlton, G. L., and S. M. Rutter. 2017. The behaviour of housed dairy cattle with and without pasture access: A review. *Appl. Anim. Behav. Sci.* 192(July):2–9. <https://doi.org/10.1016/j.applanim.2017.05.015>.
- Charlton, G. L., S. M. Rutter, M. East, and L. A. Sinclair. 2011a. Effects of providing total mixed rations indoors and on pasture on the behavior of lactating dairy cattle and their preference to be indoors or on pasture. *J. Dairy Sci.* 94:3875–3884. <https://doi.org/10.3168/jds.2011-4172>.
- Charlton, G. L., S. M. Rutter, M. East, and L. A. Sinclair. 2011b. Preference of dairy cows: Indoor cubicle housing with access to a total mixed ration vs. access to pasture. *Appl. Anim. Behav. Sci.* 130:1–9. <https://doi.org/10.1016/j.applanim.2010.11.018>.

- Charlton, G. L., S. M. Rutter, M. East, and L. A. Sinclair. 2013. The motivation of dairy cows for access to pasture. *J. Dairy Sci.* 96:4387–4396. <https://doi.org/10.3168/jds.2012-6421>.
- Edmonson, A. J., I. J. Lean, L. D. Weaver, T. Farver, and G. Webster. 1989. A body condition scoring chart for Holstein dairy cows. *J. Dairy Sci.* 72:68–78. [https://doi.org/10.3168/jds.S0022-0302\(89\)79081-0](https://doi.org/10.3168/jds.S0022-0302(89)79081-0).
- Falk, A. C., D. M. Weary, C. Winckler, and M. A. G. von Keyserlingk. 2012. Preference for pasture versus freestall housing by dairy cattle when stall availability indoors is reduced. *J. Dairy Sci.* 95:6409–6415. <https://doi.org/10.3168/jds.2011-5208>.
- Flower, F. C., and D. M. Weary. 2006. Effect of hoof pathologies on subjective assessments of dairy cow gait. *J. Dairy Sci.* 89:139–146. [https://doi.org/10.3168/jds.S0022-0302\(06\)72077-X](https://doi.org/10.3168/jds.S0022-0302(06)72077-X).
- Fraser, D., and L. R. Matthews. 1997. Preference and motivation testing. Pages 159–173 in *Animal Welfare*. M. C. Appleby and B. O. Hughes, ed. CAB International, Wallingford, UK.
- Fregonesi, J. A., C. B. Tucker, D. M. Weary, F. C. Flower, and T. Vitte. 2004. Effect of rubber flooring in front of the feed bunk on the time budgets of dairy cattle. *J. Dairy Sci.* 87:1203–1207. [https://doi.org/10.3168/jds.S0022-0302\(04\)732](https://doi.org/10.3168/jds.S0022-0302(04)732).
- Fregonesi, J. A., M. A. G. von Keyserlingk, C. B. Tucker, D. M. Veira, and D. M. Weary. 2009a. Neck-rail position in the free stall affects standing behavior and udder and stall cleanliness. *J. Dairy Sci.* 92:1979–1985. <https://doi.org/10.3168/jds.2008-1604>.
- Fregonesi, J. A., M. A. G. von Keyserlingk, and D. M. Weary. 2009b. Cow preference and usage of free stalls compared with an open pack area. *J. Dairy Sci.* 92:5497–5502. <https://doi.org/10.3168/jds.2009-2331>.
- Hamada, T. 1971. Estimation of lower critical temperatures for dry and lactating dairy cows. *J. Dairy Sci.* 54:1704–1705. [https://doi.org/10.3168/jds.S0022-0302\(71\)86093-9](https://doi.org/10.3168/jds.S0022-0302(71)86093-9).
- Haskell, M. J., L. J. Rennie, V. A. Howell, M. J. Bell, and A. B. Lawrence. 2006. Housing system, milk production, and zero-grazing effects on lameness and leg injury in dairy cows. *J. Dairy Sci.* 89:4259–4266. [https://doi.org/10.3168/jds.S0022-0302\(06\)72472-9](https://doi.org/10.3168/jds.S0022-0302(06)72472-9).
- Hernandez-Mendo, O., M. A. G. von Keyserlingk, D. M. Veira, and D. M. Weary. 2007. Effects of pasture on lameness in dairy cows. *J. Dairy Sci.* 90:1209–1214. [https://doi.org/10.3168/jds.S0022-0302\(07\)71608-9](https://doi.org/10.3168/jds.S0022-0302(07)71608-9).
- Kirkden, R. D., and E. A. Pajor. 2006. Using preference, motivation and aversion tests to ask scientific questions about animals' feelings. *Appl. Anim. Behav. Sci.* 100:29–47. <https://doi.org/10.1016/j.applanim.2006.04.009>.
- Krohn, C. C., and L. Munksgaard. 1993. Behavior of dairy-cows kept in extensive (loose housing/pasture) or intensive (tie stall) environments II. Lying and lying-down behavior. *Appl. Anim. Behav. Sci.* 37:1–16.
- Krohn, C. C., L. Munksgaard, and B. Jonassen. 1992. Behaviour of dairy cows kept in extensive (loose housing/pasture) or intensive (tie stall) environments I. Experimental procedure, facilities, time budgets—Diurnal and seasonal conditions. *Appl. Anim. Behav. Sci.* 34:37–47. [https://doi.org/10.1016/S0168-1591\(05\)80055-3](https://doi.org/10.1016/S0168-1591(05)80055-3).
- Legrand, A. L., M. A. G. von Keyserlingk, and D. M. Weary. 2009. Preference and usage of pasture versus free-stall housing by lactating dairy cattle. *J. Dairy Sci.* 92:3651–3658. <https://doi.org/10.3168/jds.2008-1733>.
- Lobeck, K. M., M. I. Endres, E. M. Shane, S. M. Godden, and J. Fetrow. 2011. Animal welfare in cross-ventilated, compost-bedded pack, and naturally ventilated dairy barns in the upper Midwest. *J. Dairy Sci.* 94:5469–5479. <https://doi.org/10.3168/jds.2011-4363>.
- Loberg, J., E. Telezhenko, C. Bergsten, and L. Lidfors. 2004. Behaviour and claw health in tied dairy cows with varying access to exercise in an outdoor paddock. *Appl. Anim. Behav. Sci.* 89:1–16. <https://doi.org/10.1016/j.applanim.2004.04.009>.
- Motupalli, P. R., L. A. Sinclair, G. L. Charlton, E. C. Bleach, and S. M. Rutter. 2014. Preference and behavior of lactating dairy cows given free access to pasture at two herbage masses and two distances. *J. Anim. Sci.* 92:5175–5184. <https://doi.org/10.2527/jas.2014-8046>.
- NRC. 2001. *Nutrient Requirements of Dairy Cattle*. 7th rev. ed. Natl. Acad. Press, Washington, DC.
- Olmos, G., L. Boyle, A. Hanlon, J. Patton, J. J. Murphy, and J. F. Mee. 2009. Hoof disorders, locomotion ability and lying times of cubicle-housed compared to pasture-based dairy cows. *Livest. Sci.* 125:199–207. <https://doi.org/10.1016/j.livsci.2009.04.009>.
- Ravagnolo, O., I. Misztal, and G. Hoogenboom. 2000. Genetic component of heat stress in dairy cattle, development of heat index function. *J. Dairy Sci.* 83:2120–2125. [https://doi.org/10.3168/jds.S0022-0302\(00\)75094-6](https://doi.org/10.3168/jds.S0022-0302(00)75094-6).
- Regula, G., J. Danuser, B. Spycher, and B. Wechsler. 2004. Health and welfare of dairy cows in different husbandry systems in Switzerland. *Prev. Vet. Med.* 66:247–264. <https://doi.org/10.1016/j.prevetmed.2004.09.004>.
- Schütz, K. E., A. R. Rogers, N. R. Cox, and C. B. Tucker. 2009. Dairy cows prefer shade that offers greater protection against solar radiation in summer: Shade use, behaviour, and body temperature. *Appl. Anim. Behav. Sci.* 116:28–34. <https://doi.org/10.1016/j.applanim.2008.07.005>.
- Tucker, C. B., D. M. Weary, and D. Fraser. 2003. Effects of three types of free-stall surfaces on preferences and stall usage by dairy cows. *J. Dairy Sci.* 86:521–529. [https://doi.org/10.3168/jds.S0022-0302\(03\)73630-3](https://doi.org/10.3168/jds.S0022-0302(03)73630-3).
- UBC AWP. 2013. *University of British Columbia Animal Welfare Program: SOP - HOB0 Data Loggers*. pp. 1–23. University of British Columbia, Vancouver, Canada. Accessed Aug. 31, 2017. <http://lfs-awp.sites.olt.ubc.ca/files/2013/11/SOP-HOB0-Datalogger-november-2013.pdf>.
- von Keyserlingk, M. A. G., A. Amorim Cestari, B. Franks, J. A. Fregonesi, and D. M. Weary. 2017. Dairy cows value access to pasture as highly as fresh feed. *Sci. Rep.* 7:44953. <https://doi.org/10.1038/srep44953>.
- von Keyserlingk, M. A. G., D. Olenick, and D. M. Weary. 2008. Acute behavioural effects of regrouping dairy cows. *J. Dairy Sci.* 91:1011–1016. <https://doi.org/10.3168/jds.2007-0532>.
- Washburn, S. P., S. L. White, J. T. Green, and G. A. Benson. 2002. Reproduction, mastitis, and body condition of seasonally calved Holstein and Jersey cows in confinement or pasture systems. *J. Dairy Sci.* 85:105–111. [https://doi.org/10.3168/jds.S0022-0302\(02\)74058-7](https://doi.org/10.3168/jds.S0022-0302(02)74058-7).