Maternal isolation behavior of Holstein dairy cows kept indoors


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**ABSTRACT:** The aim of this study was to determine if, and under what conditions, indoor-housed dairy cows would seek a shelter to calve. Seventy-two Holstein dairy cows were paired by expected calving date and moved into a maternity pen that contained an open area with no cover and a sheltered area that was covered on all sides except for the ceiling and an entrance where cows could freely enter or exit. Once the first cow of a pair calved (“pair-housed”), she was removed; the second cow remained in the pen until calving (“single-housed”). For both pair- and single-housed cows, location and time of calving was determined by video. For single-housed cows, use of each area in the 12 h before calving was measured, and for pair-housed cows, distance from partner during the 12 h before calving was measured. Single-housed cows were more likely to calve in the shelter but only when calving occurred during the day ($P = 0.03$). Pair-housed cows were more likely to calve in the open area, regardless of time of day ($P = 0.02$). Beginning about 8 h before calving, single-housed cows that calved in the shelter increased their use of the shelter, and pair-housed cows spent more time away from their partners ($P < 0.001$ and $P = 0.01$, respectively). These results suggest that indoor-housed dairy cows prefer a shelter during calving but only when they were housed individually and when calving during the daytime.

**Key words:** calving management, labor, parturition

INTRODUCTION

When cover is available and high quality forage is nearby, wild ungulates will seek shelter to calve (bison: Lott and Galland, 1985; moose: Bowyer et al., 1999; elk: Barbkniece et al., 2011). Farmed dairy cows are often housed indoors and are provided little to no opportunity to hide during parturition. When dairy cows are kept in seminatural environments, some will hide to calve, but much like their wild counterparts, this behavior only occurs when suitable conditions are present (e.g., tall grass or tree cover with appropriate grazing sites are nearby; Lidfors et al., 1994).

Dairy cattle housed indoors are provided protection from predation and typically allowed ad libitum access to energy-dense, easily accessible feed. Management practices around parturition differ among farms, but cows are generally housed in either a group pen or moved to an individual maternity pen within hours or days before calving. Calving pens are often located in high traffic areas to allow frequent observations by farm staff to better detect calving difficulties.

The period around parturition is a sensitive time for dairy cows; there is a high risk of metabolic and infectious disease immediately after calving (see Ingvartsen, 2006, for a review). It has been suggested that a better understanding of the maternal behavior of parturient cows may help producers improve the care and management of these animals (von Keyserlingk...
and Weary, 2007). Yet no research to date has assessed if, and under what conditions, indoor-housed dairy cows will hide during calving when cover is made available. The objective of this study was to determine if indoor-housed dairy cows seek shelter to calve and if this behavior is influenced by the time of day of calving or the presence of another cow in the pen.

METHODS

Animals and Housing

Eighty-eight Holstein dairy cows (62 multiparous and 26 primiparous) were used in the experiment over a period of 6 mo (July to December 2011). The study was conducted at the University of British Columbia’s Dairy Education and Research Centre in Agassiz, BC, Canada. Animals were cared for according to the guidelines provided by the Canadian Council on Animal Care (2009).

Cows were housed in a precalving pen 21 d before their expected calving date. This pen had 12 lying stalls and 12 headlocks; lying stalls contained a mattress with a layer of sand. Stocking density was maintained at 12 cows in this pen (10 m² per cow) but was dynamic as cows came and left the pen depending on their expected calving date.

Cows were paired based on expected calving date. The pair was moved into 1 of 4 maternity pens 6.6 ± 3.0 d before calving and remained in this pen until they calved. This pen was the same size as the prepartum pen but contained either 1 cow (120 m² of space per cow) or 2 cows (60 m² of space per cow). These pens were lit by barn lights over the packs and feed bunk that automatically turned on at 0500 and 1600 h and off at 0800 and 2230 h.

Each maternity pen contained 2 packs (2.4 by 7.3 m), each with a mattress base and a thick layer of sawdust (approximately 6 cm deep). Manure and urine were raked and removed from each area 4 times per day (0800, 1200, 1600, and 2000 h). Sawdust was changed or added daily or when necessary to ensure that each lying space was clean and dry. After a cow calved on an area, the sawdust bedding of that area was completely removed and fresh bedding was provided. The dam and calf were removed from the pen immediately after calving.

Preference Test and Inclusion Criteria

Each maternity pen contained a “sheltered” area with a 2.4 m tall plywood barrier around 85% of the width of the area (excluding the ceiling) except for a 2.4 m wide opening for cows to freely enter or exit and an “open” area with no barrier (Fig. 1). To eliminate the effect of any side bias, the shelter was built on alternating sides of the 4 pens.

The pair of cows was introduced to the maternity pen at least 24 h before calving to gain exposure to both areas before calving. After the first cow of the pair calved, the second cow remained alone in the pen until she calved. The first cow of the pair to calve was considered to be the focal cow when the pair was in the pen (“pair-housed”), and the second cow in the pair to calve was considered to be the focal cow when she was in the pen alone (“single-housed”).

If a cow calved within 24 h of entering the pen it was assumed that she was not familiar with the new pen and was not included in the analysis (n = 4). Cows were also excluded from the study if they had a very difficult, assisted calving (n = 9); these cows were physically moved before imminent calf delivery, so we were unable to determine their choice of calving site. Two pair-housed cows began calving in the shelter (n = 1) or the open area (n = 1) and then moved into the alley during the last moments of calving. It is unclear what caused this behavior and what the calving site of these cows was, so they were also removed from the data set before analysis. One cow was removed due to hypocalcaemia (a disease that restricts mobility) before calving. The final analysis included 72 cows (50 multiparous and 22 primiparous; single-housed: n = 34; pair-housed: n = 38).

Behavioral Measurements

Four digital video cameras (WV-CW504SP; Panasonic USA, Newark, NJ) were mounted above each maternity pen and continuously recorded video using a GeoVision 1480 digital recorder (USA Vision Systems, Irvine, CA); each camera had a view of 1 area. Red lighting above each area was used to facilitate night viewing.

Video was used to determine the time and location of calf delivery, defined to be the time that the calf’s hips were fully expelled from the dam. Once time of birth
was established, the video was monitored for 12 h period before calving and the same 12 h period on the day before calving (i.e., 36 to 24 h before calving) using 5 min scan sampling. At each scan we measured the location of the focal cow (open or sheltered area; lying or standing with at least the 2 front hooves in the area) and whether or not she was greater than 1 cow length from her partner if she was housed in a pair. These data were used to determine when cows began to selectively use the shelter and separate from their partners before calving; video data were collected for a subsample \((n = 11)\) of single-housed cows that calved in the shelter and a subsample \((n = 20)\) of cows that were housed with a partner. These subsamples were used because digital video data were lost for the remaining animals in these categories.

### Statistical Analysis

All statistical analyses were performed with SAS software (version 9.2; SAS Inst. Inc., Cary, NC) using the cow as the experimental unit. In a preliminary logistic regression we determined that there was no effect of time spent in the maternity pen on calving site location using a model \((P > 0.05)\), so this factor was not considered below.

Two-tailed \(\chi^2\) tests (PROC FREQ) were used to determine the probability that cows would calve in the open or sheltered area and if this was dependent on time of day when calving occurred (day = 0800 to 1959 h and night = 2000 to 0759 h) or whether or not there was another cow in the pen at the time of calving.

To determine if and when cows began to selectively use the shelter and separate from their partners before calving, we subtracted the amount of time cows spent in the shelter or spent away from their partner during the 12 h baseline period (by hour) from the 12 h before calving. If cows performed these behaviors the same amount of time in both periods, this change would be zero; if cows performed these behaviors more during the 12 h before calving, this change would be positive.

Based on visual inspection of both graphs, it was clear that the data were nonlinear and segmented into 2 distinct lines. Nonlinear regression (PROC NLIN) showed that the optimal breakpoint (i.e., the hour that the pattern began to change) was 8 h before calving for time spent in the shelter and 8.3 h for time spent away from partner; for simplicity we used a breakpoint of 8 h for both behaviors in the following models. A piecewise random coefficients model (PROC MIXED) was used to determine the parameters of each line (the first line included data from 12 to 9 h and the second line included data from 8 to 1 h). The intercept and slopes for each cow were considered random, and the data were modeled with autoregressive covariance.

### Results

#### Calving Site Selection

Choice of calving site was dependent on whether or not there was another cow in the pen (Fig. 2; \(\chi^2_{71} = 5.47, P = 0.02\)). Twenty-one of the 34 single-housed cows calved in the shelter whereas a minority of pair-housed cows calved in the shelter (13 of 38).

Calving site selection was dependent on the time of day for single-housed cows \(\left(\chi^2_{33} = 4.90, P = 0.03\right)\) but not pair-housed cows \(\left(\chi^2_{37} = 0.01, P = 0.91\right)\). Of the single-housed cows that calved during the daytime, 13 of 16 used the shelter. When calving occurred at night cows were equally as likely to use each area.

#### Change in Behavior as Calving Approached

Figure 3A shows the change in time that single-housed cows spent using the shelter as calving approached. Cows decreased their use of the shelter over time up until 8 h before calving (slope = −4.5, SE = 0.8, \(P < 0.001\)); after this breakpoint cows increased their use of the shelter as the time of calving approached (slope = 7.2, SE = 1.2, \(P < 0.001\)).

Figure 3B shows the change in time that pair-housed cows spent greater than 1 cow length away from their partner as calving approached. Before the 8 h breakpoint, cows decreased their time spent away from their partner over time (slope = −1.9, SE = 0.6, \(P = 0.004\)). After this breakpoint cows increased their time spent away from their partner as calving approached (slope = 3.0, SE = 1.1, \(P = 0.01\)).
DISCUSSION

The objective of this study was to determine if, and under what conditions, indoor-housed dairy cows would use a shelter to calve. Our results suggest that cows have a preference for a shelter if they calved during the day and if they were alone in the pen.

It remains unclear why cows changed their preference based on the time of day. Potential factors influencing preference include changes in light, diurnal hormones, and human activity associated with time of day (e.g., the movement of cows through the barn for milking, researchers entering the pen to clean, etc.). This study was not designed to evaluate these factors, so we can only speculate on their influence. One other study reported an effect of calving time on calving site selection in ungulates (Dzialak et al., 2011). These authors sought to determine if preparturient elk living near human activity (a gas field) would change their birth site depending on time of day. Authors found that when calving occurred during the daytime when human activity was highest, calving site was characterized by cover and general avoidance of the gas field. In contrast, when calving occurred at night, the elk showed no aversion to the gas field and instead selected calving areas characterized by valley bottoms and proximity to foraging resources. However, it remains unclear whether it was the human activity per se that caused the elk to seek shelter in the daytime. Further research is needed to determine the reason that cows preferred shelter to calve during the daytime but not at night.

Single-housed cows that calved in the shelter began to increase their use of this area about 8 h before calving. This period coincided with the time that pair-housed cows began to spend more time away from their partners. The behavioral changes occurring 8 h period before calving likely coincide with the first stage of labor, when cows also begin to show other behavioral signs of calving. It is thought that the first stage of labor (i.e., the dilation of the cervix and start of uterine contractions) in cattle begins approximately 12 h before calving (Noakes et al., 2001), but it remains unclear exactly when this stage starts. The only clear indication of this stage is a dilated cervix, but this can only be detected with palpation and this is rarely done for fear that it will interfere with labor (Wehrend et al., 2006). Behavioral changes associated with this first stage of labor include increased restlessness, decreased feeding time, increased tail raises, and increased pawing or licking at the ground (Huzzey et al., 2005; Wehrend et al., 2006; Miedema et al., 2011; Jensen, 2012).

To our knowledge, this is the first study to report an estimation of the time that indoor-housed dairy cattle begin seeking a birth site and separating from a partner. In a study using preparturient dairy cows housed on pasture, Lidfors et al. (1994) found that cows began to distance themselves from the herd on the day of calving, but the time that this behavior began to change was unknown. This separation behavior and a reduction in time spent grazing with the herd were the first behavioral signs of calving recorded by these authors. Miedema et al. (2011) measured other changes in behavior as calving approached and discovered that a reduction in feeding time has the earliest breakpoint (15.4 h before calving) although there was high variation in the timing of this behavior. Behaviors with less variation began to change between 3 and 6 h before calving (tail raising: 6.3 h, lying frequency: 4.2 h, and ground licking: 3.3 h before calving). The breakpoints for the use of the shelter and separation from partner recorded in our study occurred slightly before many of these other behaviors. These behaviors may be associated with an early part of the first stage of labor, allowing the cow to find a secure a safe place to calve before calving becomes imminent.

It is unclear what caused the increased separation of pair-housed cows. The separation may be caused by the
focal cow avoiding her partner or may be a by-product of general restlessness and activity associated with imminent calving. It is also possible that the partner cow avoids the cow that is calving although there is more evidence supporting the idea that cows will distance themselves from the herd as calving approaches rather than vice versa (e.g., Lidfors et al., 1994).

When pair-housed, cows were more likely to calve in the open area rather than the secluded shelter. We speculate that the avoidance of the shelter was socially mediated and may be associated with reduced resource holding potential around parturition; that is, cows may have been less motivated to defend the shelter against their partner during parturition. In several cases we noted that the partner was using the shelter when the focal cow was calving (5 of 14 of the subsample of pair-housed cows calving in the open area), but in other cases there was no clear reason why cows chose the open area compared with the shelter. We also noted that cows would sometimes displace their partners from the shelter, signifying dominance over this resource. These dominance interactions suggest that the current design was not ideal; future studies may also wish to provide more than one shelter per cow to better identify the effects of competition on calving site preference.

Conclusions

Indoor-housed dairy cows preferred to use a secluded calving site when housed alone in the pen and when calving during the day. For cows housed individually that calved in the shelter, the use of this area increased at about 8 h before calving. For cows housed in pairs, separation from their partner also began about 8 h before calving. Both of these behavioral changes may coincide with the onset of first stage of labor.

LITERATURE CITED


