The Importance of Lying Behavior in the Well-Being and Productivity of Dairy Cows

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Introduction

The behavior of dairy cows is dependent on the interaction between the cows and their physical environment. In the "big picture," the physical features of the facility (stall design, flooring type, feed bunk design, environmental quality) impose baseline limitations on how the cows function within the housing conditions. Further, management routines, such as grouping strategy and stocking density, affect the ability of cows to engage in natural behaviors. The emphasis of this publication is on the overall importance of providing adequate time for the behavioral needs for animal health and well-being to be met on a daily basis.

For freestall housed parlor milked herds, the general consensus is that dairy cows will spend 12 to 14 hours per day resting (or lying) and three to five hours per day feeding (Table 1). These time budget requirements constitute 60 to 80 percent of a 24-hour period, which leaves a limited number of hours for milking and other management procedures. These estimates were confirmed by a study across 16 commercial farms in Wisconsin (Gomez and Cook, 2010). The observed cows spent 11.9 hours per day resting, 4.4 hours per day feeding, 2.5 hours per day standing in the alleys, and 2.7 hours per day in the milking parlor (Gomez and Cook, 2010).

Dairy cows on farms using automatic milking systems may have slightly different time budgets. In a study conducted on Swiss dairy farms, researchers found that cows spend 7.1 hours per day in the feeding area, 11.8 hours per day in the resting area, and 45 minutes per day in the holding area (Helmreich et al., 2014). Of the time spent in the resting area, 10.6 hours per day were spent lying down (Helmreich et al., 2014). The time spent in the feeding area does not necessarily reflect true feeding time, as was found on the farm in which cows spent the longest time, on average, in the feeding area using a "feed first" cow traffic pattern (i.e., cows had to enter and pass through the feeding area to access the automatic milking systems) (Helmreich et al., 2014).

Similarly, another study found that the frequency of milking altered the daily time budgets of dairy cows (Hart et al., 2014). Cows milked three times daily, compared to twice daily, tended to spend more time feeding while consuming longer meals at a slower rate (Hart et al., 2014). Increased milking frequency did not alter lying times, however, as the additional milking only required approximately 15 minutes per day (Hart et al., 2014). This finding might not reflect the time for additional milkings on commercial settings, and it is likely that lying time might be altered by milking three times per day due to increased time outside of the pen.

Table 1. Daily time budget for lactating dairy cows (Grant, 2007)

Activity	Time devoted to activity per day
Eating	3 to 5 hours (9 to 14 meals)
Lying/resting	12 to 14 hours
Social interaction	2 to 3 hours
Ruminating	7 to 10 hours
Drinking	30 minutes
Management activities	2.5 to 3.5 hours

Why focus on the time budget?

A survey conducted on 47 farms in northeastern Spain demonstrated the significant effects of both stall availability and stall maintenance on the productivity of dairy cows (Bach et al., 2008). The freestall stocking density of the study herds averaged 90 percent (0.9 cows for each available stall within the pen) with a range of roughly 60 to 200 percent. There was a considerable amount of variation in productivity in this environment. Herds ranged from 20 to 34 kg/d of milk per cow. This variation in productivity occurred despite cows being fed the same ration mixed at a common location for all participating farms. Stall availability and stall maintenance explained approximately 40 percent of the observed differences in production. A positive relationship between stall availability and milk production indicated each unit change in ratio of stalls to cows increased milk production by 7.5 kg.

The results reported by Bach et al. (2008) are similar to those collected at the Miner Institute. Instead of evaluating production and stall availability, a comparison of hours of rest and production was made (Figure 1). Each hour increase in resting time resulted in a gain of 1.7 kg of milk production. Recent research (Fregonesi et al., 2007; Hill et al. 2007; Krawczel et al., 2008) has demonstrated the effect of stocking density, or stall availability, on resting time.

The resting behavior of dairy cows

Typically, cows rest almost 50 percent (Table 1) of the day. In a recent survey of 45 farms in British Columbia, cows spent approximately 11 hours per day lying (Ito et al., 2009). However, the variation of lying behavior displayed by individual cows is substantial. Cows spent as few as four hours per day and as much as 19.5 hours per day (Ito et al., 2009) lying. Lying bouts were similar to lying time in the sense that across farms there was little variation in the mean (approximately nine bouts per day), but tremendous variation in individual cows (ranging from one to 28 bouts per day) (Ito et al., 2009).

Within the context of time budgets, resting held a higher priority than either feeding or socializing if access to the resources required to engage in the three behaviors (lying, feeding, and socializing) was restricted (Metz, 1985; Munksgaard et al., 2005). The priority that cows place on getting the required amount of rest makes it likely that a biological consequence would occur if this behavioral need was not met.

Lying behavior is controlled by aspects related to the individual cow and management practices. Ito et al. (2014) evaluated herd-level factors associated with lying time. They reported some regional differences in the deviation of lying time in freestall herds in the northeastern US and California. In the Northeast, deep bedding and DIM were the factors included in the final model for lying time (Ito et al., 2014). For standard deviation, stall stocking density, rubber flooring, and fecal contamination were the factors included in

their final model and explained 44 percent of the variation in lying time (Ito et al., 2014). While it did not remain in the final model, barn age was associated with lying time as a univariate factor (Ito et al., 2014). In California, the response was quite different and only DIM was reported to have a significant association with daily lying time, and the standard deviation of lying time was associated with feeding frequency (Ito et al., 2014).

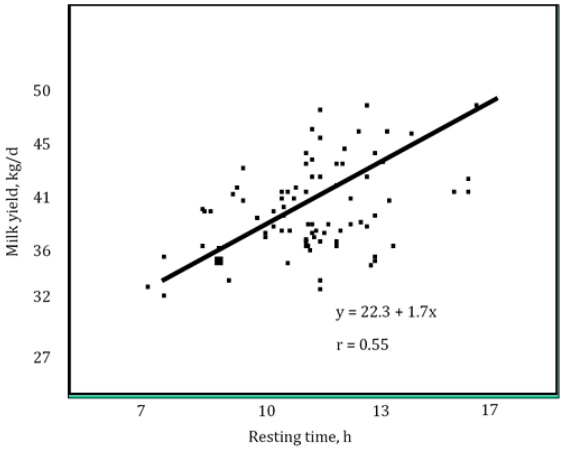

Figure 1. The relationship between daily milk yield per cow and time spent resting (Grant, 2007).

Effect of Stage of Lactation on Resting

Days in milk was a factor that consistently affected daily lying time in several studies (Bewley et al., 2010; Chaplin and Munksgaard, 2001). For freestall-housed cows, increased days in milk equaled an increase in lying time (Bewley et al., 2010). In tie-stalls, a similar relationship was observed between lying time and days in milk (Chaplin and Munksgaard, 2001). Cows in early lactation (< 100 days in milk) spent less time lying per day than cows in late lactation (> 200 days in milk) or nonlactating cows (Chaplin and Munksgaard, 2001). This finding might be due to changes in milk production over the course of lactation. Norring et al. (2012) reported a significant negative relationship between milk yield and daily lying time.

Effect of Freestall Design on Resting Behavior

The introduction of freestalls provided freedom of movement, but the design of the stall plays an integral part in how the cow perceives this aspect of her physical environment. Much of the testing for preference of dairy cows related to stall design was related to the features designed to ensure they were properly positioned within the stall to keep the bedding surface clean and maintain cow hygiene.

Brisket boards are located toward the front of the stall and their purpose is to prevent the cow from moving too far forward in the stall. When cows were offered a choice between stalls with or without a brisket board, they demonstrated a clear preference for the stalls without a brisket board (Tucker et al., 2006). The inclusion of a brisket board resulted in cows spending less time lying, shorter lying bouts, and lying in closer proximity to the end of the stall compared to the exclusion of a brisket board (Tucker et al., 2006). This decrease in lying may result in an increase in lameness, as brisket board height was a significant predictor of lameness in Minnesota dairies (Espejo and Endres, 2007).

The location of the neck rail (a bar that runs across the top of the freestall and is intended to keep the stall clean by positioning the cow within the stall) affects stall use and cow behavior (Tucker et al., 2005). Without a neck rail, cows spent more time standing with all four hooves on the surface of the stall. Furthermore, the inclusion of a neck rail at decreased heights reduced the time spent standing within a stall (Tucker et al., 2005). When offered a choice, cows spent significantly more time standing with their front hooves within a stall with the more restrictive neck rail heights and more time standing with all four hooves within a stall at the less restrictive neck rail heights (Tucker et al., 2005).

The position of the neck rail relative to the end of the stall (at a constant height) had a similar effect as height: increasing the distance from the end of the stall increased the time spent standing with four hooves within the stall and decreased the time spent standing with the front hooves within the stall (Fregonesi et al., 2009). This change in behavior resulted in a greater amount of fecal matter falling within the stall, which resulted in a numerically small, but significant, change in udder hygiene scores (Fregonesi et al., 2009). Most recently, elimination of the neck rail and much of the partitions altered how dairy cows used the freestalls (Abade et al., 2015). The more open, alternative design increased the time spent standing in a freestall, but cows preferred lying within a conventional freestall design (Abade et al., 2015).

The width of the stall also has a role in the overall comfort for the cow. This is demonstrated in a 2004 study by the increase in lying time and bouts of cows housed with 132 cm wide stalls versus those housed with 112 cm wide stalls (Tucker et al., 2004). Also, a linear effect occurred when stall width increased from 106 cm to 116 cm to 126 cm (Tucker et al., 2004).

The base of the stall can also have an effect on how cows use it. At a stocking density of 100 percent, cows spent a greater percentage of time lying in stalls with a sand base followed by two different styles of mattress (Wagner-Storch et al., 2003). In terms of total occupancy, cows spent more time on one mattress, but the same three bases that cows spent the greater percentage of time lying on were occupied the most (Wagner-Storch et al., 2003). A concrete-based stall was occupied the least (Wagner-Storch et al., 2003).

The preference for freestall base may depend on prior experience. Deep-bedded sawdust was favored over deep-bedded sand by naïve cows or by cows housed within deep-bedded sawdust in the previous lactation (Tucker et al., 2003). When these cows were housed with less preferred stall surfaces, their lying times decreased by approximately one hour, but the response was limited to one of the less preferred surfaces in each of the two experiments (Tucker et al., 2003). A similar response was reported in cows housed with rubber mats covered with sawdust (Norring et al., 2010). This stall base was preferred over concrete or sand, resulting in approximately one hour of additional lying time (Norring et al., 2010).

Effect of Bedding Quality on Resting Behavior

As demonstrated by Wagner-Storch et al. (2003), cows have a strong preference for freestalls containing some form of bedding material. Recent research investigated the role that bedding quality has on the lying behavior of cows. When subjected to stalls bedded with sawdust that was saturated with water, cows responded by decreasing their lying time by five hours (Fregonesi et al., 2007). When provided a choice, cows spent close to 13 hours lying in stalls with dry bedding and one hour in stalls with wet bedding (Fregonesi et al., 2007). A dose-response was evident, as cows subjected to four different levels of dry matter in bedding (ranging from 35-90 percent) increased their lying time as bedding dry matter increased (Reich et al., 2010). Cows housed on deep-bedded sand stalls responded in a similar manner. In a series of two experiments, as the depth of sand decreased (from 0 cm below the curb to either 6.6 cm or 13.7 cm), the lying time of cows decreased by one to two hours per day (Drissler et al., 2003).

Effect of Overstocking on Lying Behavior

The effects of stocking density on lying behavior has been of interest for several decades. The earliest research (Friend et al., 1977) suggested that total lying time was not

affected until a stocking density greater than 150 percent was imposed. Lying time at densities of 100, 120 and 150 percent was 14 hours per day, reducing to 10 and seven hours per day when stocking density was increased to 200 and 300 percent, respectively. The lying behavior of cows subjected to either under- (67 percent stocking density) or overcrowded (113 percent) conditions did not differ in terms of average lying times (10 hours per day), time spent ruminanting while lying (five hours per day), or total time within a freestall (15 hours per day) (Fregonesi and Leaver, 2002). This response may explain why Bach et al. (2008) found no benefit to undercrowding. However, fewer aggressive interactions per hour occurred in the undercrowded pen.

Conversely, increasing stocking densities incrementally from 100 to 142 or 150 percent resulted in a reduction of lying time (Krawczel et al., 2012a; Fregonesi et al., 2007), but the extent of the reduction varied. Krawczel et al. (2012a) observed a reduction of 42-48 minutes per day for cows spending 13 hours per day lying at a stocking density of 100 percent. Fregonesi et al. (2007) observed closer to a two-hour reduction in lying at 150 percent from the 13 hours per day that cows spent lying at 100 percent. Fregonesi et al. (2007) observed that a reduction of latency to lie down when stocking density exceeded 120 percent may be misinterpreted as an increase in cow comfort and may actually pose an increased risk of environmental mastitis.

Finally, a greater number of aggressive interactions per hour occurred with each increase in stocking density in both studies. This reported reduction of lying time was consistent with the reduction in the percentage of stall usage in overcrowded cows when stocking density was increased from 100 to 142 percent (Hill et al., 2007).

Importance of lying time

The reduction of resting time by overcrowding is the most likely explanation for the reduction in performance associated with stall availability. The priority for rest over feeding was evident in a recent research trial. Cows were housed in pens containing an isolation area and a resource area for various portions of the day (Munksgaard et al., 2005). Within the resource area, cows were able to rest, feed, or socialize. As time in the resource area decreased, the portion of time spent lying increased as cows attempted to maintain a consistent number of hours of rest.

Research at the Miner Institute demonstrated that overstocking results in an increasing percentage of cows standing idly waiting for access to free stalls (Hill et al., 2007). This effect becomes more pronounced between midnight and 4 a.m., the time period when the motivation to feed was reduced and the motivation to lie down increased. There is a potential for cows to spend more time waiting for a stall to become available than engaging in feeding over the course of a day. Finally, depriving cows of lying for a relatively limited period of two to four hours, which is similar to the hours reported in trial evaluating stocking density, resulted in cows attempting to recoup the lost resting time for the next 40 hours (Cooper et al., 2007). Routine management practices, such as herd health checks or free-stall maintenance, could be sufficient to deprive cows of lying for this duration.

Beyond the effects on production, there are several important health-related factors that are affected negatively by reduced lying time. First, the predominance of concrete flooring results in a greater strain on the hoof when cows are forced to stand for extended periods of time (Cook, 2002). The negative impact of the standing time is worsened further from the softening of the

hoof by the manure slurry covering the alleyways, which leads to an increased probability of infections (Guard, 2002). These factors have been associated, either individually or in combination, with increased incidences of lameness.

Changes in lying behaviors may also be an indicator of lameness (Ito et al., 2010). When housed with deep-bedded stalls, cows lying for more than 14.5 hours per day or lying for more than three hours during an single resting bout were at a greater risk of being severely lame. Second, a study show that a stress response was evident in the concentration of cortisol in cows subjected to deprivation of lying relative to control cows with the unrestricted ability to lie down (Munksgaard and Simonsen, 1996). Increases in the concentration of cortisol are commonly associated with suppression of immune function. Third, increased lying time also has a potential benefit for fetal growth. Significantly more blood flowed to the gravid uterine horn when cows were lying relative to when they were standing during several stages throughout the gestation period in a study by Nishida et al. (2004).

Finally, changes in lying behavior might be an indicator of mastitis. Contrary to the general model of sickness behavior in cattle, mastitis alters lying behavior by decreasing lying time. Cows with *E. coli* mastitis simulated with an LPS challenge decreased their lying time on the day the challenge was administered (Cyples et al., 2012). This finding was consistent with the previously reported responses (Siivonen et al., 2011; Zimov et al., 2011). However, when cows were challenged with *S. uberis*, lying times increased (Krawczel et al., 2014).

Future directions in time budget evaluations

In the near term, the increased commonality of automated devices for measuring rumination times and diurnal patterns will facilitate a greater understanding of the dynamic relationship among health, productivity, management, and this behavior (Schirmann et al., 2009). Furthermore, as these devices become more available to commerical operations, there will be a greater need to understand the changes associated with various events, such as calving or the onset of disease.

In the longer term, the recent developments in the assessment of monitoring sleep have the potential to have a much greater impact on how the time budgets of dairy cows are viewed (Ternman et al., 2012). In the present state, the equipment is too cumbersome to be used for the evaluation of sleep in loosely housed dairy cows. The recent work in this field has relied on using cows housed in tie-stalls or box stalls (Ternman et al., 2012; Ternman et al., 2014). Using behavioral indicators to predict sleep in dairy cows was unsuccessful (Ternman et al., 2014), which suggests that technology will need to be developed before sleep can be incorporated routinely as a response variable in applied dairy research project. However, if successfully developed, this technology will provide a means to move beyond assessing lying time in terms of quanity and transition to assessing the overall quality of lying time.

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