MAXIMIZING THE POTENTIAL OF DAIRY RATIONS THROUGH FEED BUNK MANAGEMENT AND DESIGN

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INTRODUCTION

In domesticated cattle production systems, animals rely on people to provide them with sufficient food, water and shelter to promote growth, productivity, health and welfare. Past research in dairy cattle nutrition has focused almost exclusively on the nutrient aspects of the diet, and has led to many discoveries and improvements in dairy cattle health and production. However, despite many advances in the field of ruminant nutrition, we are still faced with the challenge of ensuring adequate dry matter intake (DMI) to maximize production and prevent disease, particularly with lactating dairy cows. To date researchers have not considered whether an improved understanding of animal behavior may provide valuable insights leading to improvements in feeding management practices.

In North America most lactating dairy cows are intensively housed in either free-stall or dry-lot dairies and are fed a total mixed ration (TMR) along a feed bunk. Group-housing is beneficial as it allows some freedom of movement for the cows and significant labor savings for the producer, compared to the more traditional tie-stall facilities. However, this type of housing can result in high levels of competition at the feed bunk, which in turn may compromise the health and production of the cows. In this paper we will first describe the importance of feeding behavior in dairy cattle. Secondly, we will discuss factors that control the feeding behavior patterns of group-housed dairy cows. Finally, we will review studies showing how feeding management and feed bunk design can be altered in ways that reduce competition at the feed bunk, thereby allowing for increased access to feed for all animals. We anticipate that with an improved understanding of feeding behavior, combined with the continued efforts of nutritionists, dairy producers can manage and design their dairy production systems in ways that will allow their cows to fully maximize the potential of the ration provided, thereby improving the health, production and welfare of their animals.

IMPORTANCE OF FEEDING BEHAVIOR

During the transition period dairy cows are vulnerable to metabolic and infectious diseases, making early detection of disease particularly valuable. Members of the Animal Welfare Program at the University of British Columbia are currently studying whether feeding behavior can be used to identify cows at risk for metritis during early lactation. Early work showed that cows diagnosed with acute metritis after calving spent less time feeding during the prepartum period (d –12 to d –2 prior to calving) (Urton et al., 2005). A limitation of this study was that individual DMI was not measured. In a follow-up study (Huzzey et al., 2007) both individual feeding time and DMI were monitored using a larger sample size of cows. Here we found that cows with severe metritis consumed less feed and spent less time at the feed bunk during the 2 week period before calving and for nearly 3 weeks before the observation of clinical signs of infection. Cows with mild metritis also consumed less and tended to spend less time at the feed bunk during the week before calving. During the week before calving cows were 1.72 times more likely to be diagnosed with severe metritis for every 10 minute decrease in feeding time, and for every 1 kg decrease in DMI during this period, cows were nearly 3 times more likely to be diagnosed with severe metritis.

These results suggest that feeding behavior and feed intake may be used to identify cows at risk for metritis, however, we do not yet understand the causal relationship. In the study by Huzzey et al. (2007), feeding time was positively related to DMI, especially for cows with severe metritis, therefore, it stands to reason that any management and housing practices that positively affect feeding time, may also improve DMI and possibly reduce disease.

FEEDING BEHAVIOR PATTERNS

Over the past few decades, there has been a move in the dairy industry to intensively house dairy cattle. This move has been followed by a rapid increase in dairy herd sizes. Unfortunately, much of the research on dairy cattle feeding behavior has been completed with individually-housed animals in tie-stall facilities. In the majority of dairy operations today, cows are group-housed, and this environment can play a major role in the modulation of feeding patterns. When grazing, cattle often synchronize their behavior such that many animals in the group feed, ruminate, and rest at the same times (Miller and Wood-Gush, 1991). Curtis and Houpt (1983) reported that group-housed dairy cows also synchronized their behavior, particularly at feeding, whereby the act of one cow moving to the feed bunk stimulates others to feed.

It has long been accepted that dairy cattle exhibit a diurnal feeding pattern where the majority of feeding activity occurs during the day, particularly around sunrise and sunset (Albright, 1993). However, this observation is almost exclusively based on the feeding patterns exhibited by grazing cattle. Observations of housed dairy cattle indicate that times of peak feeding activity are typically associated with the time of feed delivery and milking, regardless of the time of day at which they occur (e.g. Haley et al., 2000; DeVries et al., 2003; Wagner-Storch and Palmer, 2003). On most commercial dairies, milking and feed delivery typically occur around the same time of day, making it difficult to determine which practice is acting to stimulate cows to move to the feed bunk. Therefore, we set out in an experiment to determine which of these management practices has the greater ability to stimulate dairy cattle to go to the feed bunk (DeVries and von Keyserlingk, 2005). We tested this objective by separating feed delivery and milking times, and monitoring the changes in behavior patterns of group-housed lactating dairy cows. In that study, 48 lactating Holstein cows were subjected to each of 2 treatments: 1) milking and feed delivery times coinciding, and 2) feed delivery 6 h post milking. When animals were fed 6 h post milking, they increased their total daily feeding time by 12.5%. This change was predominantly driven by a small decrease in feeding time during the first hour post-milking and a very large increase in feeding time during the first hour immediately following the delivery of fresh feed (Figure 1). These results indicate that the management practice of feed delivery acts as the primary influence on the daily feeding pattern of lactating dairy cows and not, as previously thought, the time of day.

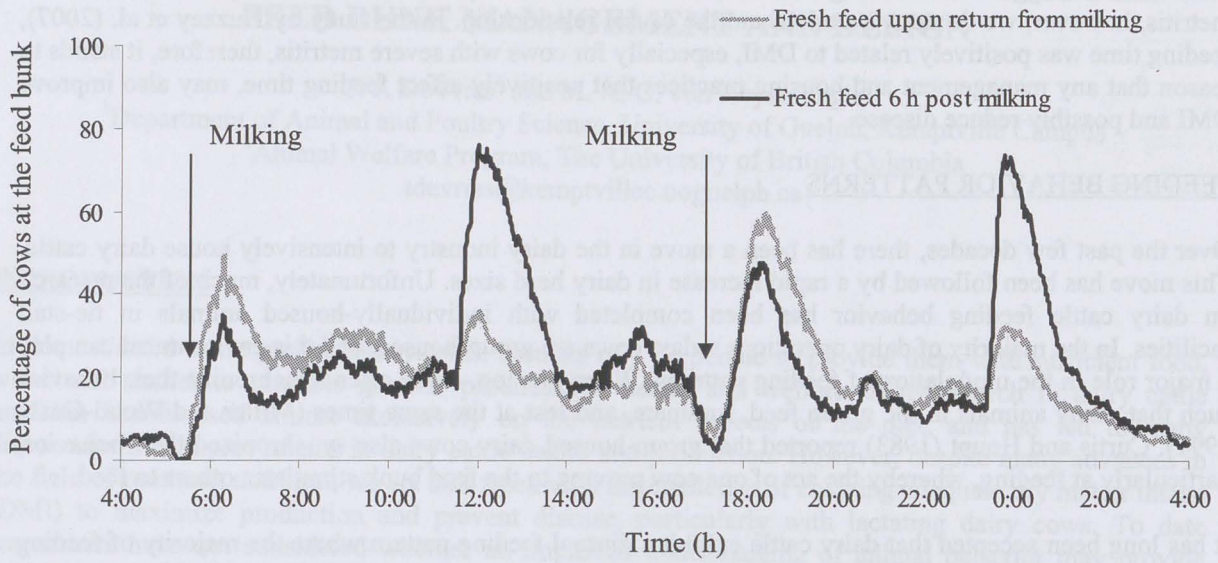

Figure 1. Feed bunk attendance when cows were provided with fresh feed upon the return from milking and when provided fresh feed 6 h post milking (from DeVries and von Keyserlingk, 2005).

FEEDING MANAGEMENT

One of the most common feeding management practices believed to stimulate feeding activity is feed push-up. When fed a TMR, dairy cows have a natural tendency to continually sort through the feed and push it around until the feed has been tossed forward where it is no longer within reach. This becomes a problem when feed is delivered via a feed alley and, thus, producers commonly push the feed closer to the cows in between feedings as a means of ensuring that cows have continuous access to the feed. In an observational study Menzi and Chase (1994) noted that the number of cows feeding increased after feed push-up, however they concluded that feed push-ups had "minor and brief effects" in comparison to milking on the feed bunk attendance. In a more recent study, we tested the stimulatory effect of feed push-up by increasing the number of feed push-ups during the late evening and early morning hours (DeVries et al., 2003). In that study, we found that the addition of extra feed push-ups did little to increase feeding activity. From these results we concluded that even though feed push-up is an important management practice to ensure that feed is accessible to cows when they want to feed, it does not have a dramatic effect in terms of increasing bunk attendance.

Contrary to the act of feed push-up we do know from our previous work that delivery of fresh feed acts to stimulate feeding activity. It follows, therefore, that the frequency of feed delivery should influence the feeding patterns of lactating dairy cows. For this reason, we conducted an experiment to determine how the frequency of feed delivery affects the behavior of group-housed dairy cows (DeVries et al., 2005). This objective was tested in two experiments. In each experiment, 48 lactating Holstein cows, split into groups of 12, were subjected to each of two treatments (over 10-d periods) in a cross-over design. The treatments for the first experiment were: 1) delivery of feed once per day (1x), and 2) delivery of feed twice per day (2x). The treatments for the second experiment were: 1) delivery of feed 2x, and 2) delivery of feed four times per day (4x). In both experiments, increased frequency of feed provision increased total daily feeding time by 10 and 14 minutes, respectively, as well as increased the distribution of feeding time throughout the day by changing the feed bunk attendance patterns of the cows (Figure 2 and 3). The changes in distribution of feeding time resulted in cows having more equal access to feed throughout the day.

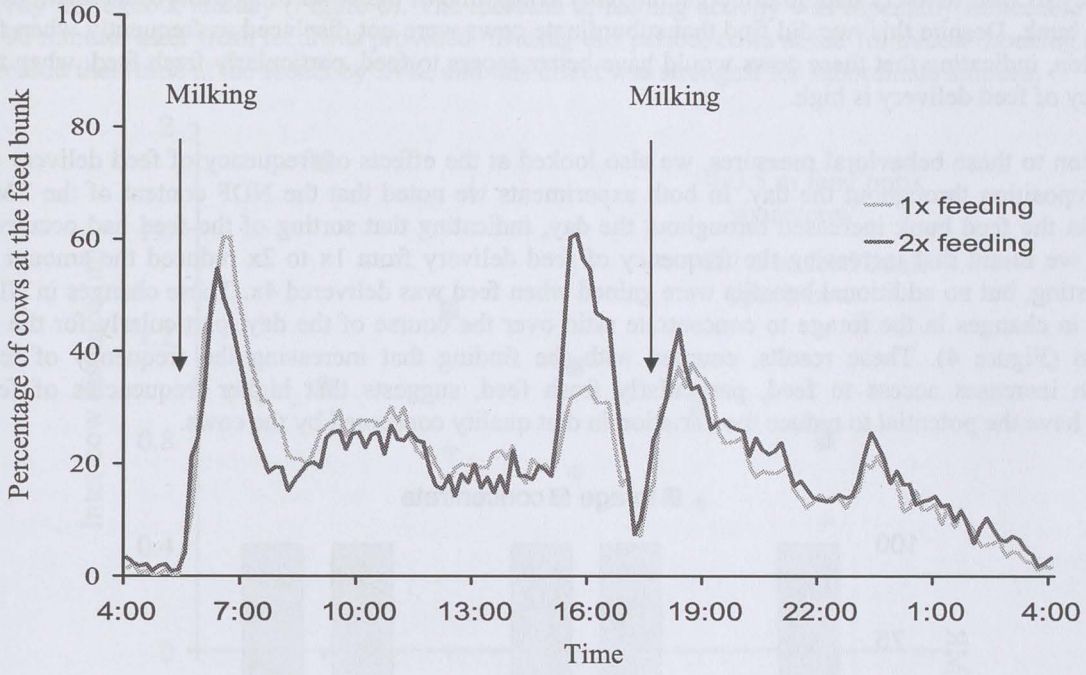

Figure 2. Feed bunk attendance when cows were provided with fresh feed 1x (0530 h) and 2x (0530 and 1515 h) (from DeVries et al., 2005).

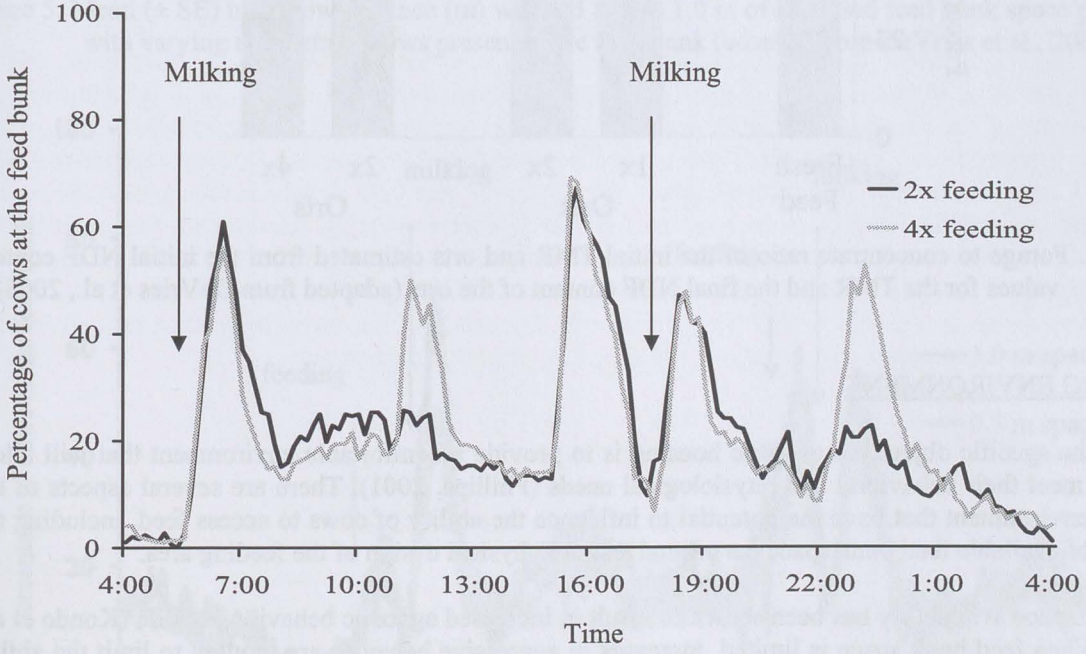

Figure 3. Feed bunk attendance when cows were provided with fresh feed 2x (0530 and 1515h) and 4x (0530, 1100, 1515, and 2230 h) (from DeVries et al., 2005).

Frequency of feed delivery had no effect on the daily lying time of the cows or aggressive interactions at the feed bunk. Despite this, we did find that subordinate cows were not displaced as frequently when fed more often, indicating that these cows would have better access to feed, particularly fresh feed, when the frequency of feed delivery is high.

In addition to these behavioral measures, we also looked at the effects of frequency of feed delivery on feed composition throughout the day. In both experiments we noted that the NDF content of the TMR present in the feed bunk increased throughout the day, indicating that sorting of the feed had occurred. Further, we found that increasing the frequency of feed delivery from 1x to 2x reduced the amount of TMR sorting, but no additional benefits were gained when feed was delivered 4x. These changes in NDF resulted in changes in the forage to concentrate ratio over the course of the day, particularly for the 1x treatment (Figure 4). These results, coupled with the finding that increasing the frequency of feed provision increases access to feed, particularly fresh feed, suggests that higher frequencies of feed delivery have the potential to reduce the variation in diet quality consumed by the cows.

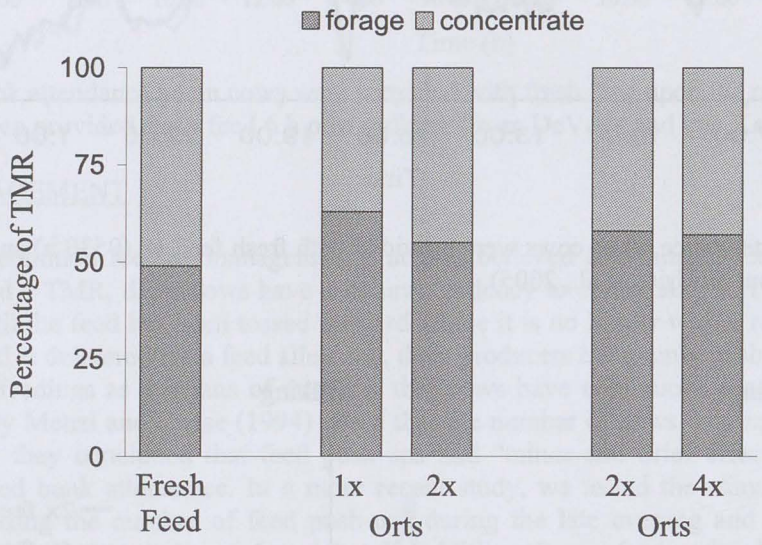

Figure 4. Forage to concentrate ratio of the initial TMR and orts estimated from the initial NDF content values for the TMR and the final NDF content of the orts (adapted from DeVries et al., 2005).

FEEDING ENVIRONMENT

One of the specific objectives of cattle housing is to provide a comfortable environment that will allow cows to meet their behavioral and physiological needs (Phillips, 2001). There are several aspects of the feeding environment that have the potential to influence the ability of cows to access feed, including the amount of available feed bunk space per animal and the physical design of the feeding area.

Reduced space availability has been shown to result in increased agnostic behavior in cattle (Kondo et al., 1989). When feed bunk space is limited, increases in aggressive behavior are thought to limit the ability of some cows to access feed at times when they want to, particularly after the delivery of fresh feed. In a recent study, we set out to determine if increased space availability at the feed bunk improves access to feed and reduces social competition (DeVries et al., 2004). Twenty-four lactating Holstein cows were subjected to two stocking densities: 0.5 m or 1.0 m of feed bunk space per cow.

When cows had access to more feed bunk space there was at least 60% more space between animals (regardless of the number of cows at the feed bunk; Figure 5) and 57% fewer aggressive interactions while feeding. These changes in spacing and aggressive behavior in turn allowed cows to increase feeding activity throughout the day (Figure 6). The increase in feeding activity was especially noticeable during the 90 minutes after fresh feed was provided. During this period, cows at the 1.0 m/cow stocking density increased their time at the feeder by 24%, and this effect was strongest for subordinate animals.

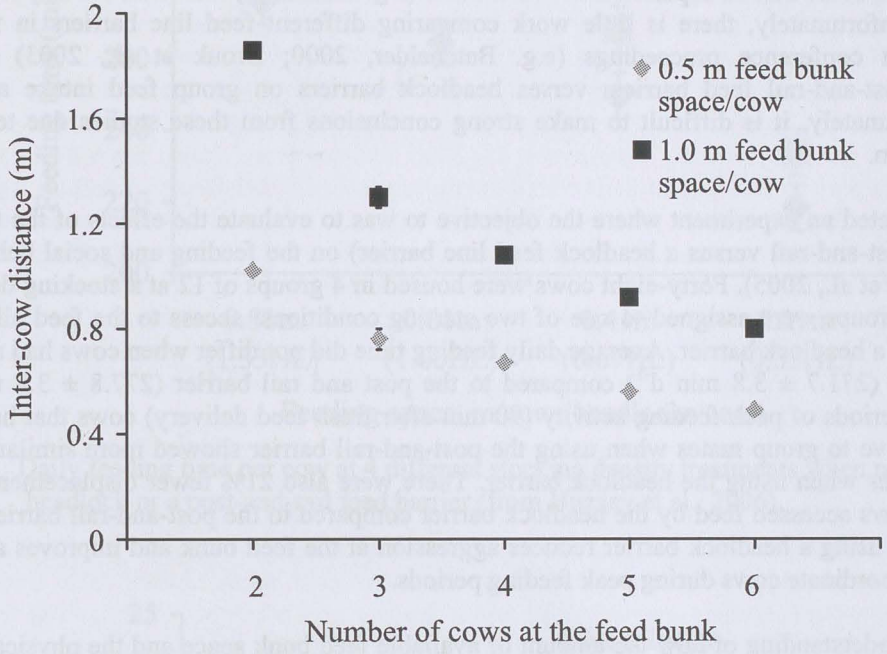

Figure 5. Mean (± SE) inter-cow distance (m) with 0.5 m and 1.0 m of allocated feed bunk space per cow with varying numbers of cows present at the feed bunk (adapted from DeVries et al., 2004).

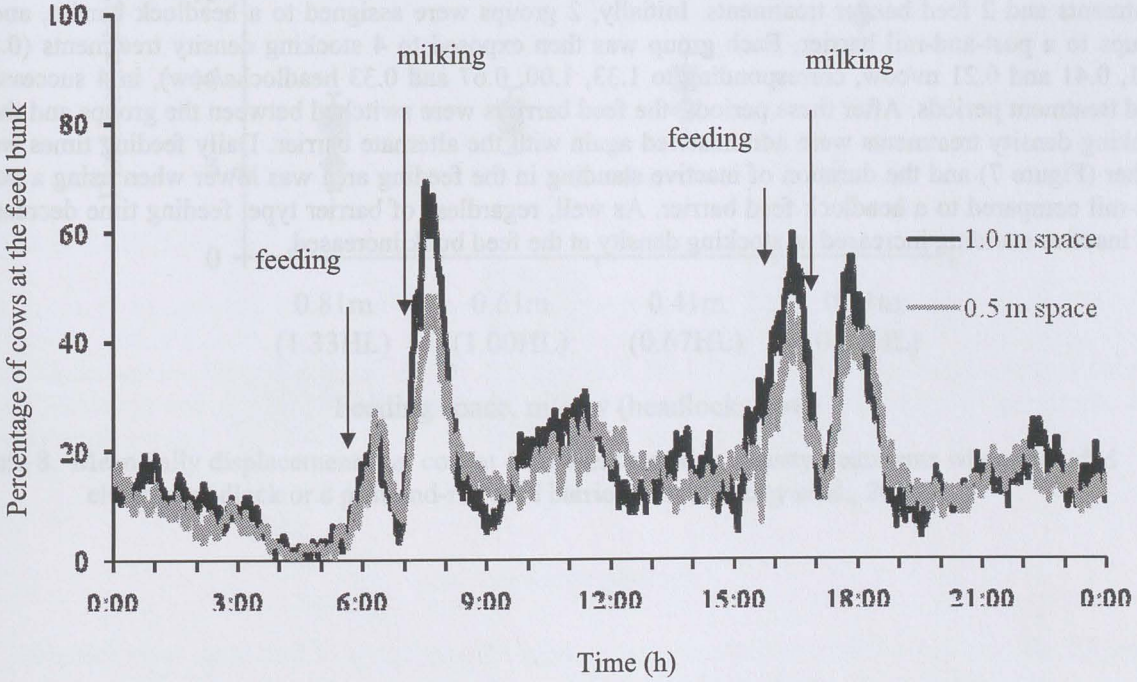

Figure 6. Feed bunk attendance with 0.5 m and 1.0 m of allocated feed bunk space per cow (from DeVries et al., 2004).

In addition to the amount of available feed bunk space, the physical design of the feeding area can influence feeding behavior. One of the most obvious features of the feeding area is the physical barrier that separates the cow and the feed. The various barriers are all designed with the intention of allowing cows equal access to feed, however, some designs can limit the cows' ability to freely access feed and increase the frequency of aggressive interactions at the feed bunk. Many producers believe that a feed line barrier that provides some sort of separation between cows (e.g. headlocks) will reduce competition and increase intake. Unfortunately, there is little work comparing different feed line barriers in free-stall barns. Two recent conference proceedings (e.g. Batchelder, 2000; Brouk et al., 2003) describe comparisons of post-and-rail feed barriers verses headlock barriers on group feed intake and milk production. Unfortunately, it is difficult to make strong conclusions from these studies due to limited treatment replication.

We recently completed an experiment where the objective to was to evaluate the effects of the two feed barrier systems (post-and-rail versus a headlock feed line barrier) on the feeding and social behavior of dairy cows (Endres et al., 2005). Forty-eight cows were housed in 4 groups of 12 at a stocking density of 0.61 m/cow. The groups were assigned to one of two starting conditions: access to the feed alley via a post-and-rail or via a headlock barrier. Average daily feeding time did not differ when cows had access to feed via headlocks (271.7 ± 3.8 min d^{-1}) compared to the post and rail barrier (277.8 ± 3.8 min d^{-1}). However, during periods of peak feeding activity (90 min after fresh feed delivery) cows that had lower feeding times relative to group mates when using the post-and-rail barrier showed more similar feeding times to group mates when using the headlock barrier. There were also 21% fewer displacements at the feed bunk when cows accessed feed by the headlock barrier compared to the post-and-rail barrier. These results suggest that using a headlock barrier reduces aggression at the feed bunk and improves access to feed for socially subordinate cows during peak feeding periods.

To gain a further understanding of how the amount of available feed bunk space and the physical design of the feeding area interact with one another, we followed up on our previous studies with a trial that examined how stocking density at the feed bunk affects the feeding and social behavior of dairy cows and to determine if this effect was further influenced by the type of feed barrier used (Huzzey et al., 2006). Thirty-six lactating Holstein cows, divided into 4 groups, were subjected to each of 4 stocking density treatments and 2 feed barrier treatments. Initially, 2 groups were assigned to a headlock barrier, and 2 groups to a post-and-rail barrier. Each group was then exposed to 4 stocking density treatments (0.81, 0.61, 0.41 and 0.21 m/cow, corresponding to 1.33, 1.00, 0.67 and 0.33 headlocks/cow), in 4 successive 10-d treatment periods. After these periods, the feed barriers were switched between the groups and the 4 stocking density treatments were administered again with the alternate barrier. Daily feeding times were higher (Figure 7) and the duration of inactive standing in the feeding area was lower when using a post-and-rail compared to a headlock feed barrier. As well, regardless of barrier type, feeding time decreased and inactive standing increased as stocking density at the feed bunk increased.

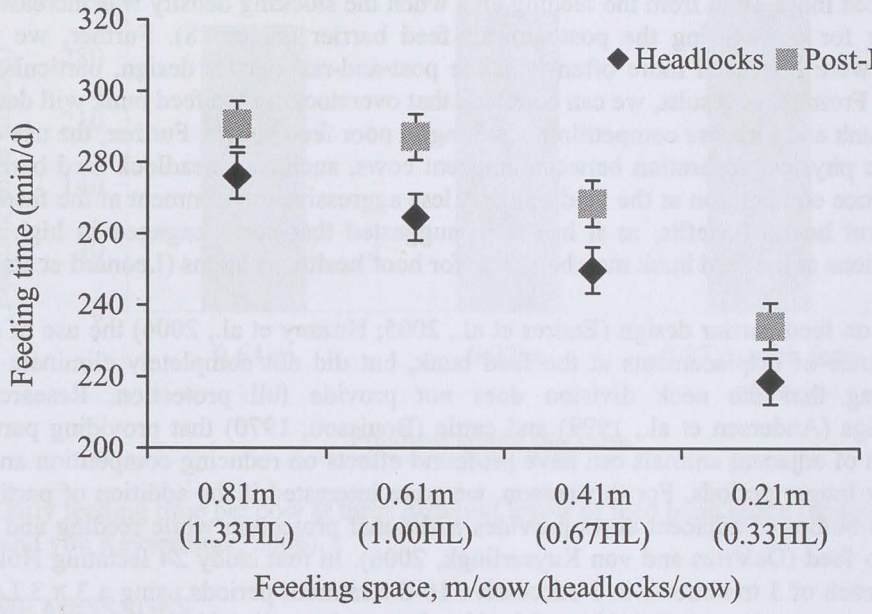

Figure 7. Daily feeding time per cow at 4 different stocking density treatments when provided either a headlock or a post-and-rail feed barrier (from Huzzey et al., 2006).

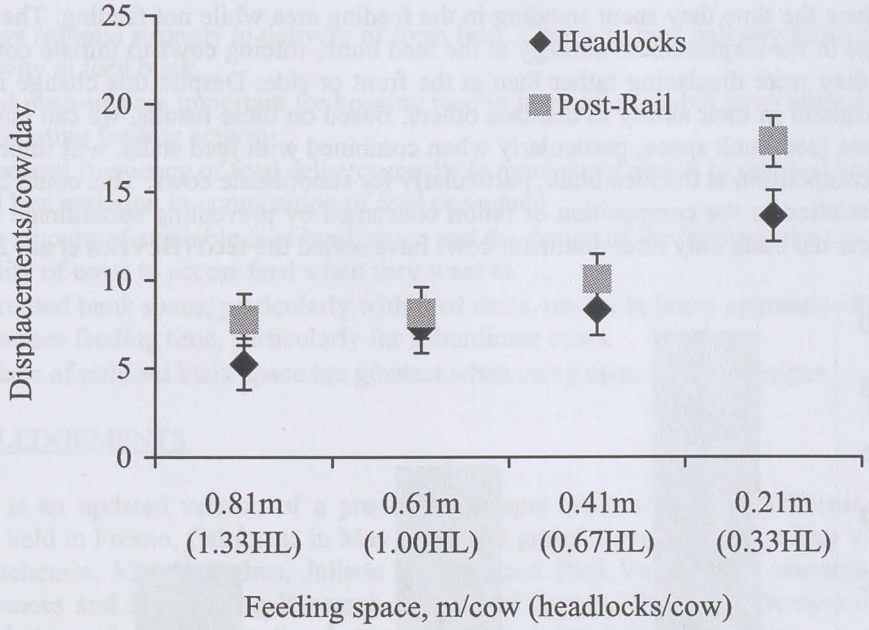

Figure 8. Mean daily displacements per cow at 4 different stocking density treatments when provided either a headlock or a post-and-rail feed barrier (from Huzzey et al., 2006).

Cows were displaced more often from the feeding area when the stocking density was increased, and this effect was greater for cows using the post-and-rail feed barrier (Figure 8). Further, we found that subordinate cows were displaced more often with the post-and-rail barrier design, particularly at high stocking densities. From these results, we can conclude that overstocking the feed bunk will decrease time spent at the feed bunk and increase competition, resulting in poor feed access. Further, the use of a barrier that provides some physical separation between adjacent cows, such as a headlock feed barrier, can be used to further reduce competition at the feed bunk. A less aggressive environment at the feed bunk may also have long term health benefits, as it has been suggested that cows engaged in high number of aggressive interactions at the feed bunk may be at risk for hoof health problems (Leonard et al., 1998).

In the two studies on feed barrier design (Endres et al., 2005; Huzzey et al., 2006) the use of a headlock reduced the incidence of displacements at the feed bunk, but did not completely eliminate aggressive behavior, indicating that the neck division does not provide full protection. Researchers have demonstrated in pigs (Andersen et al., 1999) and cattle (Bouissou, 1970) that providing partitions that separate the bodies of adjacent animals can have profound effects on reducing competition and allowing animals to feed for longer periods. For this reason, we were interested if the addition of partitions (feed stalls) between the bodies of adjacent cows provides additional protection while feeding and allows for improved access to feed (DeVries and von Keyserlingk, 2006). In that study 24 lactating Holstein cows were subjected to each of 3 treatments in 3 successive 10-d treatment periods using a 3 x 3 Latin square design. The treatments tested were: 1) 0.64 m of feed bunk space/cow, 2) 0.92 m of feed bunk space/cow, and 3) feed stalls (0.87 m of feed bunk space/cow with feed stall partitions separating adjacent cows). When animals had access to more space, particularly with the feed stalls, there were far fewer displacements while feeding (Figure 9). Further, subordinate cows benefited the most from this reduction in displacements. Reduced aggression at the feed bunk allowed cows to increase their daily feeding time (Figure 10) and reduce the time they spent standing in the feeding area while not feeding. The feed stalls also caused a change in the displacement strategy at the feed bunk, forcing cows to initiate contact at the rear of the animal they were displacing rather than at the front or side. Despite this change in strategy, cows were less successful in their ability to displace others. Based on these results, we can conclude that the provision of more feed bunk space, particularly when combined with feed stalls, will improve access to feed and reduce competition at the feed bunk, particularly for subordinate cows. This could help reduce the between-cow variation in the composition of ration consumed by preventing subordinate cows from being forced to access the bunk only after dominant cows have sorted the feed (DeVries et al., 2005).

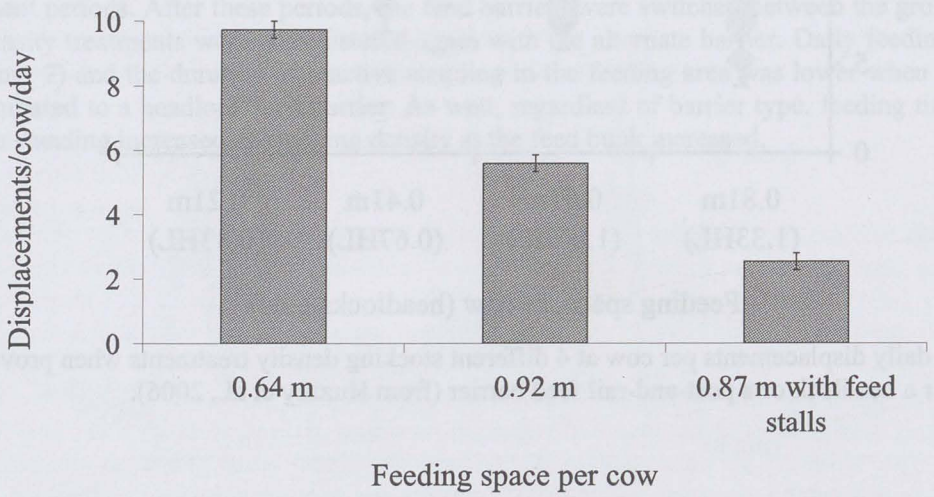

Figure 9. Daily number of displacements per cow at three different levels of feed bunk space (adapted from DeVries and von Keyserlingk, 2006).

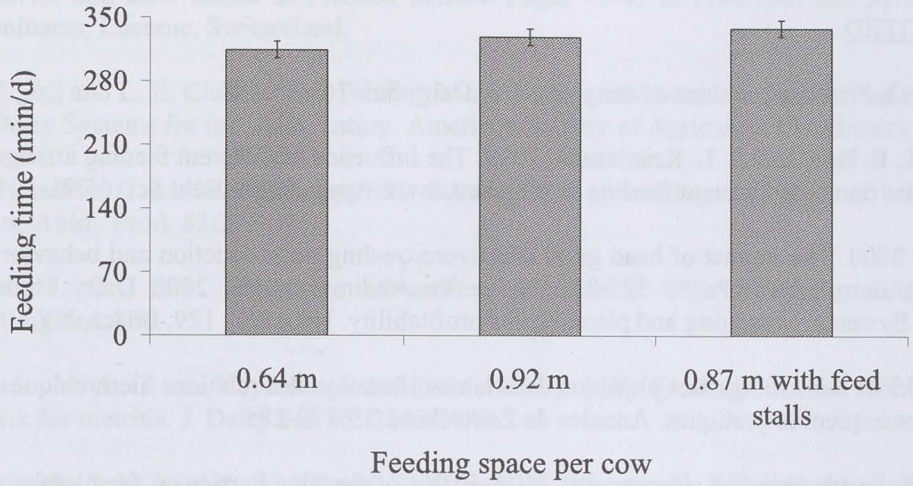

Figure 10. Daily feeding time per cow at three different levels of feed bunk space (adapted from DeVries and von Keyserlingk, 2006).

TAKE HOME MESSAGES

Our research has been focused on understanding what motivates feeding behavior in group-housed lactating dairy cows. Specifically, we have focused on how the management and physical structure of the feeding environment influences this motivation. Our take-home messages are:

- Cows respond strongly to delivery of fresh feed. Changing feed delivery times changes peak activity at feed bunk.
- Feed push-ups are important for keeping feed in front of cows, but have little effect on stimulating feeding activity
- Increased frequency of feed delivery results in more equal access to the feed bunk by all cows and less variation in composition of feed consumed
- The amount of available feed bunk space and the design of the feeding area can influence the ability of cows to access feed when they want to.
- Increased bunk space, particularly with feed stalls, results in fewer aggressive interactions and increases feeding time, particularly for subordinate cows.
- Effects of reduced bunk space are greatest when using open feeding designs

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