Behavior of Freestall Housed Cows

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TAKE HOME MESSAGES

1) Cows like softer surfaces, for both lying down and for standing upon. Deep-bedded stalls work well for cow comfort, but require maintenance.

2) When it comes to the physical structures used to build freestalls: less is more. The hardware we place in the stall is for our benefit and not the cow's. The more restrictive we design stalls, the less attractive they become for the cow.

3) Use of restrictive stall designs can help keep stalls clean; but to avoid problems with hoof health these designs need to be accompanied by better flooring options, such as softer and drier flooring.

4) The design and management of the feeding area is important. High stocking densities at the feed bunk increase aggressive competition and keep subordinate cows away from feed.

5) Physical barriers between cows, including head locks and feed stalls, can help reduce this competition and increase feeding time.

6) Socially subordinate animals may not be able to cope with frequent restructuring of the social hierarchy resulting in reduced feeding time, dry matter intake (**DMI**), and avoidance behavior in response to social confrontations; putting these cows at greater risk of nutritional deficiencies that impair immune function and increase susceptibility to disease after calving.

INTRODUCTION

Producers spend millions of dollars building indoor housing for dairy cattle, with the aim of providing a comfortable environment for their animals - one that ensures adequate rest, protection from climatic extremes, and free access to an appropriate, well-balanced diet. Despite these laudable aims, housing systems do not always function well from the perspective of the cow; as poorly designed and maintained facilities can cause injuries, increase the risk of disease, and increase competition among herd mates for access to feeding and lying space.

In this paper we review recent studies on the feeding, standing, and lying areas provided to dairy cows in modern freestall barns; and show how knowledge of cow behavior can help us better design and manage freestall housing to prevent some of the problems associated with the systems. Our work has generally evaluated housing systems from the cow's perspective by asking how the housing affects cow health (e.g. by reducing the risk of hock injuries), what housing the cow prefers, and how the housing affects behavior (e.g. by reducing competition and increasing feeding time).

In order to remain profitable, dairy producers must also have effective herd health programs in place to promptly identify and treat sick cows. Illness can influence production efficiency in 3 ways by: reducing milk production, reducing reproductive performance, and shortening the life expectancy of a dairy cow through increased culling rates. Dairy cows are particularly vulnerable to a number of metabolic and infectious diseases during the transition period (i.e. the period from 3 wk before until 3 wk after calving); therefore early detection of disease would be particularly useful during this time. In this paper we also present and discuss some of our recent research that provides evidence that behavior during the period before calving can also be used to identify cows at risk for disease (specifically metritis) after calving.

BETTER LYING AREAS

Our work on lying areas for cattle has focused on two aspects: the surface that cows lie down upon and the configuration of the stall.

Lying Surface

A growing body of research has now demonstrated that the surface we provide for cows is one of the most important factors in designing a suitable lying area. First and foremost, the housing we provide should not cause injuries or pose other health risks to the cow. Although this sounds obvious, too often poor design leads to preventable health problems. An important first step in assessing cow comfort is an understanding of how a cow behaves when she is comfortable. Several researchers have measured the stall usage of one surface at a time to assess how different bedding types affect behavior. For example, Haley et al. (2000) used a simple comparison between a space considered *high comfort* (a large box stall with a mattress) and a stall that represented *low comfort* (a tie stall with concrete flooring). The authors then measured behaviors including lying, standing, and eating times; the number of times the cows stood up; and various leg positions during lying. Lying times were 4 hr longer and cows were more willing to stand up and change positions in the high-comfort housing. Cows also spent more time standing idle in the low-comfort stalls. This study tells us which behavioral measures are likely to change if a cow is uncomfortable; namely, time spent lying and standing, as well as how often she is willing to stand up.

In some of our group's first work on cow comfort, we found that cows on farms with mattresses and little bedding have more severe hock lesions than do cows on farms using deep-bedded stalls. Although similar results have been found in other research (e.g. Wechsler et al., 2000) and most dairy professionals are aware of the risks of poorly bedded mattresses, too often this surface continues to be used.

Aside from reducing the risk of hock lesions, cows also clearly prefer lying surfaces with more bedding; and spend more time lying down in well-bedded stalls. In a more recent experiment, we examined the effect of the amount of bedding on the time spent lying and standing by cows housed in freestalls (Tucker and Weary, 2004). Each stall was fitted with a geotextile mattress, and was bedded with one of three levels of kiln-dried sawdust (0, 1, or 7 kg). Cows spent 1.5 h more time lying down in the heavily bedded stalls. In addition, cows spent less time standing with only the front legs in the stall when the mattresses were heavily bedded. These changes in both standing and lying behavior indicate that cows are hesitant to lie down on poorly bedded mattresses.

Aside from hock lesions, different stall surfaces have also been shown to affect the incidence of clinical lameness as well as udder cleanliness. Cows housed on mattresses have a higher incidence of clinical lameness (24 %) than those housed in deep-bedded sand stalls (11 %; Cook et al., 2004). Moreover, many studies have now shown the advantages to cows of using sand or other inorganic bedding as a way of reducing the growth of bacteria associated with environmental mastitis (e.g. Zdanowicz et al., 2004).

Making the decision to provide a well-bedded surface is just the first step in achieving a reasonable level of cow comfort – it is also essential that this surface be properly maintained. In a series of experiments, we documented how the sand level declines in stalls that are not maintained, and how this decline reduces stall use by cows (Drissler et al., 2005). Sand levels in deep-bedded stalls decrease over a 10-day period, with the deepest part at the center of the stall. Lying time by cows also declines as the stall empties: every inch decline decreased lying time by about 0.5 hr/d. Contact with concrete while lying down may explain lower lying times in deep-bedded stalls with less sand, and this concrete also affects leg health. Lesions on the point of the hock are common in deep-bedded stalls (Mowbray et al., 2003), likely due to contact with the concrete curb when stalls are not well maintained.

Our latest study tested the effects of wet bedding, one important aspect of bedding quality, on stall preference and use (Fregonesi et al., 2007b). Cows were restricted to freestalls with either kiln-dried or wet sawdust bedding in two *no-choice* phases of the study, followed by a *free-choice* phase in which cows could chose to use stalls with either wet or dry bedding. In the *no-choice* phases cows spent approximately 14 hr/d lying down when provided access to dry bedding, and reduced lying time by 5 hr/d when provided wet bedding. All cows showed a strong preference for the stalls with dry bedding. These results indicate that access to a dry lying surface is important to dairy cattle.

Stall Configuration

Most indoor housing provides more than just a lying surface for the cows. Typically, the space is designed to encourage the cow to lie down in a specific location, and to use the stall in such a way that feces and urine do not soil the stall. Unfortunately, most attempts to constrain how and where a cow lies down can also reduce her comfort.

Although some excellent recommendations for stall dimensions are now available, too often new constructions and renovated barns fail to provide appropriate space/lying stall. We have conducted several experiments that show how stall size and configuration affect standing and lying times. For example, we tested the effect of stall width on cow behavior (Tucker et al., 2004) by providing cows access to freestalls measuring 42, 46, or 50” between partitions. Cows spent an additional 42 min/d lying in the widest stalls, likely because they had less contact with the partitions, as they did in the narrower stalls. Cows also spent more time standing with all 4 legs in the wider stalls, reducing the time they spent standing partially (i.e. perching) or fully on the concrete flooring available elsewhere in the barn.

In addition to stall width, neck-rail placement is also important for managing standing behavior. Both the height of the neck-rail and its distance from the curb can affect standing behavior (Tucker et al., 2005); more restrictive neck-rail placements (lower and closer to the rear of the stall) prevent cows from standing fully in the stall, increasing the time cows spend on concrete flooring elsewhere in the barn. The neck-rail is designed to *index* the cow in the stall while she is standing, but the brisket board achieves this function while cows are lying down. Unfortunately, brisket boards also discourage stall use – cows spend 1.2 hr/d less time lying down when stalls have a brisket board compared to when using stalls without this barrier (Tucker et al., 2006a).

Keeping cows out of the stall obviously helps keep the stalls clean. We found that both the narrow freestalls and the more restrictive neck-rail placements reduced the amount of fecal matter that ended up in the stall. Although dirty stalls are undesirable, readers should be aware that stall cleanliness alone is a poor measure of stall design. Freestalls that have higher occupancy rates are most likely to contain feces. Thus, well-used stalls require more stall maintenance, much like other equipment used on the farm.

One challenge we have in designing suitable freestalls for cows is the perception that this one structure is responsible for it all. According to popular thinking, when cows are not in the parlor they should be eating or lying down. Unfortunately, no one seems to have explained this to the cows. In a number of studies we have found that even when cows have access to well-designed stalls they spend only about 12 hr a day lying down. Cows spend the other 12 hr a day on their feet, and we need to take this into account in designing suitable housing.

In most barns, the surface for standing outside of the stall is wet concrete, which is a known risk factor for hoof health (e.g. Borderas et al., 2004). Cows can use the stall as a refuge, providing a drier, softer surface for standing. However, if a cow is standing in the stall it increases the likelihood that she will urinate and defecate in the stall. The common response by barn designers has been to make the stalls more restrictive (as described above), forcing cows back into the concrete alley; explaining, in part, why lameness is now the most prevalent and costly health problem for cows housed in freestall barns. With our current barn designs we are stuck with 2 choices:

- use restrictive stalls that keep the stall surface cleaner, but force cows back onto the wet concrete
- or use more open designs and increase frequency of stall maintenance.

Of these 2 options we favor the latter, but there may also be a third approach: improving the standing surface elsewhere in the barn.

We have now completed a series of studies on alternative flooring surfaces in dairy barns. We have concentrated on the area where cows stand to eat, as cows spend about half of their standing time in this area. A number of studies have shown that access to pasture improves hoof health, likely because under good grazing conditions the pasture is a more comfortable and healthier surface for standing upon. In a recent study, we showed that a relatively brief period on pasture could help lame cows recover (Hernandez-Mendo et al., 2007). Non-concrete surfaces can also provide better traction and be more comfortable for cows to walk upon. Cows will typically choose to walk upon a rubber surface and avoid concrete, if the option is available. Our research shows that cows slip less frequently and show improved gait when walking on rubber compared to concrete, a difference that is especially clear for lame cows (Flower et al., 2007). Other work has shown that cows prefer to stand on softer surfaces. In one study we gave cows the choice of standing on concrete or softer surfaces, and cows spent the majority of their time standing on the softer flooring (Tucker et al., 2006b). This study also showed that when cows did not have the choice, they spent more time standing when they had access to the softer surface. In this and in an earlier experiment (Fregonesi et al., 2004) we also found that standing times increased when cows had access to a rubber standing surface in front of the feeder. These effects on standing times were only modest, so the development of new standing surfaces remains an important area for future work.

BETTER FEEDING AREAS

Feeding Space Design Can Affect Feeding and Social Behavior

There are several aspects of the feeding environment that affect a cow's ability to access feed, including the amount of available feed bunk space/animal and the physical design of the feeding area. Reductions in space availability increase competition in cattle. For example, a recent study by DeVries et al. (2004) showed that doubling feed bunk space from 20" to 40" reduced the number of aggressive interactions while feeding by half. This reduction in aggressive behavior allowed cows to increase feeding activity by 24 % at peak feeding times, an effect that was strongest for subordinate animals (Figure 1).

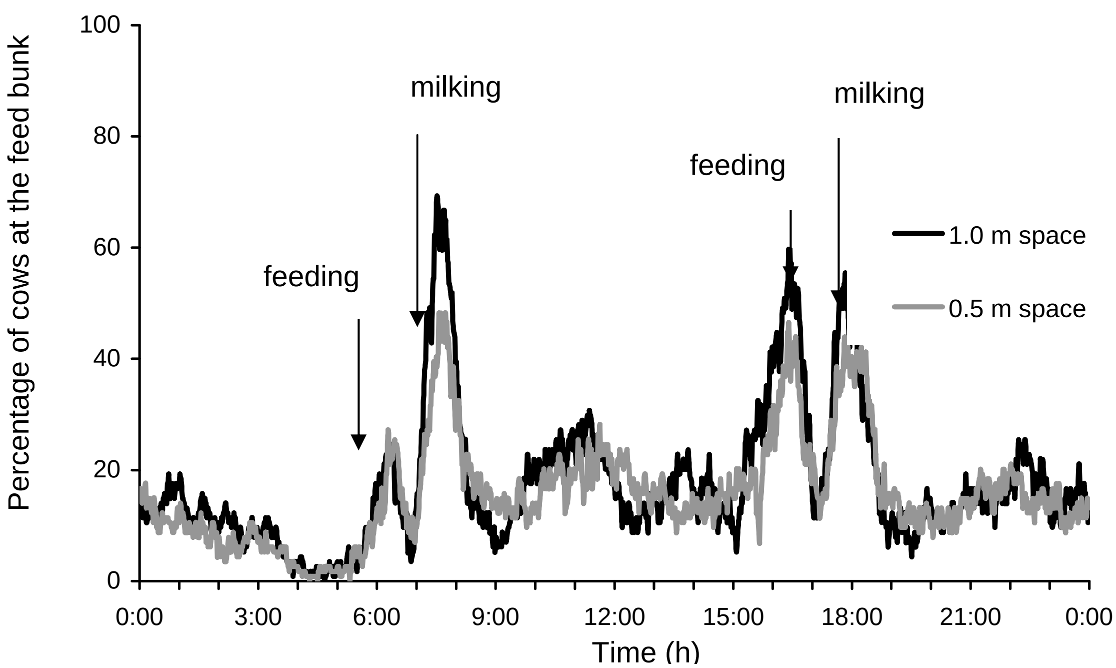

Figure 1. Feed bunk attendance with 0.5 m and 1.0 m of allocated feed bunk space/cow (adapted from DeVries et al., 2004).

In addition to the amount of available feed bunk space, the physical design of the feeding area can also influence feeding behavior of cattle. One of the most obvious features of the feeding area is the physical barrier that separates the cow and the feed. New research shows that some designs can reduce aggressive interactions at the feed bunk. For example, Endres et al. (2005) compared the effects of a post-and-rail versus a headlock feed line barrier on the feeding and social behavior of dairy cows. Average daily feeding time (about 4.5 hr/d) did not differ, but during periods of peak feeding activity (90 min after fresh feed delivery) subordinate cows had lower feeding times when using the post-and-rail barrier. This difference in feeding times was likely due to positive effects of the headlock barriers in reducing competitive interactions. There were also 21 % fewer displacements at the feed bunk with 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 subordinate cows.

In a second study we retested the effects of these two types of feed bunk barriers, but did so over a range of stocking densities (Huzzey et al., 2006). Cows were tested with the barriers described above, but using stocking densities of 0.81, 0.61, 0.41 and 0.21 m/cow (corresponding to 1.33, 1.00, 0.67 and 0.33 headlocks/cow). Daily feeding times were higher and the duration of inactive standing in the feeding area was lower when using a post-and-rail compared to a headlock feed barrier (Figure 2). Regardless of barrier type, feeding time decreased as well, and inactive standing increased as stocking density at the feed bunk increased. 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. Again we found that this effect was greatest for subordinate cows, particularly at high stocking densities. Clearly, overstocking the feed bunk decreases time spent at the feed bunk and increases competition, resulting in poor feed access. We have recently found very similar effects (less usage and more competition) when lying stalls are overstocked (Fregonesi et al., 2007).

Recent work has now shown that providing additional partitions ("feed stalls") between adjacent cows provides additional protection while feeding and allows for improved access to feed (DeVries and von Keyserlingk, 2006). Providing a feed stall resulted in less aggression and fewer competitive displacements, effects that were again greatest for subordinate cows. The reduction in aggression allowed cows to increase daily feeding time and reduce the time they spent standing in the feeding area while not feeding. Thus, the provision of more bunk space, especially when combined with feed stalls, improves access to feed and reduces competition at the feed bunk. This effect is strongest for subordinate cows. These changes in feed bunk design and management could help reduce the between-cow variation in the composition of ration consumed; since under conventional systems subordinate cows can only access the bunk after dominant cows have sorted the feed (DeVries et al., 2005). The use of a barrier that provides some physical separation between adjacent cows can reduce competition at the feed bunk. A less aggressive environment at the feed bunk may also have longer-term health benefits, as cows engaged in aggressive interactions at the feed bunk are at a higher risk for hoof health problems (Leonard et al., 1998). We now turn to some of our recent work that explores this area.

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B)

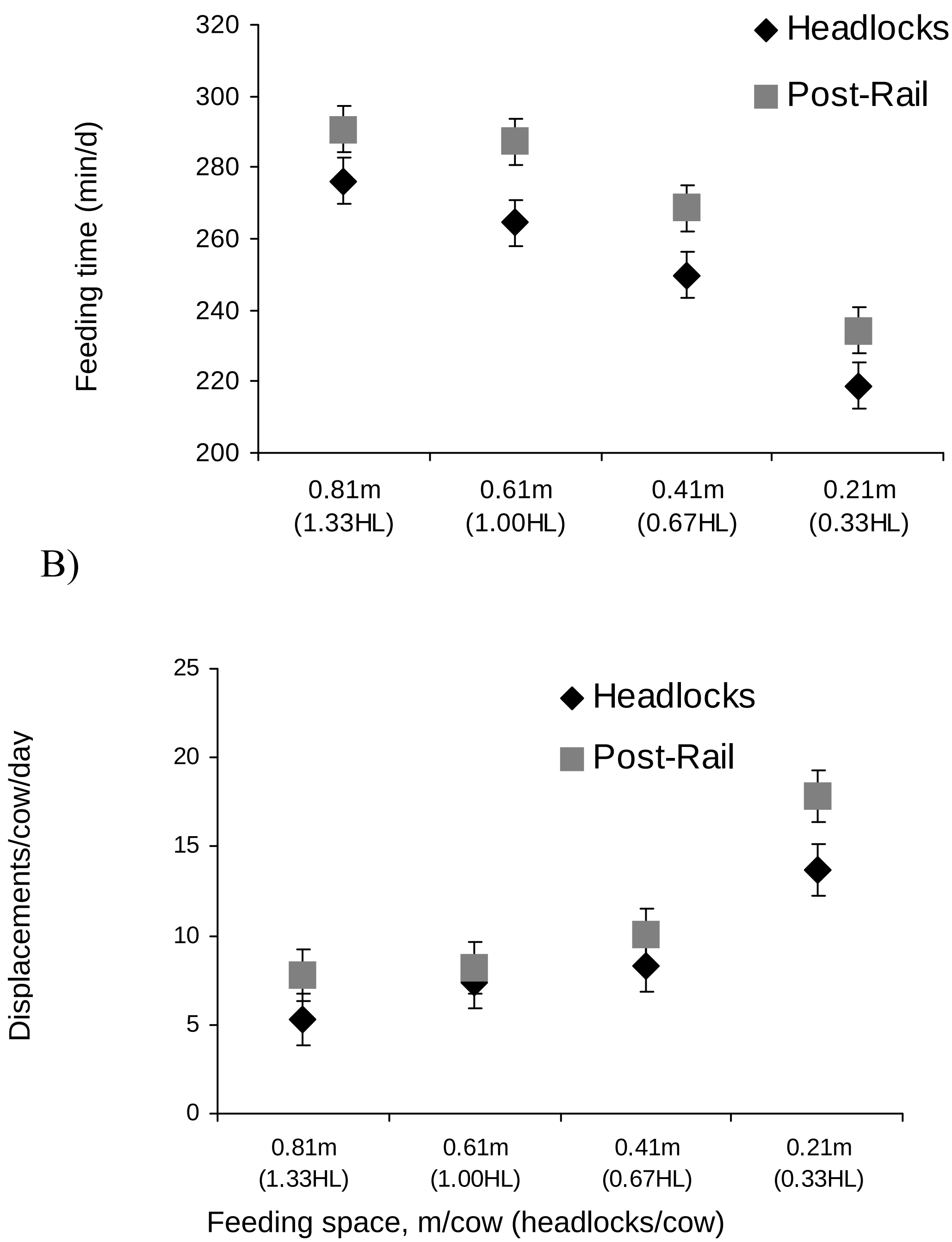
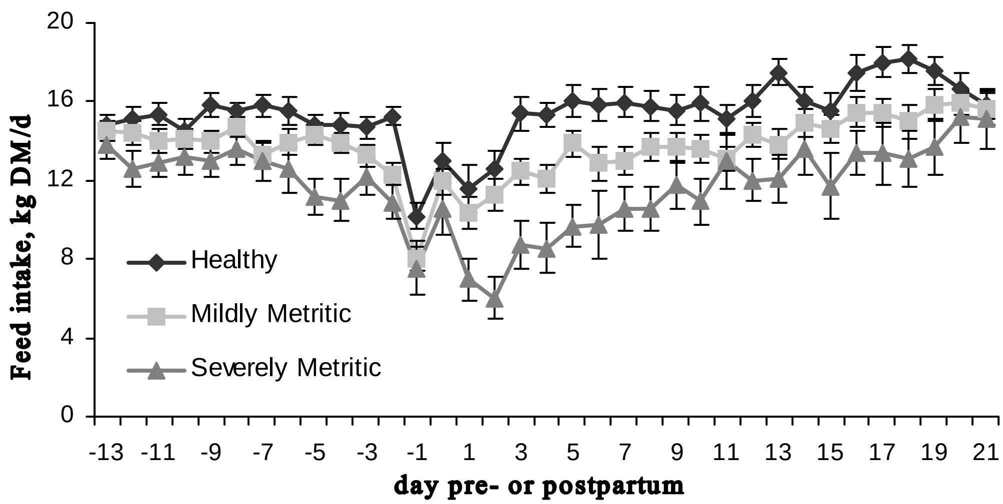


Figure 2. The effect of 4 different stocking density treatments when provided either a headlock or a post-and-rail feed barrier on (A) daily feeding time or (B) mean daily displacements/cow (adapted from Huzzey et al., 2006).



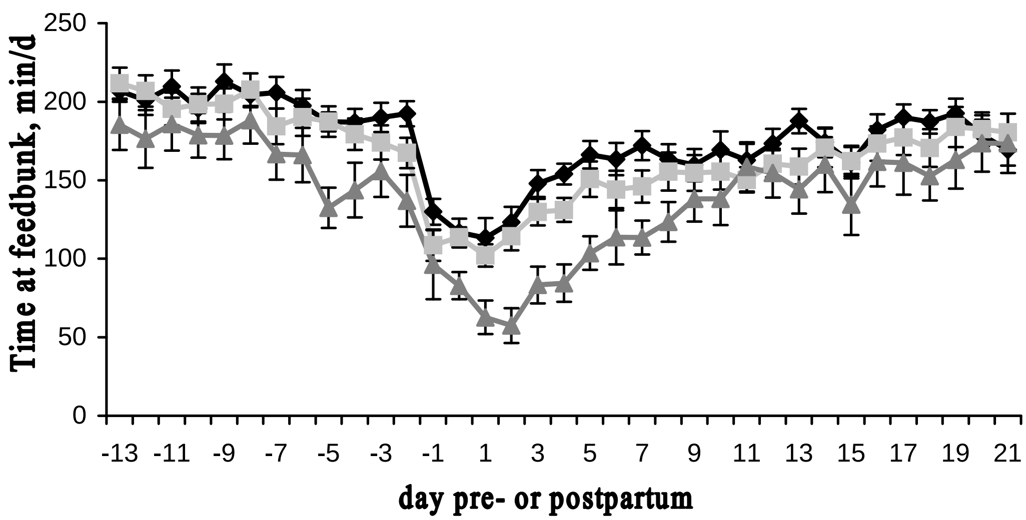


Figure 3. Average (± SE) daily DMI (kg/d; A) and feeding time (min/d; B) of healthy (n=23), mildly metritic (n=27), and severely metritic (n=12) Holstein dairy cows from 13 d before until 21 d after calving (from Huzzey et al., 2007).

FEEDING BEHAVIOR PREDICTS METRITIS

Work completed by Zamet et al. (1979) on the health and feed intake of freestall housed cows over the transition period showed that metritic cows had a 21 % lower DMI after calving than healthy cows; however these researchers failed to detect any difference in DMI between these 2 groups before calving. In 1 of our studies, the behavior of 101 dairy cows was monitored from 2 wk before until 3 wk after calving. Feeding and drinking behavior, as well as intake, was continuously monitored using the INSENTEC feed intake system; and social behavior at the feed bunk was assessed from video recordings. Metritis severity was diagnosed based on rectal body temperature as well as condition of vaginal discharge (**VD**) that was assessed every 3 d after calving until d +21. Using a combination of the VD scoring system and body temperature, cows were classified as having severe metritis (putrid discharge and body temperature ≥ 39.5 ˚C), mild metritis (abnormal, smelling discharge with or without a fever), or no metritis (normal discharge and no fever). Animals that did not meet these criteria or had clinical symptoms of other transition related disorders (i.e. milk fever, ketosis, or mastitis) were not included in the study.

The average number of days from calving to the first signs of pathological discharge was 5.3 ± 1.9 d (mean ± SD) for cows with severe metritis (n=12) and 9.1 ± 3.9 d for cows ($P < 0.001$) with mild metritis (n=27). Cows with severe metritis consumed less feed and spent less time at the feed bunk during the 2 wk period prior to calving and for nearly 3 wk prior to the observation of clinical signs of infection (Figure 3). Cows with mild metritis also consumed less and tended to spend less time at the feed bunk during the week before calving. For every 10 min decrease in average daily feeding time during the week before calving the odds of severe metritis increased by 1.72; and for every 1 kg decrease in DMI during this period, cows were nearly 3 times more likely to be diagnosed as metritic.

Our investigations into the behavior of dairy cows during the prepartum period provide the first evidence that social behavior may play an important role in disease susceptibility in dairy cattle. During the week before calving, cows later diagnosed with severe metritis engaged in fewer aggressive interactions at the feed bunk (i.e. displaced others from the feed bunk less often) and had reduced feeding and drinking times especially during the periods following fresh feed delivery.

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