Understanding Feeding Behavior to Maximize the Potential of Dairy Rations

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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, which 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. Since changes in DMI must ultimately be mediated by changes in feeding behavior, it is important to understand the factors that influence this behavior.

In this paper we will first describe the importance of understanding behavior and how knowledge in this area of science can help improve feed bunk access for dairy cows, in particular as this relates to disease and composition of feed consumed. Next, we will describe 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 AND FEED ACCESS

During the transition period dairy cows are vulnerable to metabolic and infectious diseases, making early detection of disease valuable. Researchers have shown that cows diagnosed with acute metritis after calving spent less time feeding during the prepartum period (d –12 to –2 prior to calving; Urton et al., 2005). In a follow-up study, Huzzey et al. (2007) monitored individual feeding time and DMI using a much larger sample size of cows and also monitored individual DMI. Interestingly cows diagnosed with severe metritis 7-9 d postpartum consumed less feed and spent less time at the feed bunk during the 2 wk period before calving, nearly 3 wk before the observation of clinical signs of infection. Moreover, during the week before calving cows were 1.72 times more likely to be diagnosed with severe metritis for every 10 min decrease in feeding time. For every 1 kg decrease in DMI during this period, cows were also nearly 3 times more likely to be diagnosed with severe metritis. These results suggest that changes in feeding behavior and DMI may be used to identify cows at risk for metritis; however, we do not yet understand the causal relationship. In the work described by Huzzey et al. (2007), feeding time was positively related to DMI, especially for cows with severe metritis. It follows, therefore, that management and housing practices that allow for increased feed bunk access will positively affect feeding time; and thus improve DMI and possibly reduce disease.

Ensuring adequate feeding time and equal access to the feed bunk by all cows in a group is also important as cows have been shown to preferentially sort their total mixed ration (**TMR**), typically sorting for the grain concentrate component and discriminating against the longer forage components (Leonardi and Armentano, 2003). Sorting of the diet can lead to the cows consuming an inconsistent ration, as suggested by Stone (2004). Recent research has shown that for those cows at high risk for acidosis, sorting against long fiber particles was associated with lower rumen pH (DeVries et al., 2008). This is particularly troublesome for early lactation cows; where greater sorting of a higher concentrate, lower fiber diet, coupled with rapidly increasing DMI (Kertz et al., 1991) will exacerbate the intake of highly fermentable carbohydrates and refusal of physically effective fiber; and thus increase the risk of ruminal acidosis. This in turn may result in inconsistent feed intake, poor feed efficiency, reduced feed digestibility and protein synthesis, and increased incidence of diseases. Alternatively, sorting of the TMR can reduce the nutritive value of the TMR remaining in the feed bunk, particularly in the later hours past the time of feed delivery (DeVries et al., 2005). This may be detrimental for those cows that do not have access to feed at the time when it is delivered. In such cases, these cows may not be able to maintain adequate nutrient intake to maintain high levels of milk production (Krause and Oetzel, 2006) and maintain adequate nutrient intake to allow for maximum milk production. Therefore, promoting equal feed bunk access by all cows will decrease the between-cow variation in the composition of feed consumed.

FEEDING BEHAVIOR 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 housed indoors also synchronized their behavior, particularly at feeding. They reported that when cows are fed in groups, the act of one cow moving to the feed bunk stimulates others to feed.

It has typically 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. To gain a better understanding of how management factors influence dairy cattle behavior, we examined the normal feeding pattern of group-housed lactating cows fed a TMR ad libitum (DeVries et al., 2003). In this study we found that cows consumed an average of 7.3 meals/d and had an approximate daily meal time of 6 h/d. We also found that the diurnal feeding pattern was mostly influenced by the time of feed delivery, feed push-up, and milking. Further, it was clear that the most dramatic peaks in feeding activity occur around the time of feed delivery and the return from the milking parlor.

To follow-up on this, we set out in an experiment to determine which of these management practices is the primary factor stimulating dairy cattle to go to the feed bunk (DeVries and von Keyserlingk, 2005). We tested this objective by separating feed delivery and milking times by 6 h. 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.

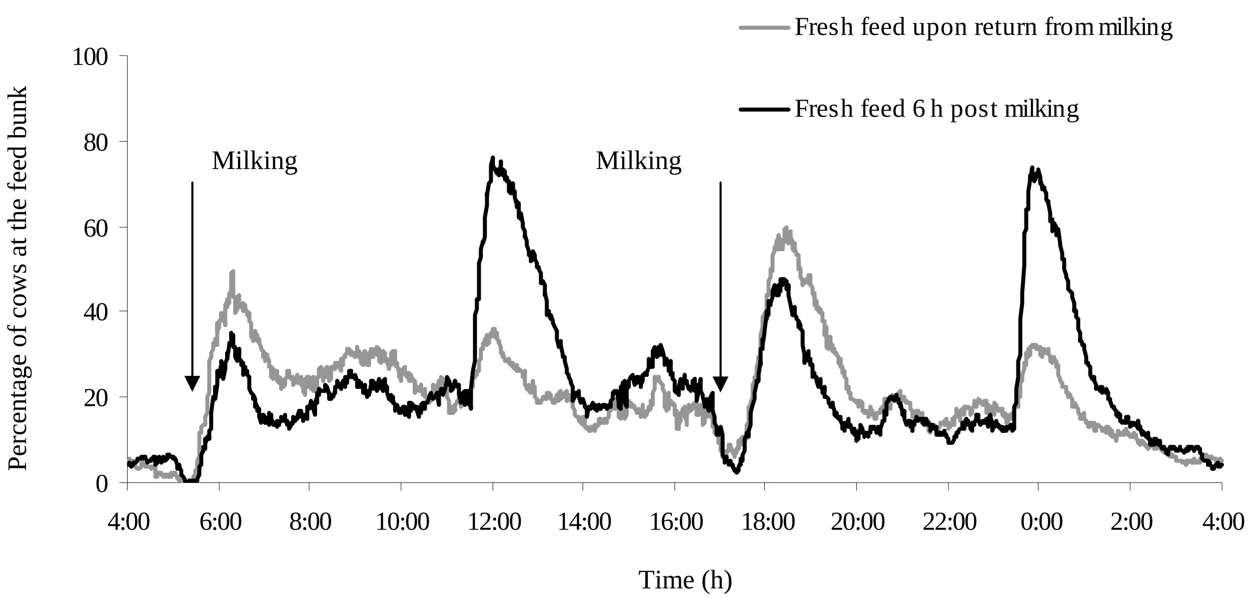

Figure 1. Feed bunk attendance when cows were provided with fresh feed upon the return from milking and when provided fresh feed 6 h post milking (from DeVries and von Keyserlingk, 2005).

FEED BUNK 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 toss it forward, where it is no longer within reach. This is particularly problematic when feed is delivered via a feed alley and, thus, producers commonly push the feed closer to the cows in between feedings to ensure that cows have continuous feed access. 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 push-ups during the late evening and early morning (DeVries et al., 2003). In that study we found that the addition of extra feed push-ups in the early morning hours did little to increase feeding activity. However, push-up does play a vital role in ensuring that feed is accessible when cows want to eat.

As mentioned above, delivery of fresh feed is clearly an important factor in stimulating cows to eat. Thus, the frequency of feed delivery should influence the feeding patterns of lactating dairy cows. To test this prediction, we conducted an experiment to determine whether increasing frequency of feed delivery affects the behavior of group-housed dairy cows (DeVries et al., 2005). This objective was tested in 2 experiments. In the first experiment, the treatments 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 min, respectively; as well as increased the distribution of feeding time throughout the day. The distribution of feeding time in both experiments indicated that cows had more equal access to feed throughout the day when provided feed more frequently. Frequency of feed delivery had no effect on the daily lying time of the cows or the total number of aggressive interactions at the feed bunk. However, we did find that subordinate cows were not displaced as frequently when fed more often, indicating that these cows would have greater 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 neutral detergent fiber (**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 further reductions in sorting 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 2). These results, coupled with the finding that increasing the frequency of feed provision increases access to feed, particularly when fresh feed is provided, suggest that higher frequencies of feed delivery have the potential to reduce the variation in diet quality consumed by the cows.

FEED BUNK DESIGN

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 aggressive 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 feeding motivation is high, particularly after the delivery of fresh feed. In a recent study we set out to determine if increased space availability at the feed bunk (40 vs. 20 in/cow) improves access to feed and reduces social competition (DeVries et al., 2004). When cows had access to more feed bunk space there was at least 60 % more space between animals 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. The increase in feeding activity was especially noticeable during the 90 min after fresh feed was provided. During this period, cows at the 40 in/cow stocking density increased their time at the feeder by 24 %, and this effect was strongest for subordinate animals.

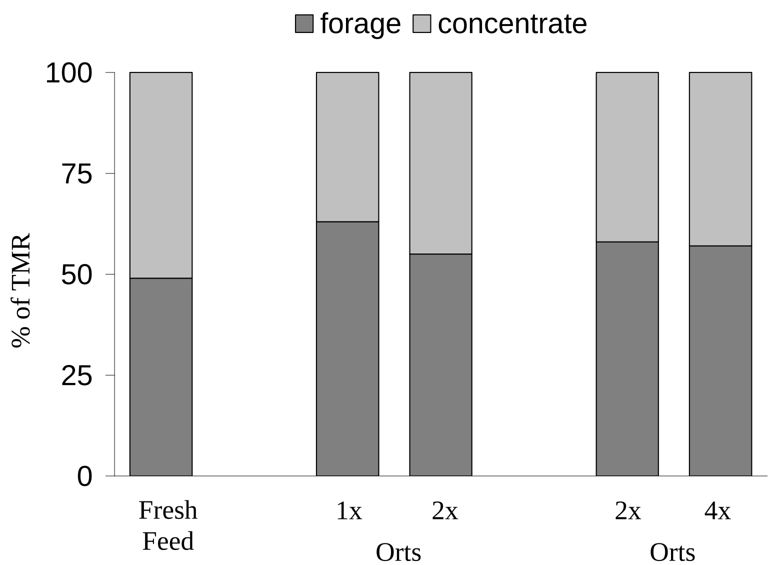

Figure 2. Forage to concentrate ratio of the initial total mixed ration (TMR) and orts estimated from the initial neutral detergent fiber (NDF) content values for the TMR and the final NDF content of the orts (adapted from DeVries et al., 2005).

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. Different feed barriers are 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 improve feed access. To test this hypothesis, we completed an experiment comparing a post-and-rail versus a headlock feed line barrier on the feeding and social behavior of dairy cows (Endres et al., 2005). 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 determine 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 if this was also affected by the type of feed barrier used (Huzzey et al., 2006). Although daily feeding times were higher (Figure 3) and the duration of inactive standing in the feeding area was lower when using a post-and-rail compared to a headlock feed barrier, we noted a significant reduction in aggressive behavior with the headlock barrier compared to the post-and-rail barrier. Regardless of barrier type, feeding time decreased 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. 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 decreases time spent at the feed bunk and increases competition, resulting in poor feed access.

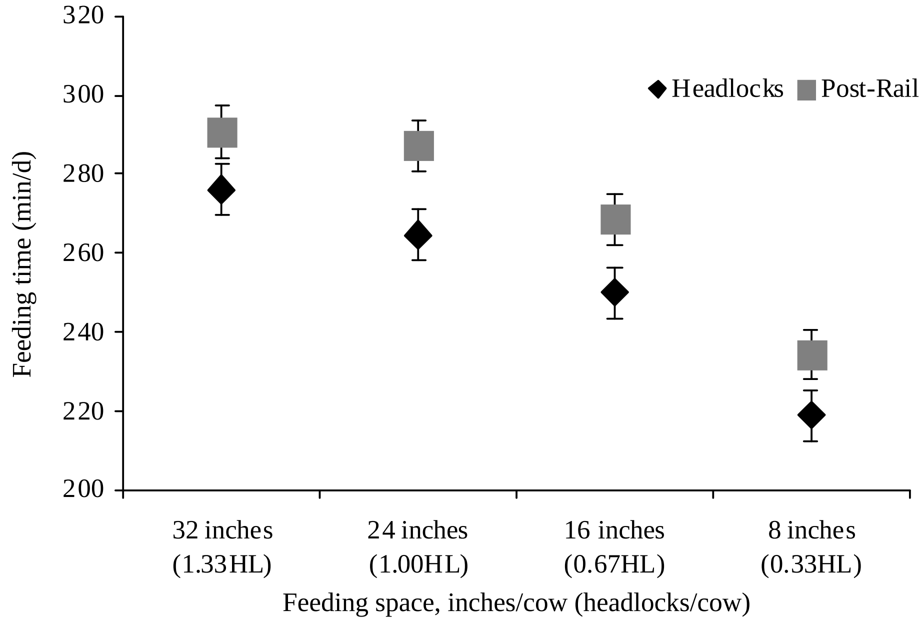

Figure 3. Daily feeding time per cow at 4 different stocking density treatments when provided either a headlock (**HL**) or a post-and-rail feed barrier (from Huzzey et al., 2006).

Further, the use of a barrier that provides some physical separation between adjacent cows, such as a headlock feed barrier, can 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 2 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). When animals had access to more space, particularly with the feed stalls, there were far fewer displacements while feeding (Figure 4). Further, subordinate cows benefited the most from this reduction in displacements. Reduced aggression

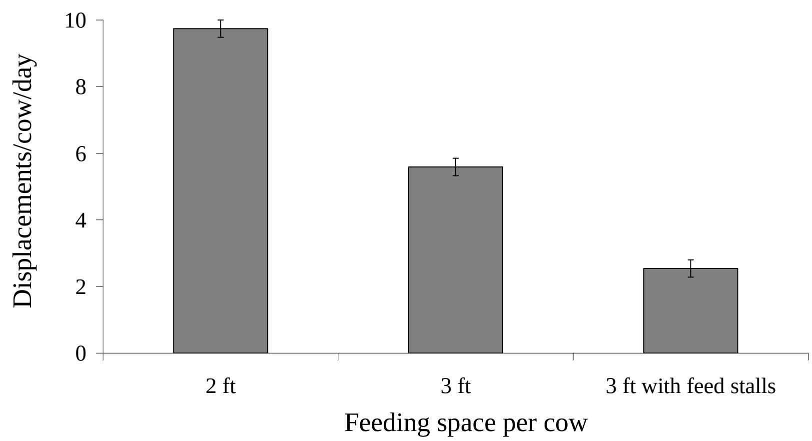

Figure 4. Daily number of displacements per cow at three different levels of feed bunk space (adapted from DeVries and von Keyserlingk, 2006).

at the feed bunk allowed cows to increase their daily feeding time and reduce the time they spent standing in the feeding area while not feeding.

Based on these results, we could 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 the ration consumed by preventing subordinate cows from being forced to access the bunk only after dominant cows have sorted the feed.

To test this prediction we recently completed a study to investigate how feed sorting is affected by competition for access to the feed bunk. Thirty-six dry Holstein cows, consuming a close-up TMR diet, were assigned to one of 2 treatments:

1) noncompetitive (1 cow/feed bin) or
2) competitive (2 cows/feed bin; Hosseinkhani et al., 2008).

Feeding behavior, DMI, and sorting behavior were monitored on 4 separate days during wk 2 and 3 before the expected calving dates of the cows. Regardless of treatment, the cows sorted against long particles and for short particles. Interestingly, there was a tendency for more sorting for short particles during the first 4 h after feed delivery. Competition at the feed bunk dramatically increased the feeding rate of the cows throughout the day (Figure 5). The competitively-fed cows also had fewer meals per day, and tended to have larger and longer meals. Competition also changed the distribution of DMI over the course of the day, resulting in higher intakes during the later hours after feed delivery after much of the feed sorting had already occurred (Figure 6). These results suggest that increased competition at the feed bunk promotes feeding behavior patterns that will likely increase the between-cow variation in composition of TMR consumed.

CONCLUSIONS

This proceedings paper summarizes a number of studies that we have undertaken that collectively provide us with a basic understanding of how feed bunk management and design can be manipulated to reduce competition, improve feed access, and reduce between-cow variation in composition of feed consumed. Future research must now determine the long-term implications of increased feed access and reduced competition at the feed bunk on the DMI, milk production, and health of lactating dairy cows; particularly those in early lactation.

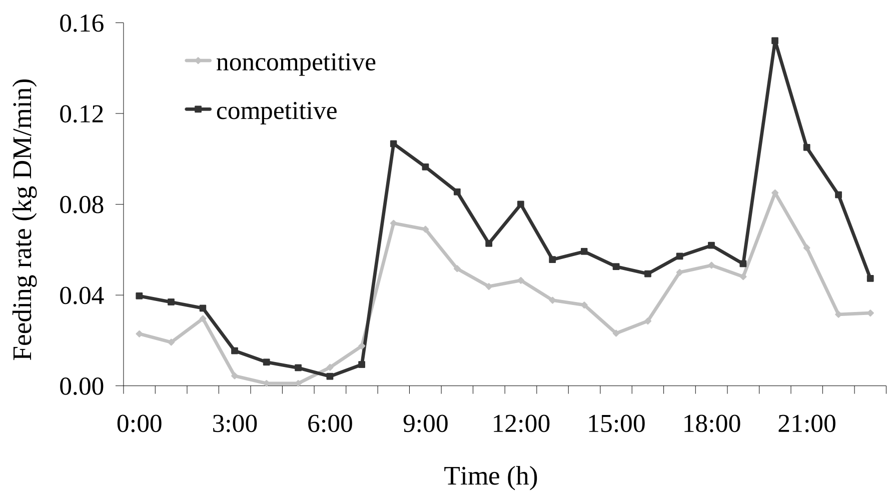

Figure 5. Average hourly feeding rate (kg/min) for cows fed noncompetitively (1 cow/feed bin) or competitively (2 cows/feed bin; from Hosseinkhani et al., 2008).

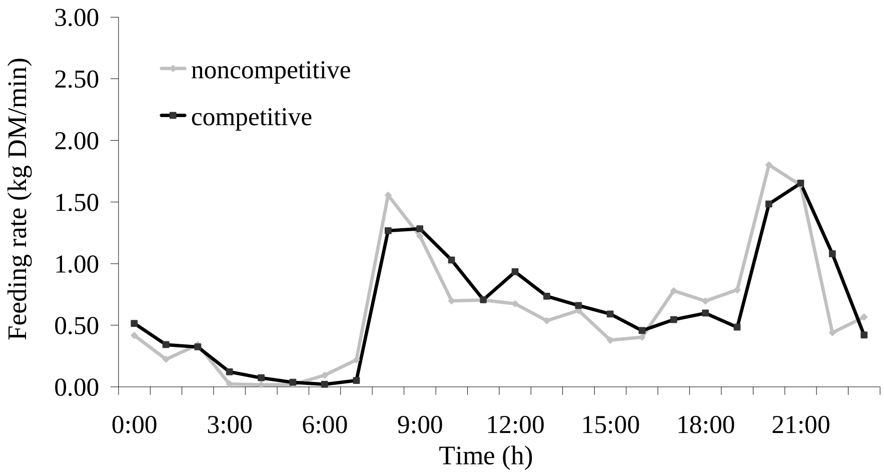

Figure 6. Average hourly dry matter intake (DMI; kg) for cows fed noncompetitively (1 cow/feed bin) or competitively (2 cows/feed bin; from Hosseinkhani et al., 2008).

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