

The Feeding Behavior of Dairy Cows: Considerations to Improve Cow Welfare and Productivity

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Abstract

One of the primary objectives of dairy producers is to promote dry matter intake (**DMI**) to support milk production. Considerable research to date has focused on improving the DMI of lactating dairy cows by changing the nutrient composition of feeds. However, the DMI of group-housed lactating dairy cows is also affected by feeding behavior, which is modulated by the environment, management, health, and social interactions. For example, management practices such as overcrowding at the feed bunk, and feeding and milking times and frequencies may affect dairy cow feeding behavior, and the social status of each cow may influence her ability to gain access to feed at the time when she wants to eat. The opportunity for high producing dairy cows to eat whenever they want is important to maintain cow health, welfare and productivity, and ultimately profitability of the farm. Therefore, dairy producers can use knowledge of animal behavior to improve cow welfare and performance.

Introduction

One of the primary objectives of dairy producers is to promote DMI to support milk production. Considerable research to date has been focused on improving DMI of lactating dairy cows by changing the nutrient composition of feeds. However, the DMI of group-housed lactating dairy cows is also affected by the feeding

behavior of the cows, which is modulated by the environment, management practices, health, and social interactions (Grant and Albright, 2001; DeVries et al., 2005). Consequently, factors which alter group and individual feeding behavior and DMI potentially have a tremendous impact on cow productivity and welfare, herd health and farm profitability. Indeed, Shabi et al. (2005) found a relationship between increased time spent eating and increased milk yield, and these researchers suggested that producers may increase performance by encouraging lactating dairy cows to spend more time eating. This paper will focus on the impact of factors such as feed bunk management practices (e.g., feed bunk space and design and frequency of fresh feed delivery) and social conditions (e.g., competition for feed and group composition) on the feeding behavior of group-housed dairy cows.

Patterns of Feeding Behavior

High-yielding dairy cows housed indoors typically spend about 4 to 6 hours/day feeding, and this total time spent feeding is divided into 9 to 14 feeding sessions, or meals, over the course of the day (Dado and Allen, 1994; Tolkamp et al., 2000; Fregonesi and Leaver, 2001; Grant and Albright, 2001; Phillips and Rind, 2001a; DeVries et al., 2003b). When dairy cows are managed on pasture, a strong temporal pattern in feeding behavior is observed, which is greatly influenced by the times of sunrise and sunset, and removal of cows from pasture for milking

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(Figure 1). At pasture, two major peaks of grazing behavior are immediately observed when the animals enter the paddock following milking and a smaller peak around midnight (O'Connell et al., 1989; Orr et al., 2001; Gibb et al., 2002). A clear relationship between time of sunset, cessation of grazing, and commencement of lying down behavior has been described for cows at pasture, with very few cows observed grazing soon after sunset (Figure 1).

The housing environment is considerably different to conditions with pasture. Changes in physical and social factors (e.g., artificial lighting, confinement, and reduced availability of space) during housing substantially alter cow behavior in terms of both the level and distribution of various behavioral activities. DeVries et al. (2003a) investigated the diurnal variation in feed alley attendance patterns of lactating dairy cows housed in a free-stall barn and fed a TMR twice daily and the effects of delivery of fresh feed, milking, and increasing the number of feed push-ups on these patterns of behavior. Although cows were present at the feed alley nearly every minute of the day, the highest percentage of cows was present during the daytime and the early evening and the lowest percentage of cows was present during the late evening and early morning (Figure 2). There was a dramatic increase in the number of animals present at the feed alley immediately following the delivery of fresh feed and the return of the cows from milking. The response in the percentage of animals present at the feed alley in the hour immediately following each of the feed push-ups was not nearly as dramatic as the response to milking and feeding.

To determine whether it is the return from milking or delivery of fresh feed that has the greater effect on the daily patterns of feeding behavior of dairy cows, DeVries and von Keyserlingk (2005) provided cows with

fresh feed upon return from milking or fresh feed 6 hours after milking. When animals were fed 6 hours after milking, they shifted their daily feeding pattern and also increased their total daily feeding time by 12.5%, predominantly by increasing feeding time during the 60 min following the delivery of fresh feed (and decreasing feeding during the period immediately following the return from milking when no fresh feed was delivered) (Figure 3). These results suggest that the delivery of fresh feed is a much stronger stimulus to get cows to feed than the return from milking, and in contrast to grazed dairy cows, the daily feeding pattern of group-housed dairy cows is largely influenced by the timing of fresh feed delivery, rather than the times of sunrise and sunset, or return from the milking parlor.

While the results of DeVries and von Keyserlingk (2005) showed that the time of provision of fresh feed strongly influenced the feeding behavior of dairy cows, these authors also found that the time of feed delivery affected lying behavior. When cows did not have fresh feed upon return from milking, they laid down about 20 min sooner than cows that had access to fresh feed. Tyler et al. (1997) found that cows that had access to feed after milking stood longer (48 versus 21 min) than cows that did not have access to feed after returning from milking. The practical significance of management practices that affect the latency for cows to lay down following milking may be substantial, due to the potential increased risk of intramammary infection when the open teat sphincter is exposed to environmental bacteria when the cow lies down soon after milking.

Frequency of Feeding

Feeding a TMR may be the optimal way to provide the balance of nutrients that ruminants need to maintain a stable and efficient microbial

population. However, the availability of the feed over time and the distribution of intake over the course of the day contribute to the maintenance of a stable ruminal microbial population (Nocek and Braund, 1985), which is important to reduce the risk of cows developing subacute ruminal acidosis. Typically, group-housed dairy cows are provided with fresh feed twice, or perhaps only once, per day. The findings of DeVries and von Keyserlingk (2005) suggest that the delivery of fresh feed is a substantial stimulus to get cows to eat, and cows increase their feeding time during the hour after fresh feed has been delivered. Thus, it is possible that the frequency of providing fresh feed to dairy cows may significantly contribute to the distribution of intake over the course of the day, with potential implications for rumen microbial stability. Indeed, research has shown that increasing the frequency of feed delivery can reduce the diurnal fluctuations in rumen pH (French and Kennelly, 1990; Shabi et al., 1999).

DeVries et al. (2005) examined how frequency of feed delivery affected the behavior of group-housed dairy cows and observed that increased frequency of feed provision increased, as well as changed, the distribution of daily feeding time, resulting in cows having more equal access to feed throughout the day (Figure 4). Although statistically significant, increases in total daily feeding times were small (10 to 14 min). Mäntysaari et al. (2006) compared cows fed a TMR once or 5 times a day and also found total eating time was longer when feed was delivered more often. However, the difference in time spent eating was small (1.4% more time spent eating by cows fed 5 times per day) and not statistically significant. Nonetheless, these authors also noted that the distribution of eating time was more even over the course of the day for cows fed more frequently, whereas cows fed once per day had a clear peak in feed consumption immediately after allocation of

fresh feed. Thus, increasing the frequency of feed delivery may result in a more even distribution of feeding time over the course of the day, and this may contribute to decreased diurnal variation in ruminal pH and possibly reduce the risk of subacute ruminal acidosis.

Overcrowding the Feed Bunk

While more frequent provision of fresh feed may enable cows to more evenly distribute their feeding time over the course of the day, the amount of bunk space provided and a cow's position within the social dominance hierarchy may influence whether cows are able to gain access to feed at the times they want to eat. Grant and Albright (2001) suggested that accessibility of feed may be more important than the actual amount of nutrients provided, and that feed intake and milk production will generally improve when cows are allowed access to feed when they want to eat. Due to costs associated with the construction and maintenance of free stall barns, dairy farmers may limit the amount of feeding space available for cows to maximize utilization of facilities. Facility design, such as whether there are 2 or 3 rows of free stalls per feeding line, may also influence the number of cows which have to share a particular resource. Furthermore, the tendency for cows to synchronize their behavior, and especially to want to feed when fresh feed is delivered, will also impact the number of cows attempting to gain access to a limited resource at the same time. Thus, there are a number of conditions under which cows may be limited in being able to access feed when they want to eat, and feed restriction may occur.

Friend et al. (1977) found that time spent eating was not reduced until only 4 inches of feeding space per cow was provided (space allowance ranged from 4 to 20 inches/cow), and Collis et al. (1980) found total feeding

time did not change when feeding space was gradually reduced from 41.6 to 5.9 inches/cow. Similarly, Wierenga and Hopster (1990) found that overcrowding the number of feeding places by 25 to 55% had almost no consequences on eating time. It was suggested that the limited effect of overcrowding on total eating time may be due to the relatively short amount of time that cows spend eating each day, which would enable a cow to easily compensate for changes in the opportunity to eat that occur due to overcrowding.

However, in contrast to findings from earlier studies, more recent research suggests that overcrowding at the feed bunk may have deleterious effects on feeding behavior. DeVries et al. (2004) found that when cows had access to more feeding space (40 inches versus 20 inches/cow of feeding space), cows increased their feeding activity throughout the day, and especially during the 90 min after fresh feed was provided. At 30% overcrowding of headlocks (1.3 cows per headlock), Batchelder (2000) observed reduced daily DMI and substantially fewer cows eating during both the hour following milking and following delivery of fresh feed. Huzzey et al. (2006) found that for both post-and-rail and headlock feed barriers, overcrowding resulted in reduced feeding times, and these changes were most obvious during the times of peak feeding activity (within 60 min following the delivery of fresh feed).

Mentink and Cook (2006) compared free stall pens with 2 or 3 rows of stalls per pen, which provide for very different amounts of feed space per cow when free stalls are stocked at similar rates. These authors observed that the extra feed space per cow in a 2-row pen improved access to feed at peak feeding times. DeVries and von Keyserlingk (2006) observed total daily feeding time increased when feed bunk space was increased from 25 to

36 inches/cow. Even though 24 inches of bunk space per cow has traditionally been regarded as adequate (Grant and Albright, 2001), results of these recent studies suggest that feeding time will likely increase if cows are provided more than 24 inches of feed bunk space per cow. Mentink and Cook (2006) suggested that the recommended width may be narrower than the width of many mature Holstein dairy cows. Furthermore, dairy cows have been shown to distribute themselves in a non-random manner at the feed bunk, maintaining some distance between neighbors while feeding, and this spacing pattern is influenced by social rank (Manson and Appleby, 1990). Therefore, although maximum utilization of the feed bunk (all feeding positions simultaneously occupied) may be rarely observed (e.g., Mentink and Cook, 2006), this may not necessarily indicate that all cows are unrestricted in being able to access feed at the times when they want to eat.

All cows are highly motivated to access freshly delivered feed (DeVries and von Keyserlingk, 2005), but when feeding space is inadequate, some cows may be prevented from feeding at the time of fresh feed delivery, and consequently, they may be forced to shift their feeding time. Several researchers have shown that cows will sort a TMR, and thus feed quality declines throughout the day (Bal et al., 2000; Kononoff et al., 2003; DeVries et al., 2005; Leonardi et al., 2005). Hence, cows that are forced to delay their feeding time due to overcrowding may consume a poorer quality diet, and these cows may be unable to maintain adequate nutrient intake to maintain high levels of milk production. Furthermore, when cows do not have access to feed when they want to eat, they may over-eat following a period of feed deprivation. This could happen when cows have limited access to feed because of overstocking. Increased feeding competition due to overstocking may reduce intake and

increase feeding rate, possibly increasing the risk for metabolic problems such as displaced abomasum and subacute ruminal acidosis (Shaver, 1997, 2002; Cook et al., 2004).

In situations in which feed space is limited because of overcrowding, some cows may be forced to stand and wait for an available feeding spot. Indeed, DeVries and von Keyserlingk (2006) observed that time spent standing inactive in the feeding area decreased when more bunk space was provided, and the greatest differences in inactive standing occurred during the periods of peak feeding activity. Huzzey et al. (2006) also observed that overcrowding resulted in increased time spent standing in the feeding area while not feeding, and this change was most obvious during the times of peak feeding activity. Batchelder (2000) noted that overcrowded cows preferred to lie down in free stalls rather than eat after returning from milking and that overcrowded cows spent more time standing in the alley waiting to lie down than they did eating. Increased time spent standing inactive in the feeding area may have long-term negative hoof health effects, which could predispose cows to lameness. Increased standing times, especially on hard surfaces, have been found to be associated with a higher risk of developing hoof and leg injuries (Colam-Ainsworth et al., 1989; Greenough and Vermunt, 1991; Singh et al., 1993; Dippel et al., 2005).

Increased aggression in the feeding area when cows are overcrowded has been noted by a number of researchers (Olofsson, 1999; DeVries et al., 2004; DeVries and von Keyserlingk, 2006; Huzzey et al., 2006). Aggression could have consequences for hoof lesion development and lameness, as less dominant cows may avoid dominant animals by turning away from them, causing twisting of the rear feet on an abrasive surface (concrete), which can cause shearing effects on the hoof and may lead to various hoof

injuries. In a preliminary study, Leonard et al. (1998) reported that cows that engaged in a high number of aggressive interactions at the feed bunk had more severe claw-horn lesion scores than cows that did not engage in such encounters. Shaver (2002) also suggested that the potential for laminitis may be greater when limited feeding space coincides with overcrowding of free stalls (as is often the case), because cows may consume fewer, but larger, meals or have reduced feed intake (due to overcrowding at the feed bunk), and spend more time standing on concrete rather than lying in stalls (due to overcrowding of free stalls).

It is important to take into consideration that reduced access to feed will most likely impact individual cows within a group in different ways. High ranking cows may be completely unaffected, while low ranking cows may struggle to eat when they wish. Olofsson (1999) noted that when competition at a TMR feeding station increased, the behavior of cows of low social rank was affected to a greater extent than that of more dominant cows. Similarly, Wierenga and Hopster (1990) observed that there were almost no significant consequences of overcrowding on the behavior of high-ranking animals, but for low-ranking animals, the effects of overcrowding were sometimes considerable. DeVries and von Keyserlingk (2006) observed that the frequency of aggressive interactions at the feed bunk decreased when more bunk space was provided, and when the cows were provided additional feeding space, those cows with lower social status at the feed bunk experienced the greatest decreases in the number of times they were displaced per day. These results indicate that providing increased feed bunk space will improve access to feed and reduce competition at the feed bunk, particularly for subordinate cows.

Feed Bunk Design

While management practices at the feed bunk, such as the frequency of fresh feed delivery and the amount of overcrowding, have been shown to influence the feeding behavior of dairy cows, the physical environment at the feed bunk may also influence feeding behavior. Investigating the effect of the design of the feed-line barrier system, Endres et al. (2005) observed that average daily feeding times did not differ when dairy cows used either headlock barrier or post-and-rail barrier feed systems. In contrast, Huzzey et al. (2006) observed that daily feeding times were greater when using a post-and-rail compared with a headlock feed barrier, and Batchelder (2000) observed that group DMI was greater when using a post-and-rail barrier design. Differences in feeding behavior may be due to post-and-rail feed barriers being more comfortable for the cows, or cows may have a learned aversion to headlocks (Huzzey et al., 2006). However, Endres et al. (2005) observed that during periods of peak feeding activity, 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 with the post-and-rail barrier. Similarly, Huzzey et al. (2006) found cows ranked lower in the social hierarchy at the feed bunk were displaced more often when feeding at a post-and-rail barrier. These results suggest that using a headlock barrier system reduces aggression at the feed bunk and improves access to feed for socially subordinate cows during peak feeding periods. Headlocks may provide some protection against competitive interactions at the feed bunk by offering some physical separation between adjacent cows.

Similar to the physical design of the feed-line, the type of flooring used in front of

the feed bunk may also influence cow behavior. Fregonesi et al. (2004) observed that cows spent only slightly more time (0.7% more of the total time in the pen) standing on a rubber surface in front of the feed bunk than when animals had access to only concrete surfaces, and no differences in time spent eating were detected. In contrast, Olsson et al. (2005) observed that cows on rubber flooring spent significantly more time eating at the feed bunk than cows on either slatted concrete or mastic asphalt (slip-resistant) floors. Cows on rubber also spent longer standing without eating and walking in the alleys than cows on the slatted concrete surface. Tucker et al. (2006) found that when cows were given a choice to stand and feed on a concrete or sawdust platform, cows spent more time eating, standing without eating, and more total time on the sawdust surface than on concrete.

When cows were housed with either rubber matting or concrete in front of the feed bunk, Tucker et al. (2006) also observed that cows spent more time standing near the feeder (both eating and not eating) and less time standing elsewhere in the pen when the rubber surface was available. In one experiment, cows increased the time spent lying down in front of the feed bunk when provided with rubber flooring. This is clearly an undesirable behavior, but it suggests that the comfort of the free stalls was inadequate in this situation and highlights the importance of taking into consideration the comfort of the entire facility rather than concentrating on just a single component (Tucker et al., 2006). These results reveal that cows clearly prefer to stand on softer flooring surfaces than concrete when eating (indicating that concrete flooring is uncomfortable) and that having softer surfaces near feed bunks may increase the time cows spend in the area, including time spent eating. There is also increasing evidence of a link between concrete flooring and development of lameness (Vokey et al., 2001; Cook, 2003; Somers et al., 2003; Vanegas et al., 2006).

Social Effects

Social rank is often closely related to factors such as age and body size. Therefore, heifers probably often have lower positions in a group's dominance hierarchy than older cows. Through the effects of aggression at the feed bunk on feeding behavior (discussed above), it may be beneficial to manage primiparous cows in a separate group. However, there is limited research investigating the effects on feeding behavior of housing primiparous cows alone or together with multiparous cows. On pasture, Phillips and Rind (2001b) found that a mixed group of multiparous and primiparous cows grazed for less time than either multiparous or primiparous cows grouped alone. Krohn and Konggaard (1979) found heifers housed separately from older cows increased eating time and had a higher DMI when housed in free stalls. In contrast, Bach et al. (2006) observed primiparous cows that were loose-housed and milked with a robotic milking unit and found total eating time was about 30 min longer in primiparous cows housed in a mixed parity group than primiparous cows housed alone. Further research is required to determine if there are any potential benefits on feeding behavior and DMI of separately managing primiparous and multiparous cows.

Ruminating and Lying Behaviors

Feeding behavior is an important factor affecting the DMI of lactating dairy cows. However, cows also need to ruminate to fully and efficiently digest their feed. Cows prefer to ruminate while lying down (Phillips and Leaver, 1986; Cooper et al., 2007), and it is therefore important that cows are readily able to access a comfortable and inviting place to lie down to maximize rumination time. Interestingly, Batchelder (2000) observed that overcrowded cows spent significantly less time ruminating

during a 24-hour period than did cows that were not overcrowded.

Sufficient lying time is essential not only to enable cows to achieve sufficient rumination times but also because lying behavior and rest are very important for dairy cows, and cows are highly motivated to lie down, even after short periods (2 to 4 hours) of deprivation. The cows' need for lying behavior is demonstrated by an increase in this behavior immediately after cows have been deprived of the opportunity to lie down (Metz, 1984; Bolinger et al., 1997; Cooper et al., 2007). Cows have a rather inelastic demand for lying, and lying has a higher priority over eating after cows have simultaneously been deprived of the opportunity to do both (Metz, 1984; Fisher et al., 2003). Increased lying behavior is also associated with a reduction in lameness and increased blood flow to the udder, so maximizing lying time may ultimately increase longevity, reduce health costs, increase productivity, and improve cow welfare. As high-producing dairy cows generally need to spend more time eating to achieve high energy intakes to support increased milk production, there will be less time available for lying and other activities, and under some conditions, cows may not be able to fulfill their needs for eating and lying time. This may have serious implications for dairy cow health, welfare, and productivity.

Conclusions

The feeding behavior of group-housed dairy cows is influenced by management practices at the feed bunk and factors associated with the physical and social environment. The feeding pattern of group-housed dairy cows is largely influenced by the timing of fresh feed delivery, and delivery of fresh feed has a greater impact on stimulating cows to eat than does the return from milking. Delivering fresh feed more frequently improves access to fresh feed

for all cows and reduces sorting of the TMR. This will potentially reduce variation in diet quality consumed by cows, with benefits for milk production and reduction in risk of subacute ruminal acidosis. Reducing overcrowding at the feed bunk increases feeding time, particularly during periods of peak eating activity, reduces the time cows spend standing idle waiting to gain access to the feed bunk, and reduces aggression in the feeding area. The use of headlock feed barriers may reduce aggression at the feed bunk and enable subordinate cows more equal access to feed, particularly if cows are overcrowded at the feed bunk. Cows clearly prefer to stand on softer flooring surfaces than concrete, and providing softer surfaces such as rubber mats near the feed bunk may increase the time cows spend in the area, including time spent eating, and may be beneficial for hoof health and lameness. In conclusion, farmers can use knowledge of dairy cow feeding behavior to improve DMI, cow health, welfare and performance, and farm profitability.

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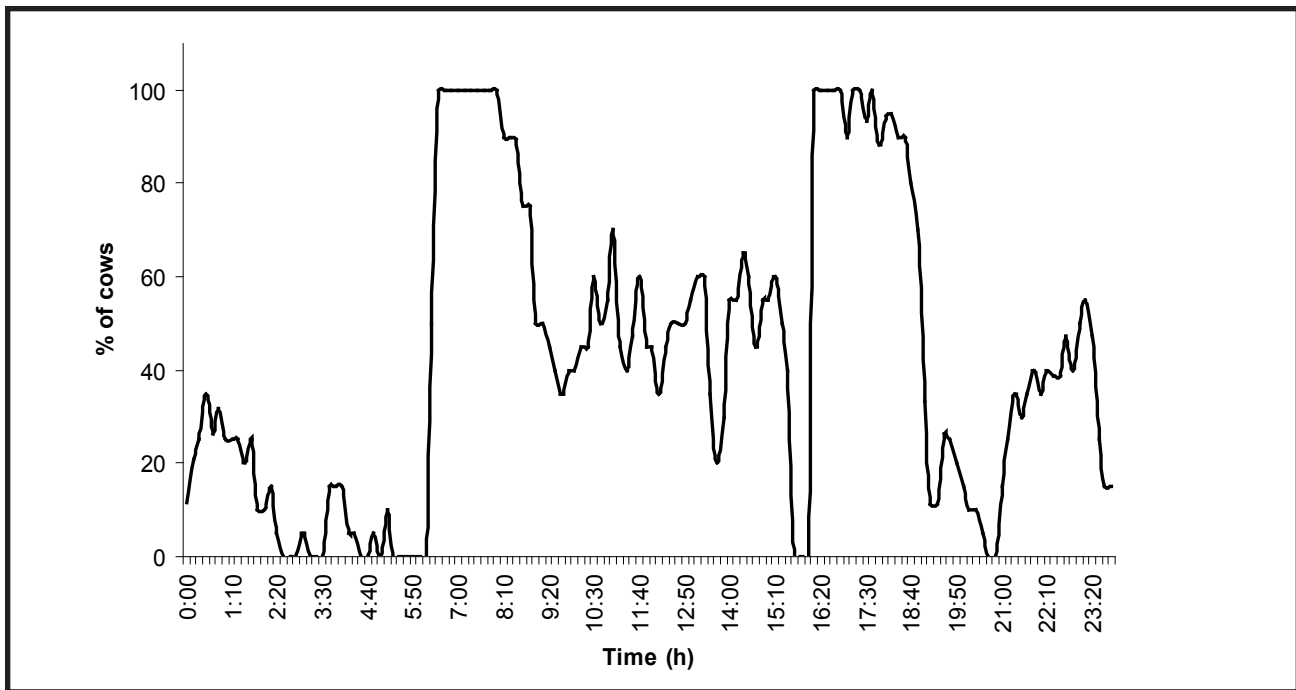


Figure 1. Temporal pattern of dairy cow feeding behavior at pasture; percentage of 20 cows grazing over a 24-hour period (Botheras, unpublished data).

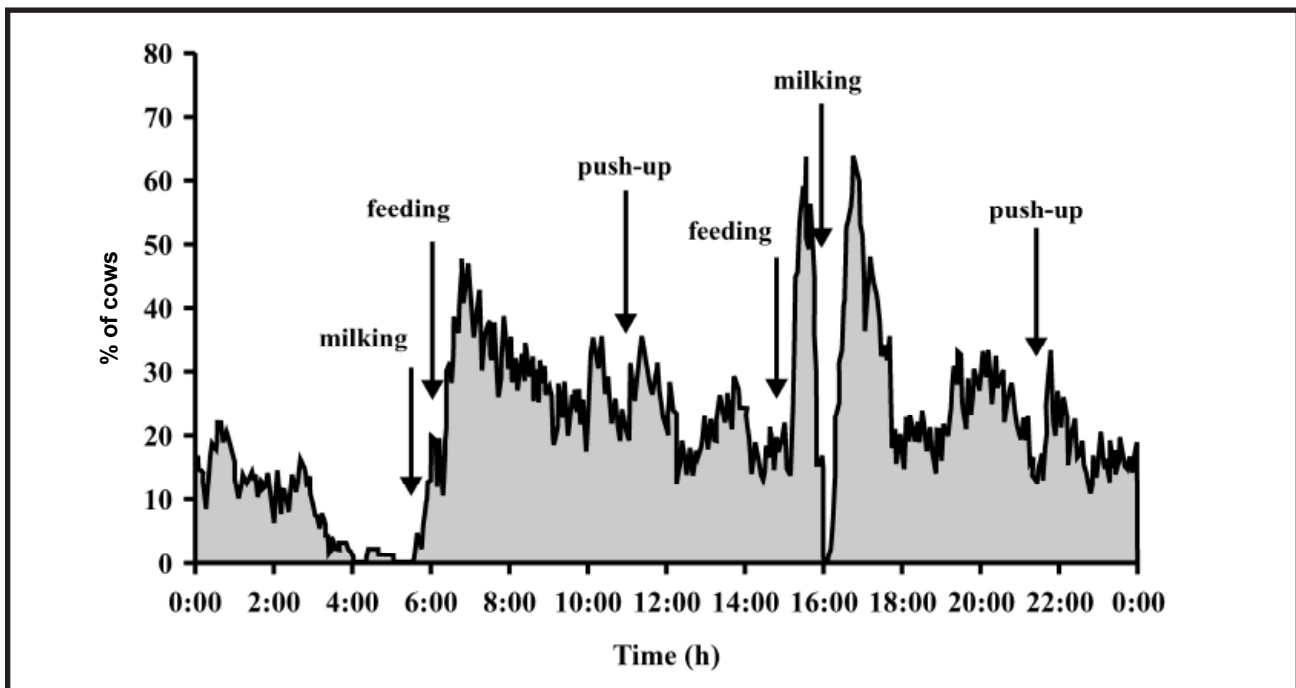


Figure 2. Temporal pattern of dairy cow feeding behavior indoors; percentage of 24 cows present at the feed alley over a 24-hour period (DeVries et al., 2003a).

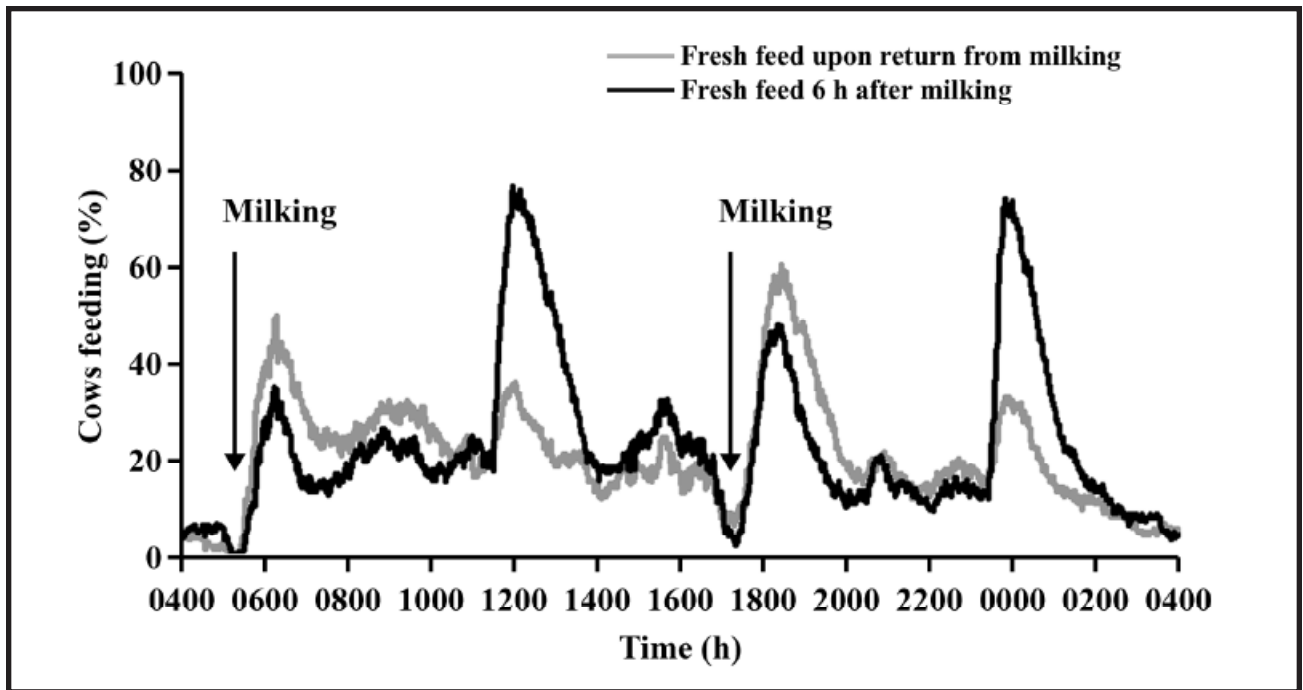


Figure 3. Percentage of 12 cows per group present at the feed alley over a 24-hour period for cows that were milked and fed at 0530 and 1730 h, and cows that were milked at 0530 and 1730 h and fed at 1130 and 2130 h (DeVries and von Keyserlingk, 2005).

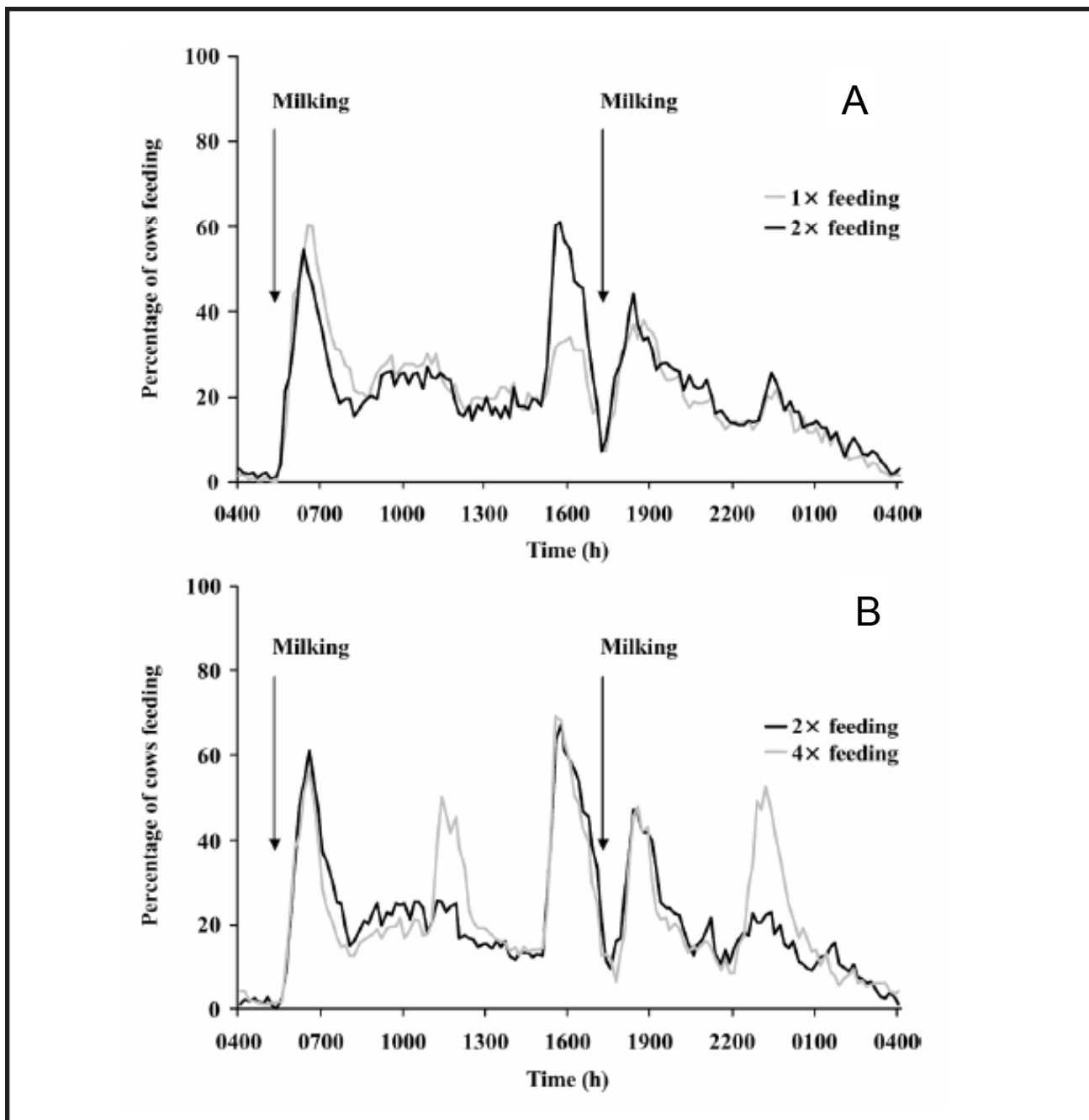


Figure 4. Percentage of 12 cows per group present at the feed bunk over a 24-hour period for A) cows fed once per day at 0530 h, or twice per day at 0530 and 1515 h, and B) cows fed twice per day at 0530 and 1515 h, or four times per day at 0530, 1100, 1515, and 2230 h (DeVries et al., 2005).