Fresh Cows – Management for Best Behavior!

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Introduction

Promoting feed intake by lactating dairy cows, particularly those in early lactation, is critical for the improvement and maintenance of milk production and health. Many dairy cows are capable of producing quantities of milk in much greater amounts than which can be maintained by nutrient intake in early lactation. Research in dairy cattle nutritional management has resulted in many discoveries and improvements in dairy cow health and production. Despite many advances in this field we are still faced with the challenge of ensuring adequate dry matter intake (DMI) to maximize production and prevent disease, particularly in dairy cows during the early lactation period.

Field observations, in addition to empirical evidence, suggest that housing and management can play as large of a role as nutrition in the performance and health of early lactation dairy cows. Much of that impact is mediated through the effects of those factors on the behavior of dairy cows. This paper will, thus, describe the importance of understanding cow behavior in early lactation and how knowledge in this area of science can be used to evaluate nutritional management and housing strategies. In particular, focus will be on allowing cows the time to perform behaviours they require, dietary transition, feeding management, stocking density, and grouping strategies. It is anticipated that with an improved understanding of the behavioral patterns of these cows, combined with proper nutrition, dairy producers can manage their fresh cows to optimize health and production.

Do Cows have Time to Behave Properly?

A dairy cow has a number of things that she needs to accomplish every day. Dairy cows, fed a TMR and kept in free-stall housing, will spend 3-5 h/d at the feed bunk, 0.5 h/d drinking, 10-13 h/d lying down, 2.5-3.5 h/d outside the pen (milking), and 7-9 h/d ruminating. While every 24-h day should be enough time to allow cows to do these things, we know that any factor which may impinge of the cow's ability to devote her time to those activities may have negative consequences. This is particularly problematic in early lactation, as at calving, feeding, resting, and ruminating activity all decrease, while standing time increases.

Dairy cows are motivated to spend approximately half of their day lying down; Jensen et al. (2005) demonstrated that cows have an inelastic demand for about 12-13 h/d of rest. Other researchers have shown that when opportunities to perform behaviors are restricted, lying behavior takes precedence over eating and social behavior (Munksgaard et al., 2005). Adequate lying time has not only been linked to ensuring good milk production (Grant, 2004), but prevention of cows spending too much time standing has also been linked to prevention of hoof pathologies (Proudfoot et al., 2010) and resultant lameness. In fact, factors that are linked to encouraging resting time in dairy cows, such as larger, less-restrictive stalls, use of well-maintained, deep-bedding, have all been linked to lower prevalence of lameness (Chapinal et al., 2013). Thus, anything that limits the ability of cows to devote the time she needs to lying down, may have negative consequences.

One of the behavioral challenges that dairy cows face at freshening is the sudden increase in time devoted to milking and being outside of her pen. The more time that cows are required to be away from their pen and resources (feed, water, rest), the more they are forced to reduce the amount of time that they devote to things like resting or eating, with consequence. Field studies have shown that cows are often outside of their pens for 4+ h/d (Espejo and Endres, 2007; von Keyserlingk et al., 2012). Espejo and Endres (2007) reported a positive association between the prevalence of lameness in high-producing pens and greater time spent outside the pen. Matzke (2003) demonstrated that mature cows and first-lactation heifers gained + 2 and 4 h/d of rest and 2.3 and 3.6 kg/d of milk when they were outside the pen for only 3 versus 6 h/d.

The feeding behavior of dairy cows is also important factor to consider, as it directly relates to the DMI level of the cow, as well as to her rumen health and digestion. The feed intake of a dairy cow is simply a function of her eating behavior. The total DMI (kg/d) of a cow is the result of the number of meals consumed daily (#/d) and the size of those meals (kg/meal). Similarly, the DMI can be expressed as a function of the total time a cow spends feeding per day (min/d) multiplied by the rate (kg DM/min) at which she consumes that feed. Thus, if a cow is to consume more feed, she needs to adjust some aspect of her feeding behavior. In recent analyses, we have demonstrated that gains in DMI may be more consistent by getting cows to spend more time feeding at the bunk, broken up into more frequent meals (Johnston and DeVries, 2015). Thus, maximizing time available to eat, to ensure high levels of DMI, is critical. This is particularly important for fresh cows, who often cannot keep up their nutrient intake in early lactation to match meet production and maintenance demands. An excessive or prolonged drop in DMI after calving may result in non-adaptive negative-energy balance, which may lead to subclinical ketosis (SCK), which is estimated to affect ~40% of dairy cows (McArt et al., 2012).

Maximizing time spent feeding at the bunk, in smaller meals, is also important for keeping the rumen stable, by avoiding large post-prandial drops in rumen pH associated with large meals and resultant risk of sub-acute ruminal acidosis (SARA)(Krause and Oetzel, 2006). Not only how cows eat, but also what they eat is important. Sorting of a TMR by dairy cows can result in the ration actually consumed by cows being quite different from that intended. As result, cows do not consume the predicted levels of effective fiber, thereby increasing the risk of depressed rumen pH (DeVries et al., 2008) and low milk fat (DeVries et al., 2011). Further, imbalanced nutrient intake and altered rumen fermentation, as result of sorting, has the potential to impact the efficiency of digestion and production (Sova et al., 2013).

The importance of devoting sufficient time to rumination should also not be overlooked. Dairy cows rely on the process of rumination to fully digest their food. Rumination serves to assist in the breakdown of particles, which not only also for greater microbial activity, thus increasing the rate of fermentation (Welch, 1982). It also assists in passage of material from the rumen. Thus, rumination also contributes to ability of cows to maximize their DMI. Rumination also serves to stimulate saliva production and, therefore, assist in rumen buffering and maintenance of a stable rumen environment (Beauchemin, 1991). While rumination time is largely dictated by the diet consumed (and its amount), factors which influence the daily activity patterns of cows have the potential to influence rumination. Dairy cows typically ruminate in a diurnal pattern during the time periods when the animal is not active (feeding, milking), but when at rest (lying down). As such, most rumination activity occurs at night, with other major bouts of rumination occurring during the middle of the day in-between other periods of activity (DeVries et al., 2009). As a result, a disruption to a cow's normal rest time due to other factors (for example: poor stall comfort or availability, increased need to walk, activity related to social agitation) may result in a decrease in rumination time.

What are the Benefits of Monitoring Behavior?

Given the link between feeding behavior and DMI, there is evidence that monitoring feeding behaviors may be important for the detection of health problems in dairy cows. In work by Goldhawk et al. (2009), cows diagnosed with SCK during the week after calving showed differences in feeding behaviour and DMI at the time of diagnosis. Interestingly, those differences were apparent as early as 1 wk before calving. Those researchers estimated that for every 1 kg decrease in DMI and 10 min decrease in feeding time during the week prior to calving, the odds of developing SCK increased by 2.2 and 1.9 times, respectively (Goldhawk et al., 2009).

Another behaviour which may be important to monitor during the transition period is rumination behavior. Shorter rumination times may be indicative of low DMI (Clement et al., 2014), and risk of negative energy balance, during the post-fresh period. For example, Calamari et al. (2014), studying a small group of cows (n=23), reported that cows that were diagnosed with at least one clinical disease postpartum had a lower rumination time in the first week after calving and their increase in rumination time after calving was slower compared with healthy cows. In a larger study by Liboreiro et al. (2015), cows diagnosed with SCK had reduced rumination time from calving to 8 d postpartum, as compared with healthy cows. In a recent study by our group, we demonstrated that multiparous cows who developed SCK, not only had reduced rumination time during the first weeks after calving, but also during the week prior to calving, compared to those cows that remained healthy (Figure 1; Kaufman et al., 2016). These differences were accentuated in those cows that not only were diagnosed with subclinical ketosis, but also with one or more other health problems post-partum.

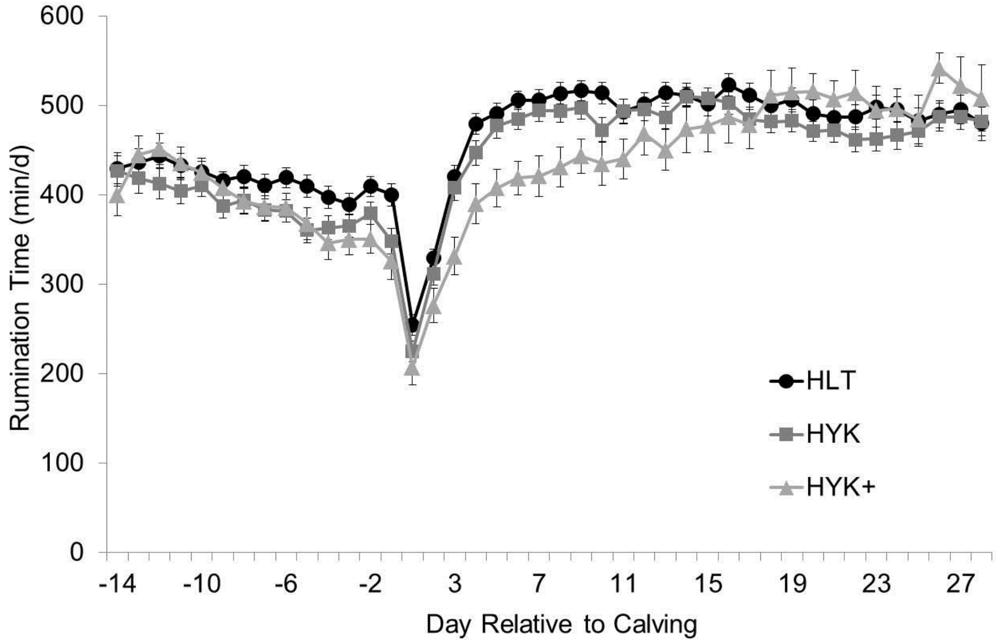

Figure 1. *Daily rumination time over the transition period for multiparous cows that were: healthy with no other recorded illnesses (HLT; n = 87), subclinically ketotic with no other health problems (HYK; n = 76) and subclinically ketotic with other health problems (HYK+; n = 39) (adapted from Kaufman et al., 2016*).

The results of these studies suggest that careful monitoring of cow behavior in the post-fresh period, as well as before calving, may be useful for identifying cows experiencing illness, or even at risk for illness. This is becoming a reality on many dairy farms with the development, validation, and commercialization of various technologies to automatically capture such behavioral changes (Schirmann et al., 2009; Bikker et al., 2014).

How Does Diet Affect Behavior?

One of the most notable changes for the dairy cow at calving is the transition from the dry to lactating diet. It is well established that cows take anywhere from 7 to 14 days to adjust their DMI in response to a dietary change (Grant et al., 2015). Given the difference in composition of dry cow and fresh cow diets, an associated lag in DMI is not always surprising. The susceptibility of dairy cows to SARA is also highest in early lactation (Penner et al., 2007), but also highly variable between cows, despite similar feeding management and transitioning strategies (Penner et al., 2007). Moving from a high-forage dry cow diet to a lower forage, higher NFC fresh-cow diet will not only directly impact the rumen environment, but have impacts on the eating behavior of cows. It is plausible that some of variability may be due to the eating behavior of said diets in early lactation. As compared to eating a dry cow diet, a fresh cow diet will be consumed much faster and in larger meals (DeVries et al., 2007). Such diets are also sorted to a greater degree (DeVries et al., 2007; 2008) and, as result of lower fibre content and particle size, ruminated for shorter periods of time per unit of feed consumed. Therefore, formulations for fresh cow diets should be aimed at minimizing these impacts on the eating behavior of the cows, by providing adequate physically-effective fiber, while limiting the use of highly fermentable starch sources.

Given that fresh cow diets still require a significant amount of highly-fermentable feed sources to ensure sufficient DMI and to meet nutrient requirements, other opportunities to modify the feeding patterns and rumination of cows on such rations need to be explored. Feed additives that have a positive impact on the rumen environment can also have concurrent benefits for feeding and rumination behavior. We demonstrated that supplementing peak-production lactating cows with a live strain of *Saccharomyces cerevisiae* yeast had beneficial impacts on meal patterning (DeVries and Chevaux, 2014): cows had more frequent meals that were smaller and occurred closer in time together. This research supported previous work by Bach et al. (2007) whereby similar effects on feeding behavior were seen as well as a positive impact on raising and stabilizing rumen pH. In DeVries and Chevaux (2014), cows supplemented with live yeast tended to ruminate longer and have less periods of elevated rumen temperature, which could be associated with less long bouts of depressed rumen pH. Likely, as result of these improvements in nutrient flow, rumination, and stabilized rumen, the live yeast-supplemented cows tended to have higher milk fat content and yield. Yuan et al. (2015) demonstrated that feeding a yeast culture-enzymatically hydrolyzed yeast product to cows during the dry period and early post-partum period has similar impacts on feeding behavior, with dry cows having more frequent, smaller meals.

Similar results have been demonstrated with other feed additives – including monensin. Lunn et al. (2005) demonstrated that providing monensin increased meal frequency in lactating cows experiencing sub-acute ruminal acidosis. Similarly, Mullins et al. (2012) found that feeding monensin in the first few days after dairy cows were transitioned to a lactation ration resulted in increased meal frequency and decreased the time between meals.

The common thread in all of these studies is an association between favorable meal patterns and a reduction in ruminal pH variation. Whereas meal patterning may, in itself, affect ruminal pH, it is likely that feed additives, such as live yeast or monensin, that have the potential to stabilize ruminal pH and fermentation, affect meal patterning as a secondary effect. Specifically, a more consistent fermentation pattern should result in less variation in volatile fatty acid production, improved fiber digestibility, and quicker return to eating. Feed additives that promote healthy eating patterns and have a positive impact on the rumen environment and rumination are then particularly useful for early lactation cows, which are at greater risk of experiencing SARA. For these cows, the use of such additives, in addition to proper feed bunk management (as described below), will allow cows to optimize the potential of the feed provided to them and remain healthy and productive during this critical period of time.

How Does Feed Availability Affect Behavior?

Beyond the diet provided, management of fresh cows must be focused on stimulating eating activity to help cows meet their lactational demands. In a series of studies we have shown that for TMR-fed dairy cattle, feed delivery acts as the primary stimulant on their daily feeding activity patterns (DeVries et al., 2003; DeVries and von Keyserlingk, 2005; King et al., 2016). Therefore, the frequency and timing of delivery of fresh feed are important factors for stimulating intake in fresh cows.

More frequent feed delivery (than 1x/d) results in cow more evenly distributing their intake across the day (DeVries et al., 2005; Mantysaari et al., 2006) as well as improving access to fresh feed by subordinate cows (DeVries et al. (2005). Further, providing more than 1x/d has been demonstrated to reduce the amount of feed sorting (DeVries et al., 2005; Sova et al., 2013), which further contributes to more consistent nutrient intakes over the course of the day. Such desirable feeding patterns are conducive to more consistent rumen pH and likely contributes to improved milk fat (Rottman et al., 2014), fiber digestibility (Dhiman et al., 2002), and the increased production efficiency (Mantysaari et al., 2006) observed when cows are fed more frequently than 1x/d. Improvement in DMI (Hart et al, 2014) and milk production (Sova et al., 2013) are also possible with more frequent feed delivery; however, less expected.

While moving to more frequent feed delivery may be difficult to operationalize on some farms, there is potential to alter the timing of feed delivery to increase the distribution of feed intake across the day. While the delivery of fresh TMR has the greatest impact of stimulating feeding activity, cows are also prone to eat around the time of milking, as well as around other management events during the day. It is possible then to stimulate more meals across the day by staggering these management events, for example, by moving the time of feed delivery away from milking. King et al. (2016) recently shifted feed delivery (2x/d) ahead of milking (3x/d) by 3.5 h and found that this resulted in cows consuming their feed more slowly in smaller, more frequent meals across the day (Figure 2), improving the efficiency of milk production.

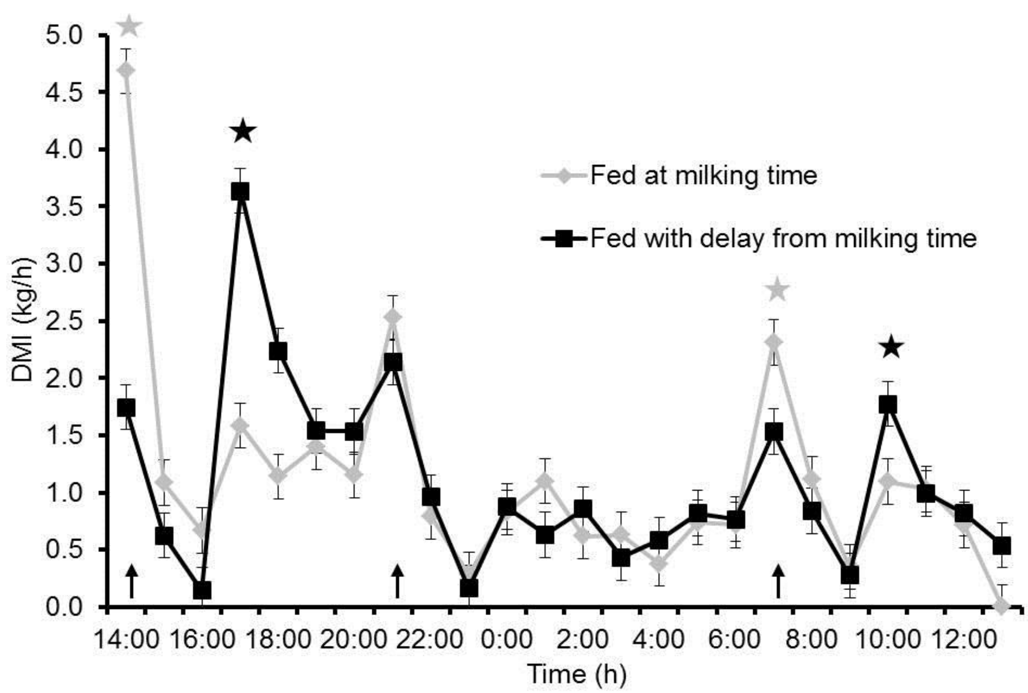

Figure 2. *Hourly average DMI (kg) of lactating dairy cows fed 2x/d: 1) at milking time (at 1400 and 0700 h, denoted with) or 2) fed with delay from milking time (at 1730 and 1030 h, denoted with). Cows were milked 3×/d at 1400, 2100, and 0700 h (denoted with ↑) (adapted from King et al., 2016).*

Feed push-up is another important factor in ensuring feed availability throughout the day. It must be noted, however, that we have no research evidence to say that feed push-up has the same stimulatory impact on feeding activity as does the delivery of fresh feed (DeVries et al., 2003). There is also no scientific evidence to suggest that pushing up feed more frequently will stimulate more DMI. That being said, feed push-up needs to occur frequently enough such that any time a cow decides to go to the feed bunk, there is feed available to her at that time. This ensures that DMI is not limited. By mixing up the feed that is no longer in reach, pushing it up will also help minimize the variation in feed consumed. Thus, pushing up feed frequently is necessary, particularly in the first few hours after feed delivery, when the bulk of the feeding activity at the bunk occurs.

Do Cows Have Space to Behave Properly?

One of the key components to ensuring that cows devote the proper amount of time to the behaviors they need to perform each day is to provide them adequate access to the resources they desire (i.e. feed, water, and lying areas). This is particularly true given that dairy cattle are allelomimetic, that is, they like to perform similar behaviors at the same time (i.e. synchronized).

When dairy cattle are overcrowded (i.e. situations where there are more cows than available feeding and/or lying spaces), they do not simply shift their eating and lying patterns to accommodate, but rather reduce the time they devote to those activities.

There are several studies where a reduction in lying time associated with lower stall availability has been described. For example, Fregonesi et al. (2007) demonstrated that increasing stocking density from 100 to 150% (1.5 cows per stall) reduced lying time by ~2 h per day. Similarly, Krawczel et al. (2012) demonstrated that for cows averaging 13 h/d of lying at a stocking density of 100%, increasing free-stall and feed bunk stocking density simultaneously from 100 to 142% resulted in a decrease of lying time of 42 to 48 min per day (Krawczel et al., 2012). Reduced lying time associated with overcrowding forces cows to spend more time standing on potentially hard, wet floors, which is tough on hoof health and may increase risk of lameness (Westin et al., 2016). Further, overcrowding may lead to reductions in rumination behavior. Krawczel et al. (2012) demonstrated that increasing free stall and headlock stocking density from 100 to 142% resulted in a drop of rumination time by 0.4 h/d; this change in rumination was associated with more time spent ruminating while standing and less time spent ruminating while lying down. These may all cumulate, then, in reduced milk production; Bach et al. (2008) demonstrated in a cross-sectional study of 47 herds, all with similar genetics and feeding the exact same TMR, a positive association ($r = 0.57$) between the stalls/cow and milk yield.

Similarly, overcrowding at the feed bunk results in increased aggressive behavior, and may limit the ability of some cows to access feed at times when feeding motivation is high, particularly after the delivery of fresh feed (DeVries et al., 2004; Huzzey et al., 2006). As a result, increased feed bunk competition will increase feeding rate at which cows feed throughout the day, resulting in cows having fewer meals per day, which tend to be larger and longer (Hosseinkhani et al., 2008). Feed bunk competition may also force some cows to shift their intake patterns by consuming more feed later in the day after much of the feed sorting has already occurred. Alternatively, reducing feed bunk competition, by providing adequate feed bunk space, particularly when combined with a physical partition (e.g. headlocks or feed stalls), will improve access to feed, particularly for subordinate dairy cattle (DeVries and von Keyserlingk, 2006; Huzzey et al., 2006). This, in turn, will contribute to more consistent DMI patterns, both within and between animals, as well as promote healthy feeding behavior patterns. It is not surprising that Sova et al. (2013) found in a cross-sectional study of parlor-milked, free-stall herds in Canada that every 4 inch [10 cm]/cow increase in bunk space (mean = 21 inch/cow; range = 14 to 39 inches/cow) was associated with 0.06 percentage point increase in group average milk fat and a 13% decrease in group-average somatic cell count. With greater bunk space available, cows are able to consume their feed in a manner more conducive to maintaining stable rumen fermentation, and thus have greater milk fat production. This may be particularly important for early lactation cows, which as described above, are at greatest risk of experiencing SARA during this time period. Also, with more bunk space (and lying space) cows are not forced to choose to lie down too quickly after milking rather than compete for a feeding or lying spot (Fregonesi et al, 2007), and thus reduce their risk of intramammary infection from environmental pathogens (DeVries et al., 2010). Finally, reduced feed bunk space has also been linked to compromised reproductive performance (Caraviello et al. 2006; Schefers et al., 2010). To date, much of work on the research on transition cows has focused on available feed bunk space during the close-up pre-partum period, where it has been shown that limiting bunk space can limit DMI (Proudfoot et al., 2009) and increase risk of post-partum disease (Kaufman et al., 2016). There is little research on this factor for the fresh-cow pen. However, given the vulnerability of cows at this time period, it is expected that these effects may be magnified at this time period. Thus, every effort should be made to manage fresh cow pens to provide sufficient space for all cows to each simultaneously (i.e. 30 inches [0.75m] of bunk space per cow).

In addition to access to feed and lying spots, some consideration must also be given to another, typically forgotten, nutrient: water. Water is perhaps the most important nutrient, however its quality and availability is often overlooked. In a recent field study of free-stall herds, Sova et al. (2013) found that milk yield tended to increase by 0.77 kg/d (1.7 lb/d) for every 2 cm/cow increase in water trough space available on the study herds (mean: 7.2 cm/cow; range: 3.8 to 11.7 cm/cow). While cause and effect were not established in that study, this result highlights the importance of water availability for group housed cows and provides further evidence that resource availability has the potential to greatly impact productivity.

How Do Grouping and Pen Movement Affect Behavior?

The optimal grouping of cows, particularly in the post-fresh period, remains a question. Over the years there have been a number of studies highlighting the differences in behavior of first-calf heifers as compared to mature cows. Krohn and Konggaard (1979) found first-calf heifers housed in a free stall separately from mature cows had increased eating time and higher DMI. Phillips and Rind (2001) reported that a mixed group of first-calf heifers and mature cows on pasture grazed for less time than either parity group kept alone. Most recently, Neave et al. (2017) found that, as compared to mature cows, first-calf heifers in mixed-parity groups spent more spent more time feeding, ate more slowly, visited the feed bunk more frequently, explored their feeding environment more, lay down more frequently in shorter bouts, and were replaced at the feeder more often. Given these differences, there appears to be benefits in keeping first-calf heifers and mature cows in separate groups. Phelps (1992) reported that first-calf heifers kept in groups produced 729 kg more milk per lactation than those kept in groups mixed with mature cows. Bach et al. (2006) observed first-calf heifers housed alone, as compared to those mixed with mature cows, to experience lesser loss of bodyweight and greater efficiency of milk production during the first part of lactation, as well as to milk more frequently in a robotic milking system. In a study done on commercial herds, Østergaard et al. (2010) found that keeping first-lactation heifers groups separate from mature cows after calving (for one month) positively affected production and health (with reduced treatments of ketosis) in those animals. Based on these data, it is recommended that first-calf heifers and mature cows are housed separately in early lactation to ensure optimal health and production of those first-lactation animals. However, due to herd size and facility design, this is not always possible. This was recently highlighted in a study by Espadamala et al. (2016) of 45 large herds in California, where ~50% of the herds did not keep first-calf heifers in separate groups. For those herds that do not, or are not able to, keep separate groups, it is important there to be sufficient lying, feeding, and water space, and the lying stalls are designed to fit the largest animals in the pen.

Another important factor to consider in relation to grouping of fresh cows, in the frequency and timing of moving animals into new groups (relocation). It is well established that every time a cow is moved into a new pen, it can disrupt the social complex of the group and have specific negative impacts on the moved individual. The negative effects of relocation can be seen for up to 3 d following placement in a new pen, and include increased competition for feed access, greater feeding rate, and reduced production, DMI, and rumination time (von Keyserlingk et al., 2008; Schirmann et al., 2011). Torres-Cardona et al. (2014) also demonstrated that relocation can reduce milk production on the day of relocation, with a greater impact on first-lactation heifers as compared to mature cows. Talebi et al. (2014) demonstrated that the negative effects of relocation can be reduced by decreasing the stocking density of the pen being introduced into. Further, Tesfa (2013) demonstrated that lactating cows, introduced into new groups of cows as pairs, showed no drop in milk production as seen in previous studies. Therefore, for fresh cows, which inevitably will be moved into a new pen at calving, and potentially again later into another lactating cow pen, steps should be taken to minimize the impacts of such relocation. Examples of this include not overcrowding pens, potentially moving cows with familiar companions, or moving cows into new pens during quieter times of the day (away from time of management events, such as feeding or milking).

Summary

Housing and management play a significant role in the performance and health of fresh cows. Much of the impact is mediated through the effects of those factors on the behavior of dairy cows. Dairy cows need the time and availability of resources to perform those behaviors which are important for them for maintaining good production and health. Fresh cow diets should be formulated to maximize eating time and DMI, while minimizing sorting. Management of that feed should be focused on maximizing opportunities for cows to go the bunk across the day, either by increasing the frequency of feed delivery or by altering the timing of feed delivery, while pushing up feed continually between feedings to ensure constant access. Overcrowding must be avoided for fresh cow pens, so that cows can maximize their eating and lying opportunities. Further, keeping first-lactation heifers in separate groups, as well as minimizing group changes, helps decrease social stress. Finally, behavioral monitoring during the post-partum period may also be important for identification of health issues in early lactation, and also for the evaluation of herd-level management strategies and events.

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