IMPROVING THE BOTTOM-LINE – MORE COWS OR LESS CROWDING

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Dairy producers housing cows in a freestall barn or on dry-lots are striving to achieve consistently healthy cows, maximum pounds of milk shipped, and optimum feed conversion of dry matter consumed to milk produced. At the same time, in order to maximize asset turnover ratio (revenue dollars divided by total assets), dairies are focused on spreading capital costs over a greater number of "revenue units" (milk producing cows), and enhancing labor efficiency by being able to manage more cows per full-time equivalent. The bottom-line is freestall barns are often over-stocked, with cow comfort and flow compromised. Where freestalls are designed to maximize stocking density and labor efficiency, they may not always adequately address cow comfort, health and behavioral needs of the cows.

The question is….does one improve the bottom-line of a dairy by milking more cows in over-stocked conditions likely generating more total pounds of milk shipped, or would less crowding and a better cow environment improve milk production and cow health to the point of generating the best overall profitability?

Providing a cow environment that reduces stress is very important. Good cow husbandry and providing good care to cows is in the best interest of every dairy producer. It was W.D. Hoard, years ago, who said "*remember that this is the home of mothers, treat each cow as a mother, the giving of milk is a function of motherhood, rough treatment lessens the flow, always keep these ideas in mind in dealing with my cattle*". This probably speaks well for most every well-managed dairy on their expectations for the well being of their cows.

Dairy facilities and the environment in which the cow is housed can have a dramatic impact on milk production and cow health. Particularly over the last decade, field observations and research data has been used to improve cow comfort and dairy housing. With improved cow comfort, dairies have taken advantage of better facilities by over-stocking with more cows to reduce the capital costs and debt load per cow. In some cases, the over-stocking has improved cash flow through higher total pounds of milk shipped, while at other times allowing herd expansion to occur while minimizing the number of barns (capital invested per cow) needed to house future cow numbers. On the other hand, over-stocking has often led to a series of production, health, and feed efficiency issues that are often masked by the fact that short-term the total pounds of milk shipped increased with higher cow numbers.

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Particularly with transition cows, significant health and economic issues with over-crowded prefresh and postfresh cows have been encountered throughout the country, and needs to be better addressed.

There is a general lack of scientific data on what really is "well-being" for a dairy cow. The way humans perceive an environment and the "comfort zones", and how cows perceive the same environment is different. An example might be at what temperature cows begin to experience heat stress (temperature-humidity index around ~72 degrees F), while humans typically find the same temperature conditions nearly ideal. A better understanding of what constitutes an "ideal cow environment" can support higher profitability through better cow health, production, efficiency and longevity.

Better Cow Environment Incentives

Over and above the financial incentives for better understanding what environment is "ideal" for cows, are the forces external to our industry that are becoming more influential in how dairy housing is designed and how cow's are managed. Ultimately, dairy housing and the cow's environment must address the consumer's perceptions and demands for animal "well-being", while allowing our industry to consistently produce and provide a high quality product.

It's often suggested that "pushing cows for milk and stressing them out" is what motivates and drives our industry. In fact, that's really backwards from reality….higher milk production is what you get when cows are not exposed to environmental stress, or another words more milk is the result of removing stress contributing factors from the cow's environment. Ironically, by better addressing animal "well-being" considerations such as over-stocking, heat stress, poor freestall design, or providing ample waterer space are exactly what leads to higher milk production, while also addressing consumer concerns. High production in itself is not stressful, but rather the product of removing stress from the cow.

The dairy industry is at an opportune time to address the common misconception that equates high milk production with animal stress or lack of animal "well-being". The opportunity exists to address some of the external industry concerns on animal well-being, by improving overall cow comfort, reducing over-stocking if an issue, and addressing other stress related environmental factors such as heat stress, with the net return being improvements in milk production, herd health and longevity.

Nutrient management - another incentive to improve the cow's environment deals with improving animal efficiency. Production efficiency has been measured in many ways over the years. On a global scale, when considering the limited availability of land for food production, efficiency of production has often been defined per unit of land or acre. As technology has significantly boosted production per acre, the rapidly evolving efficiency consideration is "how do we maintain or grow productivity while decreasing environmental expenses such as excess nutrients in the form of nitrogen (N) and phosphorus (P)".

Kohn (1997) discussed how manure production of N and P on a dairy could vary significantly based on feeding, ration formulation, and animal grouping. Improving the cow's utilization efficiency of nutrients, for targeted purposes, is the single most important mechanism for reducing nutrient losses from the dairy. Over-stocking can impact or reduce animal productive efficiency when over-stocked stressed cows redirect nutrients for higher body maintenance requirements (energy used for standing, panting, pushing, etc…) versus production, and should be considered a factor when assessing future nutrient efficiency and environmental considerations .

Cow Behavior Considerations

The amount of over-crowding that a dairy can manage largely depends on their ability to create day-to-day consistency in key management areas that are related to "normal cow behavior" such as resting or lying time, TMR and feed consistency, feed availability and intake, feeding times and meal behavior, parlor through-put, and the ability for cows to move about from one activity to another without competition from pen-mates.

Over-stocking and cow comfort, in many ways, should be considered one of the same. However, where cow comfort is typically directly associated with the physical environment (stall dimensions, bunk space, heat abatement system, holding pen time, etc…) in which the cow lives, determining when cows are over-stocked to the point of being detrimental to production and health needs to consider behavioral aspects of the cow.

Cow social behavior is not likely the first thing one thinks of when making cow-grouping decisions, when striving to increase feed intake, improve health, or increase milk production.

Determining an ideal stocking density must consider cow behavioral consequences that can affect performance and health. Cow behavior comes into play particularly when space is limited and where cows can't move about freely without competition to feed, lying, or water. Limited space allows boss cows to control water troughs, feed bunks, and limit normal cow traffic flow in the alleys, which in turns disrupts the normal behavior pattern of high producing cows.

When cows are housed in well-designed tie-stalls, every cow obviously has her own space, while management changes are brought to her and the stall. Freestall and open drylot pens with larger group sizes creates cow movement from pen to pen. These pen-to-pen cow movements aren't made without some social adjustment, and often impact the resting and feed intake of the cows. Research indicates that the re-establishment of dominance and normal pen cow behavior takes about 2-5 days after cows have been resorted and moved (Grant, 1995). During this adjustment period, after pen resorting, it's been shown that feed intake and cow lying times are altered and suffer for 3-7 days (Konggaard and Krohn, 1978). In contrast, Baird, et al. (2002) found no effects on feeding frequency or duration when regrouping heifers and cows in an unfamiliar group for a period of 4 days. In this study, the lack of regrouping having an impact might be that small groups (12 cows per pen) were used.

Cow Behavior – What's Important

Well-designed dairy systems accommodate normal behavior of cows to improve animal comfort and well-being. For example, having fresh feed accessible during times of the day when cows when cows prefer to eat, as when leaving the milking parlor, promotes greater feeding activity (Menzi and Chase, 1994). Several researchers have observed dairy cows to better understand what is "normal behavior", and have attempted to identify any behavior characteristics that differentiate higher producing cows from their contemporary herd-mates (Albright, 1998; Dado and Allen, 1994; Grant and Albright, 1997; Singh et al., 1994; Phillips and Rind, 2001).

Daily feed intake is determined by the number of meals consumed, the length of each meal, and the rate of eating. The eating behavior of high producing cows differs considerably from those of lower producing cows (Dado and Allen, 1994, Grant and Albright, 1995). To achieve consistency in the feeding and daily behavior of high producing cows, the cow's environment must be such that it ensures cow comfort, non-disrupted feeding activity, and normal social behavior and movement to feeding, lying, drinking, and milking activities.

Social dominance correlates strongly with animal age, body size, and seniority in the herd or pen (Grant and Albright, 1995). Social hierarchies and competition for feed and water affect feeding behavior of individual animals. A highly competitive time at the bunk coincides with the return of cows from milking and when fresh feed is offered. In order to meet the needs of more submissive cows, particularly if over-stocked, fresh feed must be available at all times and especially upon the return from milking. Over-stocking cows can alter the normal behavior and normal activities time budget.

Grant (2001) suggested cows have the following behavior and daily time budget:

- 3 to 5 hours eating
- 9 to 14 meals per day
- 10-14 hours lying/resting, including 7 to 10 hrs ruminating
- 30 minutes or less drinking
- 2 to 3 hours milking

In order to determine the self-selected amount of lying time by cows, animal studies need to be done in an unencumbered environment. Singh et al.(1994) and Phillips and Rind (2001) looked at lying time and behavior of cows in deep straw bedded yards and on pasture, and found lying times of 10 hours and an average of 11.3 hours per day, respectively. Cook (2002) and others have suggested that sub-optimal environments that increase the proportion of cows standing, thus reducing the lying time to less than 10-11 hours daily put cows at risk of developing lameness and other health problems.

My personal experience agrees with others, that apparent subtle changes in the lying time of cows can have a significant negative impact not only on foot health, but also feed conversion, milk production, and cow cleanliness. Factors contributing to lower lying

time include improper freestall design, inadequate heat abatement, and over-stocking either stalls or a bedded pack area.

Defining Stocking Density

Bunk Space

Despite the importance of cow comfort and cow behavior, making an accurate assessment of housing systems and the level of stocking density a given facility can support, while achieving optimal performance can be difficult. Historically, evaluation of linear bunk space per head, and calculating the number of cows expressed as a percentage of the available functional freestalls have been used as monitors of stocking density. For example, 120 cows in a 100 stall pen would be considered over-stock by 20% when evaluating the number of cows relative to stalls as an index of stocking density.

Various studies led Grant and Albright (2001) to conclude that bunk space greater than 20 inches per head showed no consistent benefit on dry matter intake, while bunk space of 8 to 20 inches across studies showed increased competition and variable effects on intake. The likely reason for the variability in response with bunk space limited below 20 inches has to do with several factors, including hours of fresh feed availability, waterer availability, alleyway widths, feed bunk and barrier design, and adaptation period (if any) to limited bunk space prior to intake measurements. Batchelder (2002) found that feed intake actually increased as bunk space was reduced, with the suggestion it was due to cows being more aggressive and competitive for feed. The researcher concluded that it isn't the bunk space that is limiting when overcrowded, but rather the ability to access feed, ability for cows to move about freely without competition, and having access to comfortable stalls with cows lying down. My field experiences would agree exactly!

A systems approach - using bunk space alone as a primary indicator of whether a barn is over-stocked is only of limited value. Bunk space is only part of the overall housing environment and system that must be evaluated. As long as linear bunk space is at least 15-16" per cow, a much better indicator of whether the bunk space and feeding may be limiting performance is to evaluate the day-to-day consistency in which fresh non-sorted TMR is continuously available and can be accessed by all animals in the pen in a comfortable environment, where cows can move about freely without competition to and from feed, water, and lying down (Barmore, 2002). ***Making an evaluation on whether a barn or pen is over-stocked really needs to focus on the entire system and not just the bunk space or cow numbers relative to the freestalls. Bunk space alone is not a particularly good indicator of stocking density impact.***

Over-stocking Impacts Feeding Behavior

Batchelder (2000) looked at the impact of over-stocking on intake and feeding behavior, with or without head gates, and found there clearly was a difference in when cows ate relative to whether the pen was 100% or 130% over-stocked. In this Cornell University study, the treatments were headlocks or post-n-rail manger design, and either 100% or 130% cows relative to freestall stocking density .

The treatment periods lasted 3.5 weeks, with a 1-week adjustment period prior to data collection. The TMR, days-in-milk, and daily milk production were paired for the study. Cows were observed for behavior every 15 minutes for one 24-hour period, with intake and milk data recorded over a one-week period. Data was collected on cows standing, eating, cud-chewing, drinking, and lying down. Milking times were at 9 am, 5 pm, and 1 am; the cows were fed twice daily at 9 am and 3 pm. Feed was pushed up 3-5 times between each milking. Cows were housed in a four-row barn, again with the feed manger barrier either being headlocks or post-n-rail. In the 100% stocking density, the linear bunk space was 2.3 ft/cow with headlocks, and 2.4 ft/cow without them. In the 30% over-stocked scenario, the bunk space was 1.75 linear ft/cow for the headlocks, and 1.84 ft/cow without them. The pens were relatively small, with only 20 or 26 cows for the 100% and 130% densities, respectively.

Although intakes were not significantly different between the 100% and 130% stocking, there was a trend for intake to diminish with over-stocking; however this was in a pen size of relatively few animals. I would suspect that the differences in intake might have been greater with larger animal numbers within a pen. Interesting from this study, is the differences in eating behavior between the 130% over-stocked and 100% stocked groups.

There was clearly three major feeding times, which occurred… after each milking. However, there was a large difference in the percentage of cows eating one-hour post-milking between the 130% over-stocked and 100% stocked pens. The percentage of cows eating post-milking ranged from 45-66% for the 100% stocked, and only 30-38% of the cows in the 130% over-stocked pen. Given a choice in this study, the cows in the over-stocked pen preferred lying down to feeding post-milking. This is similar to my observations in larger commercial dairies. Particularly in 3-row or 6-row barns that are over-stocked, cows returning from milking are likely to choose lying down to feeding, particularly the last half of the cows to return from the parlor.

There are many potential practical ramifications of over-stocking, found in the Cornell study, need to be considered in commercial herds in terms of feeding management. Over-stocking can have an impact on overall feed intake, meal patterns and possible slug feeding, actual ration intake variation due to sorting, intake variation across animals within pen, and lastly any impact cows lying down immediately post-milking may have on bacteria exposure from the stall surface while teat-ends are more dilated from milking.

One other interesting observation from this study was the range and distribution in cud-chewing for 100% versus over-stocked cows. At no time did cud-chewing exceed 32% of the cows in the over-stocked pen, while cows not over-stocked were well above 40%, reaching as high as 55% of the cows at times. Over-stocked cows spent 2 hours less per day ruminating. The author noted, “irrespective of ration NDF or effective fiber levels, what could the impetus of differences in cud-chewing observed be on saliva production and the buffering capacity of the rumen. Over-stocking is a factor that we need to consider as feed and acidosis issues continue to be of major concern on many of our dairies”.

Headlocks an Issue?
Current industry cow handling systems are headlocks, sort gates, palpation rails, chutes, and combinations of these systems. Headlocks are a very efficient way to handle a large number of cows; however they can be mismanaged. Strive to limit time in the headlocks to a maximum of 1 to 1.5 hours per day (Smith, et al. 2001). Avoid locking cows in the warmer summer afternoons. Springing heifers should always be exposed to and trained to use headlocks prior to entering the prefresh or transition pen.

Batchelder (2002) looked at the impact of headlocks compared to a post-n-rail manger on feed intake and feeding behavior. Results of the short-term study showed a 3-5% decrease in dry matter intake when headlocks were used.

A larger, longer-term, study was conducted on a commercial dairy with 216 milking Holsteins by Smith et al. (2001) in the summer of 2000. All animals, prior to the study, had been exposed to headlocks. In this study, headlocks did not appear to affect milk production when well managed. Personal experience with over-stocking and headlocks has been similar to the results of the Smith (2001) study.

Management of the feed mixing, and feed delivery and push-up, is far more significant of a factor than is the manger barrier design, when animals have previously been exposed to headlocks. In fact, if one observes how many cows will stand in a 10 foot filled section of bunk with headlocks, it's typically 5 cows; the same 10 foot of post-n-rail design bunk will often only have 4 cows due to the competitive nature of some cows which are able to stand at an angle taking additional space from less dominant cows. The key is prior adaptation to headlocks before entering the transition period. Data is limited, but experience would indicate that there isn't an advantage to either headlocks or post-n-rail manger designs in over-stocked conditions if both are well managed.

Stall Comfort and Lying Rates
Stall use can be used as an indicator of cow "comfort" Clearly, improving cow comfort and stall use can affect milk production, feed efficiency, health, and productive life of a cow. Stall design and stall base influence cow acceptance and lying time. McFarland (2003) nicely discusses the components of a freestall include the partitions, neck rail, brisket board, curb, stall bed (base and bedding). Collectively, the components of a freestall work together to convince a cow to enter the stall, and provide a comfortable resting experience, which in turn encourages the cow's return and use of the stall. Ultimately, cows by proper use and refusal of the stalls, will determine the success of a freestall barn. There are several good discussions of freestall modifications and design to maximize cow comfort and cleanliness, including the recent paper by McFarland (2003).

Gaworski (2003) looked at the effects of stall design and dimensions on stall use and lying rates comparing two different freestall designs. A practical finding of this controlled study was the differences in stall use relative to their location to the feed alley, and relative to the ends of the pen. The stalls closest to the feed and central to the pen

were used significantly more than stalls on the end of the pen and away from the feed. Not surprisingly, the stalls with frequent use were also more likely to be soiled.

Dairy consultants and veterinarians generally agree that cows should spend at least 10-11 hours per day lying down comfortably, and that stocking density can impact how stalls are utilized. Many have used on-farm walk-through observations to assess freestall usage and comfort, often calculating a stall usage index based on the number of cows standing relative to lying down.

The proportion of cows lying down properly in a stall, relative to the total number of stalls occupied in any manner is an observation monitor often called "stall comfort index", or SCI. This adjusts for cows that are eating, drinking, and moving about in alleys. This same calculated figure is also known as the "cow comfort index", where a value greater than 85% is considered a goal (Overton, 2002). Generally speaking, there's agreement that herds that consistently achieve a SCI over 85% will have better herd health, feed efficiency, and milk production. Likewise, many consultants feel that over-stocking can have a negative impact on the SCI, and thus herd performance.

Although there is some agreement about the goal for stall use and comfort, there is no standard for collecting the data and little research to help interpret the single point-in-time observations (Overton, 2002).

Factors impacting lying rates

- feeding times
- cow handling
- time of day
- temperature & solar conditions
- freestall dimensions and stall base
- air exchange in the barn and over stalls
- time relative to milking times
- parlor efficiency throughput
- time away from pen and lock-up time
- stocking density

Using time lapsed video, Overton (2002) concluded that cows preferred to lie down the most at 6 a.m and the least at 9 p.m. Cows in this study were milked three times daily at 4 a.m., noon, and 7:45 p.m, and housed in a newer freestall barn, that included low pressure sprinklers and fans. Alleys were flushed 5 to 8 times daily. Total time spent away from the stalls was 2-3 hours per day, with a TMR fed once daily and pushed up 6 times per day. As temperature-humidity index increased, the proportion of cows lying decreased (Overton, 2002). The highest proportion of cows lying (86%) was observed during the lowest recorded temperatures (58.8 ^{o}F). Despite the presence of fans and sprinklers and well-bedded sand freestalls, the combination of radiant heat from direct sunlight on the east end of the barn and the daily rising temperatures reduced lying rates.

The highest proportion of cows lying was 2 hours after the cows left for the early morning milking, with lowest proportion lying recorded 1 hour after the afternoon and evening milkings. This is very similar to the results of Palmer (2002) who found the highest SCI was in the morning, and specifically early morning before milking and feeding had occurred.

Individuals evaluating freestall barns for "cow comfort" and SCI should carefully consider the impact of management practices on recorded observations, particularly time since last milked and the temperature-humidity index.

Stocking Density and Lying Rates

There is very little data available from controlled studies that have looked at the impact of stocking density on lying rates. Most of the studies done looked specifically at surface cushion and type of freestall, and have not attempted to address any potential impact of stocking density per se. Palmer (2002) using time-lapse video measured the percent of stalls with cows lying (SCI) for different types of stall bases, and for low stocking density (66% cows relative to stalls) compared to 100% stocking density (one cow per available stall). This study found that the higher stocking density had higher lying rates. One must realize that the lying rates were calculated as the percentage of cows lying down relative to the total number of cows occupying a stall, and did not make any indication of total hours spent lying, resting and ruminating over a 24 hour period. One must be careful not to confuse lying rate with total lying time.

My work with commercial dairies has shown similar behavioral patterns and lying rates with stocking densities below 100%, another words adding a few more cows (if less than 100% stocking rate) will typically increase lying rates and possibly even encourage more aggressive feeding behavior. However, as freestall stocking densities exceed approximately 85-90% for transition cows, and over 100-105% for milking strings it's likely that total daily lying times per individual cow is going to suffer, yet lying rates (SCI) may actually remain fairly high. As found by Palmer (2002), the stall base can have a significant impact on the total lying time, as well as the lying rate (SCI).

Determining an optimum stocking density is really about evaluating the entire housing and milking center as a system. There really isn't any one ideal stocking density that can be recommended, but rather the correct answer when asked "what is the best stocking density", should be, "it depends, based on each individual dairies situation and housing system".

Factors Determining Optimal Stocking Density and Group Size

- Stall comfort index (SCI) and lying rate
- Actual number of functional stalls-consider location and maintenance
- Overall cow space – sq. footage per cow
- Alley & cross-over widths - cow flow without competition or injury
- Parlor throughput - time away from feed, water, and resting
- Availability and accessibility of fresh non-sorted TMR
- Fresh water availability and accessibility
- Air exchange capacity and effectiveness of heat abatement system
- Distribution and average of cow body size, age, and social dominance

Factors Determining Optimal Stocking Density and Group Size

- Stage of production and body condition
- Transition period is a key and critical period
- Consistency and level of variation that occurs in key areas
- Cow handling abilities – calm cows
- Existing foot health and overall cow health
- Nutrient efficiency environmental management considerations
- Expansion and growth plans

Sand or Mattresses

Numerous studies have evaluated stall base and cushion, and the impact on lying rates (Palmer, 2002; Haley, 2000; Cook, 2002). One of the most critical aspects of stall use and lying rates is the stall surface cushion and comfort. More recent research on stall preference and lying rates and cow health has demonstrated the benefits of sand over mattresses (Cook, 2002; Palmer, 2002). Albeit, sand has some significant liabilities in terms of handling, and is not currently a realistic choice in methane digester systems.

Working with commercial dairies, I've found there is a large significant difference in the overall cow comfort of well-managed sand freestalls relative to similarly managed mattress barns in terms of lying rates, hock lesions, foot health, milk production, and the potential successful stocking rates. Sand has been shown to have an advantage over mattresses in that there are less hock health issues (Weary and Tazskum, 2000; Cook, 2002). This not to say that well-managed mattress freestall barns aren't capable of supporting high levels of performance; however, in most situations sand freestalls will support a higher SCI, and thus potentially a higher stocking density if required.

Over-stocking is Common

A Cornell University field study (Stone, 2000) of 160 Northeast U.S. herds (86,523 cows) analyzed prefresh pens and calving data using on-farm Dairy Comp 305 records, and compared housing space to expected calvings per month as a method of looking at prefresh stocking density. When discussing achieving a 100% stocking density, people will often take the herd size and calving interval and assume they'll be calving the same number of animals each month. Based on this, the Cornell study assumed prefresh housing area was designed to accommodate cows freshening in a uniform monthly distribution throughout the year, and then **compared stocking density for a uniform calving pattern to the actual calving patterns that occurred on these 160 dairies.**

The Cornell study, found that 65% of the herds were 25% over-stocked in the prefresh housing at least two months of the year, while 40% of the herds were 35% over-stocked at least two months of the year! Over 40% of the herds in the study would have had at least one month per year where the prefresh housing was over-stocked by at least 50%.

Monitoring the Impact of Stocking Density

- Incidence of foot health challenges and lameness
- Fresh cow health challenges
- Pounds of milk per pound of dry matter consumed (feed efficiency)
- Cows standing, yet not eating or drinking
- Meal behavior and patterns
- Consistency of dry matter intake within pen or herd
- Incidence rate of loose manure within pen or group
- First 50 day milk production ascent – all fresh animals
- First calf heifer performance
- Injury rate and cull rate
- String or pen movement effects on milk production
- Dirty cow scoring – particularly lower leg and udder
- Milk quality – somatic cell count

The Hidden Costs of Over-stocking

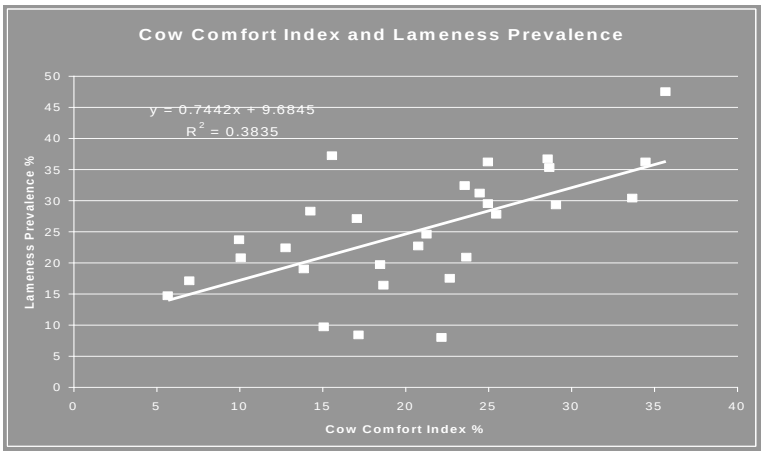
Lameness – the link between rumen acidosis and lameness is well established and documented. Maybe less obvious is the relationship to time on concrete and lameness. Over-crowding and less than optimum cow comfort leave cows on their feet too long, which in turn can cause lameness without actually having a primary case of acidosis (Leonard, et al.,1996). Particularly with fresh cows, excessive time standing might lead to greater incidence of foot problems. It's been discussed that excessive weight bearing on the cow's feet facilitates the loosening and elasticity of foot tissue at the dermal epidermal lamellar junction, triggered by the activation of enzymes from hormonal events associated with calving (Tarlton and Webster, 2002). This in turn may be associated with foot health issues of cows as lactation progresses. Increased time spent lying per day will ultimately reduce the severity of different types of foot problems, and should not be underestimated in its impact on overall foot health.

Cattle housed in wet manure contaminated conditions, often associated with over-stocking, are more likely to suffer infectious diseases of the foot, such as foot rot and hairy heel warts. Poor footing and subsequent rated injuries are other predisposing causes of lameness that often are associated with over-stocking conditions. Additional cow numbers and overcrowding increases manure in the alleys which accumulates prior to scraping, while additional cow numbers often create high traffic volume through foot bathes. By simple math, one can calculate that a three-row pen with three cross-overs, designed to house 100 cows, will have less square feet of surface area for manure than a two-row pen with equal cow numbers. Excessive cow numbers through footbaths, between cleanings, quickly creates contaminated slurry rather than the intended disinfecting clean bath. If over-stocked, the three-row pen quickly becomes a foot and leg hygiene concern. Simply, over-stocking leads to more manure deposited per square foot of alley, and left mismanaged will amplify dirty cow problems and lameness.

There is a growing body of evidence that increased lying times have a beneficial effect on lameness prevalence, with less time spent in the alleyways leading to cleaner drier feet. Leonard, et al., (1994) found decreased lying times and increased time standing half in and half out of stalls, with a more restrictive divider style stall, was associated with reduced foot health. Galindo and Broom (2000) showed that cows low in the group hierarchy spent more than 45% of the time standing in alleys, and had significantly more sole, interdigital, and heel lesions associated with the standing time.

Cook (2002) demonstrated that a Stall Usage Index, measured as the proportion of cows in stalls that were standing either completely in, or half-in, one hour before milking, was significantly related to lameness prevalence in a recent Wisconsin dairy herd lameness survey (Figure 1).

Figure 1. (Cook, 2002)



Milk quality concerns – an indirect consequence of over-stocking is the likelihood that cows will be dirtier due to more manure in the alley between scrapings, and from the higher traffic pattern in the freestalls. Dirtier cows often show up as manure soiled lower legs and udders; both of which are usually caused by dirty feet that are constantly in manure and is tracked into the freestalls.

Keeping cows clean is an essential part of environmental mastitis control, trying to minimize the bacteria load to the teat-end. Cook (2002) has described a hygiene scoring system developed and used on Milk Quality Control Investigations by their group for over two years. The scoring system charts the degree of manure contamination in three main zones: the udder, the lower rear legs, and the upper rear leg and flank. This has proven to be an effective on-farm evaluation tool to monitor effects of over-stocking and how cow freestall use and cleanliness may be impacted.

Group Heifers Separately

When practical, first calf heifers should be grouped separately from older cows both during the transition period and lactation. Heifers have a smaller body size, higher growth requirements, and frequently are lower in the social dominance hierarchy of the group. Phelps (1992) reported significantly more milk when heifers were separated from larger mature cows. Competition from the older cows resulted in the heifers consuming less dry matter, and thus produced less milk. The difference in performance was proportional to the difference in body size.

When heifers were separated from older cows, eating time increased by 11.4%, meals per day increased by 8.5%, lying time increased 8.8%, and lying periods increased by 19% per day (Konggaard, 1978). Others have shown that first calf heifers have different eating behaviors from older cows, suggesting that managing a separate heifer group would be beneficial (Beauchemin, 1994; Dado and Allen, 1994; Phillips and Rind, 2001).

When older cows and first calf heifers are mixed in the same pen and over-stocked, often the impact of over-stocking is greater on the heifers than the cows. This is a significant practical consideration for expanding dairies that may have higher than normal numbers of first calf heifers, yet are forced to over-stock until future freestall housing is completed.

Transition Cows are Key!

The transition period is truly a "glass ball" that can't be dropped without large financial losses, which often separates the top dairies from the average ones. When speaking of transition cows, I'm referring to the three weeks before and two to three weeks after calving. The transition period imposes many biological and environmental changes on the animal calving. Health, feed intake, and milk production are all at risk, while the financial success of the dairy is highly related to the success of the transition program and fresh cows. Most recommendations on improving the transition cow environment have come from lactating cow studies and experiences, and then extrapolated to the transition cow. One must be cautious assuming that the environmental needs of a cow close to calving are the same as a high producing cow. To date, direct studies are limited on what is necessary to provide an ideal environment and cow comfort for the transition cow.

Providing <u>adequate space</u> pretty well sums up where to start to improve transition cow results. The higher level of over-stocking, the less space per cow, the more stress and metabolic problems that occur. If housed in freestalls, large breed cows need 48" wide stalls with ample cushion and bedding (sand is ideal), proper heat abatement and air exchange over the stalls, proximity to at least two waterers providing at least 3-4 inches of trough space per cow, and ideally 3 ft/cow of linear bunk space with sprinkling at the manger when appropriate. Stocking density relative to freestalls should be limited to less than 90% (less than one cow per stall) when feasible, particularly if first calf heifers are mixed with older larger cows. Stone (2000) cites at least 80-100 sq. ft/cow of bedded pack should be provided to minimize risks associated with over-crowding.

Take Home Messages

- High production in itself is not stressful, but rather the product of removing cow stress.
- Over-stocking can impact or reduce animal productive efficiency, when over-stocked cows redirect nutrients for higher body maintenance requirements.
- Determining an ideal stocking density must consider cow behavioral consequences that can affect performance and health.
- Subtle changes in the lying time of cows can have a significant negative impact not only on foot health, but also feed conversion, milk production, and cow cleanliness.
- Bunk space alone is not a particularly good indicator of stocking density impact.
- Over-stocking is a predisposing factor that needs to be considered as feed and acidosis issues continue to be of concern on many dairies.
- Making an evaluation on whether a pen is over-stocked really needs to focus on the entire housing system, and not just the bunk space or cow numbers relative to the freestalls.
- There are many factors that impact stall comfort index (SCI) and lying rates.
- When evaluating freestall barns for "cow comfort" and SCI, carefully consider the impact of management practices on recorded observations, particularly time since last milked and the temperature-humidity index.
- There really isn't any one ideal stocking density, but rather it depends on each individual dairies situation and housing system.
- In most situations, sand freestalls will support a higher SCI, and thus potentially a higher stocking density if necessary.
- Reduced lameness, better milk quality, improved first calf heifer performance, and better transition cow management are key financial incentives for monitoring stocking density.
- There are several useful monitors for tracking the impact of stocking density.

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