Getting Stocking Density Right for Your Cows

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Take Home Messages

- Providing enough space for your cattle is the right thing to do, and is your commitment under the Code of Practice
- Consider stocking rates separately by resource — lots of stalls but too few feeding positions still results in an overstocked barn
- Not all space is created equal — include only fully usable space in your measures — poorly maintained or designed spaces should not be included
- Overstocking densities causes competition among cows, reduces their ability to access essential resources, and harms their health and wellbeing

Introduction

We build new barns rarely, perhaps too rarely. Good barn planning means forecasting your needs over the life of the facility, but it is all too easy to get this wrong. It is also natural to look for ways to cut building costs, and this can mean that we build facilities a little smaller than we think is ideal. Together this means that farms may face the problem of having more animals than the space allows for.

The aim of this paper is to review what science tells us about the effects of overstocking on cow comfort. I start by briefly defining stocking density, and then describing our commitments under the Code of Practice. Getting stocking density right means giving cows the right space, not just any space, so I review some key messages from the cow comfort literature. I then go on to describe various studies examining the effects of stocking rates on cattle. This work points to one conclusion: higher stocking densities are almost always a bad idea.

▪ Calculating Stocking Rates

Calculating the stocking rate in a barn should be easy: just take the number of cows and divide by the number of cow spaces available. In practice this can be difficult for a number of reasons.

One is that ‘space’ really means ‘comfortable and appropriate space’, so this requires judgment of whether, for example, each of your stalls really count as useful from the cows’ perspective. Stalls that have been damaged, poorly installed, poorly maintained, etc., need to be excluded.

Stocking density needs to be calculated in terms of each resource you provide your cows. Comfortable lying space is key, but so is the amount of feeding space available. Many barns that are designed and managed to provide 1 stall/cow still provide too little feeding space. This means that cows can be well stocked for one resource (lying) but overstocked for another (feeding).

For resources that are provided in clear cow units, the density can be calculated as the number of animals in relation to the number of available units. For example, in free stall barns this can be the number of cows:usable stalls. If the resource is continuous (like space in an open barn), then the number of cows should be divided by the total amount of usable space. For some resources like feeding space, both the number of spaces (e.g. head locker positions) and the space are important; cows will be overstocked if either the number of spaces is too low, or the amount of space provided is too low.

Although this may seem obvious, effort is required to make sure that the right number of cows are in each pen. In my experience doing large, multi-farm studies, staff typically estimate cow numbers to be lower (sometimes much lower) than the number of cows actually housed in that space. Thus a good way to start your efforts to get stocking right is to systematically measure the current situation on your farm: routinely count the actual number of animals in each pen and divide this number by an accurate and current measure of the usable space (separately for each resource important to cows).

▪ Our Commitment to the Cows and to Our Industry

Providing a comfortable environment for the animals under our care is fundamental to what it means to be a good dairy farmer, and is something we take pride in as an industry. This is one reason why cow comfort features prominently in Canada’s Code of Practice for the Care and Handling of Dairy Cattle (DFC-NFACC, 2009).

Included in the code are specifications for maximum stocking density, separately for at least a few of the most important resources that we provide our cows. For example, the Code specifies at least 1 lying stall for each cow. For barns that use open lying areas, the code asks for a minimum of 11 m^2/cow. For feeding spaces, the code asks for at least 60 cm of bunk space/cow, and 76 cm/cow for pregnant cows. The total amount of standing space per cow is not addressed in the Code, although it does specify that the alley from which cows access feed should be at least 4.3 m wide to allow cows to pass freely behind any animals that are at the feed bunk.

The good news is that most farms seem to be respecting these commitments. In survey work we have done on farms in British Columbia, California, and the north-eastern United States, we have found that most free stall barns have no more than one cow for each stall (von Keyserlingk et al., 2012). More recently, Charlton et al. (2012) assessed stocking density on farms across Canada, and found that this averaged 96.2%, meaning that on more than 50% of farms, each cow had access to a lying place. Although these averages look good, both surveys found that many farms overstock their cows, with some farms keeping 3 or more cows for every two lying spaces (for a recent review on stocking rates within the U.S. see Krawczel, 2015).

The Code requires more than just space; it specifies that this space needs to work for the cow. For example, the Code of Practice specifies that *“Cattle must have a bed that provides comfort, insulation, warmth, dryness and traction”, “Bare concrete platforms or hard rubber mats without bedding are unacceptable surfaces for the humane housing of cows*”, and *“Daily removal of cow patties and use of generous amounts of bedding assures cleanliness of cows kept in bedded-pack pens.”* A large and rapidly growing body of research has focused on getting space to work well for the cow. I briefly review some of the key messages from the cow comfort literature below.

Comfortable Space

The barns we provide our cows sometimes fail to meet their needs. One way to identify problems in stall design is to look for certain behaviors such as lying outside of the stall in the alley, dog-sitting, and perching with just the front hooves on the stall surface. Also look for problems as the cow lies down and stands up. For example, do you see (or hear) the cow coming into contact with the stall surface, including the stall partitions and neck rail, or do you see cows having problems as they lunge forward to stand up? Although these behaviors can still be common on some farms, each can be indicative of problems with the stalls.

A practical way to avoid these problems is to measure each stall to determine if the right space is available. For example, are stalls at least 1.2 m wide, and 3 m in length to allow for adequate lunge space? Are stall partitions bent out of place such that some stalls are too narrow? Is there anything to obstruct the lunge space, including fencing, excess bedding, etc.? Is the stall surface well maintained, with copious amounts of clean, dry bedding? If the cow can feel or see anything on the lying surface other than bedding then the stall is unsuitable for use (Fregonesi et al., 2007a; Abade et al., 2015). Mattresses, rubber mats or any other surface with little or no bedding put comfort at risk (Tucker et al., 2003), as do stall structures that restrict free standing and lying movements (Tucker et al., 2005; Bernardi et al., 2009).

Cow comfort studies often focus on changes in lying time as a measure of stall suitability, as good stalls are likely to be used more than poorly designed or managed stalls. The number and structure of lying bouts also can be relevant in assessing the suitability of open lying areas. For example, Campler et al. (2014) found that cows were better able to transition between standing and lying when kept on deep-bedded surfaces in contrast with poorly bedded mats. This difference was greatest around calving when the rate of position changes is typically very high.

Another way to judge the adequacy of the stalls is to look for characteristic injuries. Hock injuries are a good example, as these are clearly associated with stalls that are not properly bedded (Weary and Taszkun, 2000; Barrientos et al., 2013).

For feeding space, a key behavior to look for is aggression at the feeder. Do you see cows displacing one another as they are eating? Do you see cows in the feeding area waiting to approach the feed bunk? Do you see some cows immediately return to the lying stall instead of feeding after milking? As with the lying area, the presence of certain injuries can be indicative of problems with the design of the feeding space. Lesions on the neck are associated with improperly designed or maintained post-and-rail type feeders, where cows have repetitive contact between their withers and the rail on the feeder. Lesions on front legs can be associated with cows straining against the curb to reach for feed that has not been pushed up.

This sobering list describes only a subset of the many factors that can make our barns less suitable for the cows that they were designed for. It is important to keep these in mind as we consider the effects of stocking density. Farms can get one factor right (e.g. density), but if other factors are wrong the barn will still provide poor comfort.

It is also important to consider that the animals in the barn can have different needs. For example, some animals are socially subordinate, meaning that they face heightened risks in competitive environments. Younger, first lactation cows are often among these more subordinate animals, as are animals that are lame or sick. This variation among animals helps to explain why some cows can still do well within poor facilities. Winckler et al. (2015)

showed that in an overstocked facility, dominant cows were still able to have access to stalls; it was the most vulnerable cows in the herd that were negatively affected by overstocking. In the next section I describe this study in more detail, showing how stocking density can be varied experimentally, and the range of ways in which dairy cattle respond to changes in stocking rates.

The Anatomy of a Stocking Study

To better understand the scientific results from experiments on stocking density, it is important to know how these studies are conducted, what is measured, and why.

As an example, I have picked a recent publication (Winckler et al., 2015) describing a study conducted at the UBC Dairy Education and Research Centre in Agassiz, BC. Like many of the cow comfort studies at UBC, we tested how the same groups of animals respond to different conditions. This 'within-group' design is especially useful in cases where the responses are expected to vary between groups. A large body of research has shown that even when housed under identical conditions, cows vary greatly in behaviour, and perhaps especially in standing and lying behaviour. These are key outcome measures for studies that vary stall stocking rates. For example, Ito et al. (2010) showed that lying times vary greatly within commercial dairy farms; indeed, variation among cows within a farm is often much more than the variation in average lying times among farms. This means that a sensitive test of changes in stocking requires that the same animals be tested under each condition.

As described above, the stocking density is the ratio of the number of animals sharing the resource to the amount of resource available, for example, cows:stalls. This means that stocking density can be varied by changing the amount of resource available (e.g. floor space), the size of the group, or both. Unfortunately, researchers have rarely examined the effects of space and group size independently. One exception is the study by Telezhenko et al. (2012) that varied pen size and group size, as well as how these two factors combined to result in different stocking densities. This study showed that pen size especially affected cow movements, as animals were able to cover larger distances in larger pens. Cows tended to spend more time lying down in the free stalls when housed in smaller groups, but otherwise group size had little effect on cow behaviour. The interaction between the pen size and group size (i.e. stocking density) had powerful effects on lying time, driven by increased competition for lying stalls at higher stocking densities.

Together these results suggest that experimental work on stocking density needs to avoid changes in group composition. Although some change in pen size or group size is necessary to change stocking density, these changes need to be done with care. With these constraints in mind, Winckler et al.

(2015) tested stable groups of 9 cows, always in identically sized pens, experimentally varying only the number of stalls that these cows could access. During some weeks the cows were provided access to only 6 free stalls (creating a stocking density of 150%), sometimes 9 stalls (100% stocking), and sometimes 12 stalls (75% stocking). Different groups were tested under the different conditions at different times, to prevent any effects of season etc. interfering with our test of treatment. Cows were tested under each condition for a week, and after tests at the higher density treatments (100 and 150% stocking) cows were provided a rest period at the lowest density (75%) to prevent any carryover effects between treatments.

The results from this study showed very clear effects: the amount of time cows were able to spend lying in their stalls was reduced by one hour per day when housed in the 150% stocking treatment in comparison with 100% stocking. Lying time was slightly higher still (about 15 min/day) when cows were understocked (at 75%), suggesting that even in the 100% condition there was some competition for stalls (likely because some stalls are less preferred, including stalls further away from the feed alley and stalls adjacent to a solid wall; Gaworski et al., 2003). Fregonesi et al. (2007b) found that *"At the 100% stocking level, the least popular stalls were occupied for about 6 h/d but the most popular stalls were occupied more than 15 h/d*."

Reduced lying time at higher stocking densities is driven by changes in lying time at night (Winckler et al., 2015). Cows show a distinctive diurnal pattern in the lying behaviour with most lying occurring at night and most feeding (and hence standing) happening during the day, meaning that the competitive pressure for access to the lying stalls is greatest at night when most cows are motivated to lie down (Fregonesi et al., 2007b).

In a well-designed barn, cows rarely lie down in the alleyways, meaning that the reduced lying time at higher stocking rates is associated with more time standing up. One might hope that this increased standing time would translate into more time spent eating, but Winckler et al. (2015) found that this was not the case. Instead, cows spent more time standing inactive in the alley adjacent to the feed bunk, and especially in the back alley between the two rows of free stalls. They likely preferred this location as it was easier to then access a stall if one became available. Of course, some cows did not simply wait patiently for a stall to become free; they competitively displaced subordinate cows and then took their stall. The rate of these competitive displacements was about 3 times higher when cows were stocked at 150% versus 100%.

The aim of the Winckler et al. (2015) study was to understand how changes in stall availability affected different cow behaviours. To provide a clear test of changes in stall availability, the study contrasted high and low stocking densities. Other studies have examined a range of intermediate densities.

Fregonesi et al. (2007b) provided stable groups of 12 cows with access to 12, 11, 10, 9 or 8 stalls, and found that lying times declined gradually over this range in stocking densities (the rate of decline was greatest when stall availability was reduced from 12 stalls:12 cows to 11 stalls:12 cows). This gradual decline in lying behaviour with even modest levels of overstocking is seen across a wide range of studies testing the effect of changes in stocking in different ways (see Krawczel, 2015).

In summary for this section, overstocking at the free stall reduces stall usage (especially lying times, and especially for the more vulnerable cows). However, stalls for lying are not the only resource important to housed dairy cattle; cows also require comfortable places to stand when they are not in the stall (or comfortable stalls to stand in; Bernardi et al., 2009) and a comfortable place to feed. The feeder is a place where there is much competition between cattle, and so also a place where pressure from overstocking is likely to be felt. Competition for access to feed can be a problem for all cattle, but is known to be especially so for the more vulnerable cows, especially during the weeks around calving (Proudfoot at al., 2009). I turn to problems with overstocking at the feeding area in the following section.

Overstocking at the Feeder

We often see competitive behaviours at the feed bunk as cows attempt to access feed, especially fresh feed that cows are most highly motivated to consume (DeVries et al., 2004). One reason for this competition at the feeder is that free stall barns are often overstocked in terms of feeding space. For example, in our survey work on commercial farms we have found that many farms offer less than the 0.6 m required for cattle (von Keyserlingk et al., 2012), and that very few farms provide the approximately 0.8 m recommended for pregnant cattle in the Code of Practice (DFC-NFACC, 2009).

One reason why overstocking at the feeder is so common is flawed barn design. Pen layout should start with the constraint of how much space is required for all cows to feed comfortably. At 0.8 m/cow, a 100 cow pen requires at least 80 m of bunk space from which the cows can access feed delivered in the feed alley. If cows are also provided stalls that are the standard 1.2 m in width, then two rows of 50 free stalls each will require just 60 m, leaving plenty of space for wide crossover alleys, or even wider stalls. This layout results in a “2-row” (or “4-row” if built as a mirror image) barn, as two rows of stalls access a single feed alley. These barns are long (in this example 80 m) and narrow (say 15 m to allow room for lots of lunge space in the stalls and wide alleys).

Unfortunately, all too often these design constraints are reversed. The designer instead calculates the maximum number of lying stalls that can fit into a given space, favouring barns with a square-shaped layout. The same floor area as I described in the previous example (80 x 15 = 1200 m^2), could be configured as a 60 m long and 20 m wide pen, with 130 stalls in 3 rows (hence the extra width). But this configuration leaves each cow with less than 0.5 m of feeding space, much less than she requires. To avoid overstocking at the feed bunk, start your barn planning by making sure that each cow will have lots of feeding space, and as a rule of thumb, avoid 3-row (and 6-row) layouts.

A series of studies have shown that competition for feed increases rapidly as stocking density at the feed bunk increases over the range described above. Huzzey et al. (2006) found that cows were more likely to competitively displace one another from the feeder as feeding space per cow declined from 0.8, to 0.6, to 0.4, and then to 0.2 m per cow. As expected, this competition at the feeder was greatest when cows returned from milking to fresh feed. At the lowest density (corresponding to the 2 row example described above) more that 80% of the cows in the pen were able to feed at the same time, but as stocking density increased the percentage of cows able to access the feeder at peak times declined rapidly to about 50% in the 0.4 m treatment, and about 30% in the 0.2 m treatment. The reduced access resulted in reduced feeding times, and more time standing inactive in the feed alley as cows waited to access feed.

As with overstocking in the lying stalls, good facility design can help to reduce these harmful effects. Huzzey et al. (2006) found that feeding times declined with increased stocking rates when cows accessed the feed through either a post-and-rail feed barrier, or through a head-locking barrier. However, cows were more likely to competitively displace other cows from the feed bunk when feed was accessed using a post-and-rail barrier, likely because cows could more easily use their head as a weapon to knock other cows away from the feeding area. Subsequent work has shown that competition at the feeder can be further reduced by adding partitions that separate cows at the feeder; these so called ‘feed stalls’ can reduce the rate of competitive displacements at the feeder to less than half the rate observed without the barriers (DeVries and von Keyserlingk, 2006).

▪ Conclusion

My key message is simple — avoid overstocking. Your responsibility to your cows is to provide them the space they need to access important resources, and this is also the commitment that we have all made in the Code of Practice.

When measuring the stocking rates in your barn, do this separately for each resource that your cows require. Sometimes a pen can be appropriately stocked in terms of one type of space (e.g. stalls for lying) but be overstocked in terms of another important resource (e.g. space at the feeder).

Also consider the quality of the space. For example, in many barns some stalls are not suitable for the cows (e.g. because of damage or serious errors in stall design); these stalls should not be included in your calculation of stocking rates. Even in well designed and maintained facilities some stalls are much less desirable to the cows (e.g. those further from the feed alley), meaning that a pen that appears to be understocked to us can be overstocked from the cows' perspective.

There is a large body of scientific evidence showing the problems for cows associated with overstocking at both the lying stall and the feed alley. Overstocking increases competition for these resources and reduces the cow's ability to lie down and to feed, especially at key times of the day when she is most highly motivated to engage in these activities. Overstocking is especially harmful for the most vulnerable animals in our herd, including the sick and lame animals that are socially subordinate.

This review has focused on stocking in the lying and feeding areas. Overstocking may also be a problem in terms of other spaces but there has been little research on these other resources. For example, more research is required to provide science-based recommendations in terms of floor space in the pen. Also, many farms now provide cows access to a mechanical brush. Brush access appears to be important to the cows, but there is little research on the correct ratio of brushes to cows. Similarly, cows are highly motivated to access an outdoor paddock, but there is little work on how much space should be provided.

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