

The Dual Roles of Cow Comfort in the 'Get Lamé – Stay Lamé' Hypothesis

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Abstract. Although there is a general understanding that there is a link between poor cow comfort and lameness, the mechanisms by which one leads to the other are poorly understood. The objective of this article is to review the environmental impacts on hoof health in the dairy cow, describing the potential interactions between cow comfort and the trigger factors which ensure cows 'get lame' and the subsequent interactions once cows become lame which ensure that she 'stays lame'. These are the dual roles of cow comfort. The discussion will make the case that it is the duration of daily standing activity, combined with the type of surface that the cow stands upon, that are the principal components of cow comfort that need to be addressed if we are to break the cycle of 'get lame – stay lame'.

Keywords. Lameness, Cow Comfort.

Introduction

Poor cow comfort has long been associated with increased rates of lameness in dairy cattle. Excessive time spent standing on concrete walking surfaces in intensively managed dairy herds appears to predispose cows to claw horn lesion development (Bazeley and Pinsent, 1984; Greenough and Vermont, 1991), while poor lying times have also been identified as a significant risk factor for lameness (Leonard et al., 1996). However, the mechanisms by which poor cow comfort alter herd lameness dynamics has been poorly described. This article makes the case that increased time spent standing when the cow would rather be lying, and the surface on which she must stand, are the major factors driving differences in lameness prevalence at the herd level.

Lesions of the claw horn, which include sole hemorrhage, sole ulcer and white line disease, are very common causes of lameness in dairy cattle and have traditionally been referred to collectively as 'laminitis' (Cook et al., 2004). Laminitis is still regarded by many as a nutritional disease, despite a growing amount of evidence to suggest lesions such as sole ulceration are merely 'clinical signs' on the sole surface of the hoof. In much the same way that we do not instantly know the causative agent when a cow presents with a cough, the presence of a claw horn lesion merely represents the end result of several possible causative pathways. The trigger factors for claw horn lesion development are described along with the interactions of cow comfort in the 'get lame-stay lame' hypothesis which attempts to explain herd lameness dynamics. Infectious causes of lameness are not discussed in this article.

Discussion

Trigger Factors

In recent years, three main trigger factors for claw horn lesion development have emerged from the literature. These include:

- Calving induced changes in the claw.

The suspensory apparatus of the third phalanx within the claw horn capsule, described by Lischer et al., (2002), appears to be weakened around calving time. An inevitable increase in the incidence of sole hemorrhage has been described around the time of first calving (Webster, 2001) and this appears to be associated with an up-regulation of certain gelatinoprotease enzymes (metalloproteinases and 'hoofase') in the corium of the claw (Tarlton et al., 2002); a process which may be stimulated by changes in the

concentration of hormones such as relaxin. These enzymes appear to weaken the bond between the third phalanx and the claw horn capsule leading to increased mobility during the periparturient period.

- Nutrition induced changes in the claw.

The importance of biotin and trace elements such as zinc methionine in maintaining horn quality has been well demonstrated in recent years (Blowey, 2005) and work in Denmark on experimental induction of rumen acidosis and claw horn changes using a fructan sugar (oligofructose) may help us improve our understanding of the actual mechanisms linking acidosis with claw horn lesion development (Thoenfer et al., 2004). At this time, increased mobility of the third phalanx is believed to be induced by one of two pathways; lamellar hypoxia induced by arterio-venous shunting resulting from histamine release in the rumen, or enzymatic stimulation and remodeling of the corium, triggered by an exotoxin released by *Streptococcus bovis*, which is known to overgrow in the rumen early in the course of sub-acute ruminal acidosis (Cook et al., 2004).

- Trauma is a third trigger factor involved in the development of claw horn lesions.

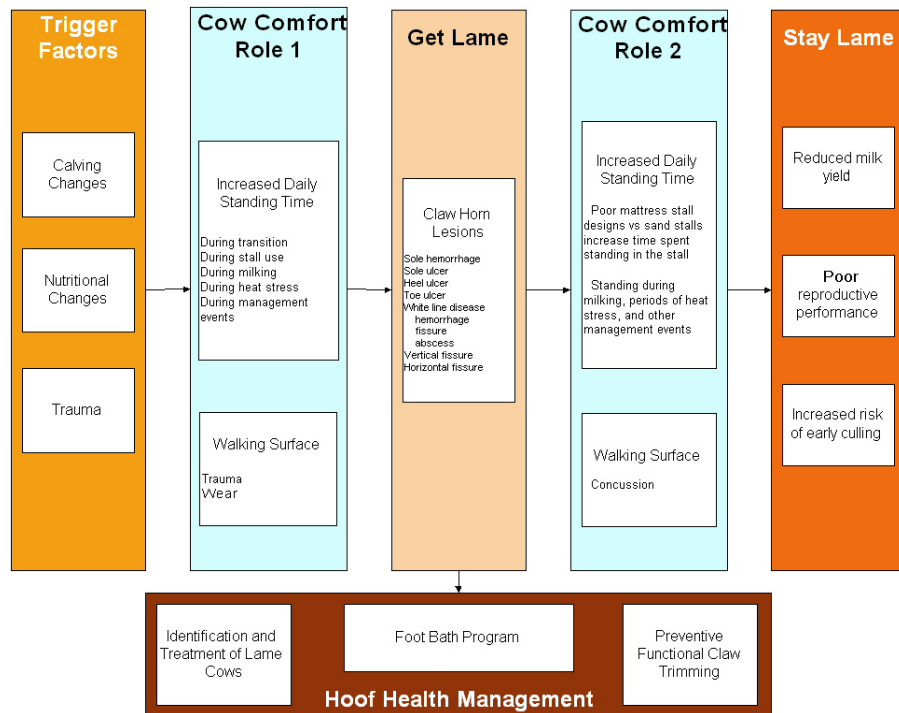
In most herds this occurs as a consequence of overgrowth and overloading of the outer claw of the rear foot – explaining the preponderance of lesions in this claw. However, in larger herds, we also see excessive wear triggering lesion development – a problem which may be exacerbated by too much horn removal at routine hoof-trimming. Slippery floors appear to be a particular risk factor for white line lesion development and rubber flooring may help to reduce this risk.

Whatever the trigger factor, integral to the mechanism for the development of sole hemorrhage, ulceration or white line disease, is the requirement for the weight of the animal to place downward pressure on the third phalanx within the claw horn capsule, thereby compressing the corium beneath the bone and initiating claw horn lesion development. Cow comfort therefore has a role to play in determining the duration and timing of standing behavior.

Dual Roles of Cow Comfort: Role 1

When we consider the dual roles of cow comfort in herd lameness dynamics (shown in Figure 1), the first role is where poor cow comfort results in time spent standing when the cow would rather be lying at a time when she is exposed to one of the three trigger factors described above. This occurs in five main situations; changes in behavior during transition, poor stall design enforcing aberrant standing behavior, enforced standing time resulting from very long milking times, changes in behavior during periods of heat stress, and cow management effects on time budgets.

Figure 1. The ‘get lame-stay lame’ hypothesis to explain the dual roles of cow comfort in herd lameness dynamics.



Changes in Standing Behavior

- During the transition period

Webster (2001) showed a reduction in sole hemorrhage around calving time in heifers kept in a straw bedded pack barn compared to a poorly designed freestall barn. While time budgets were not recorded, increased lying time in straw yards compared to similar free stall housing has been documented by others (Singh et al., 1993), and it is now common in the UK to advise first lactation heifers be kept separate from mature cows on a straw bedded area up to around 30 days in milk (Blowey, 2005). Our knowledge of how the time budgets of heifers and mature cows change through the transition period is rudimentary. In a study tracking mature cows through a sand free stall facility from pre-fresh to post-fresh groups via a straw bedded maternity pen, daily time spent standing increased by 3 hours from 4 days before calving to one day after (Huzzey et al., 2005). It is likely greater shifts would be observed in heifers introduced to freestalls for the first time, in facilities with poor stall designs, in overstocked pens, and where cows are subjected to multiple pen moves close to calving, creating repeated social disturbances.

- During stall use

Non-lame, high yielding dairy cows in well designed, comfortable well bedded stalls lie down for around 12 h/d or more and stand in stalls for less than 2h/d (Cook et al., 2004). Stall designs which fail to provide for the movements of lying and rising, adequate resting space, or a cushioned surface tend to reduce lying behavior to less than 10h/d and increase standing time in the stall. In one study, free stalls with a concrete surface and a restrictive divider design resulted in reduced lying time, increased periods spent perching (standing half in and half out of the stall) and significantly worse claw hemorrhage scores and an increased rate of clinical lameness in heifers two months after calving compared with heifers kept in a stall with greater surface cushion and a less restrictive divider design. Correlation between reduced lying behavior and worsening claw health was observed in heifers in the more comfortable stalls (Leonard et al., 1994). The significance of perching in the stall, rather than total time spent standing in the stall may have been overstressed as a risk factor for lameness, and may merely be a function of neck rail placement (Cook et al., 2005).

Conditions of overstocking create changes in daily stall use patterns of sub-ordinate 'outlier' cattle, placing them at increased risk for increased daily standing times (Wierenga and Hopster, 1990), and overstocked dairy heifers with short daily lying times are known to be at increased risk for claw horn lesion development (Leonard et al., 1996).

- During milking

Groups in large freestall dairy herds are typically designed to be no larger than 4.5 times the number of milking stalls in the parlor. Assuming parlor throughput exceeds four turns per hour, this target returns cows to the pen from the parlor within one hour – leading to total daily milking times of 2-3 hours in 2 and 3 times a day milked herds. This recommendation however, assumes the order through the parlor is random. We know this is not the case (Rathore, 1982) – which means that while some cows can be milked three times in as short a time as 30 minutes per day, other cows spend much longer being milked, especially in large management groups milked through inappropriately sized milking facilities. The problem is particularly acute in large grazing herds which manage only one group of cows. Under-sized parlors result in daily milking times which exceed 7 hours per day. Such problems are exacerbated in early lactation primiparous cows which may commingle at the rear of the holding area.

- During periods of heat stress

The highest rates of claw horn lesion development are seen in the late summer in North America (Cook, 2004). It has been suggested this could be due to an increase in the rate of sub-acute ruminal acidosis (SARA), an increase in standing times, or a combination of the two (Stone, 2004). While heat stress associated ruminal acidosis has been documented, changes in behavior when cows become heat stressed have not been investigated in detail. We recently determined that between mean daily average temperature humidity index (THI) readings of between 56 and 74, cows were observed to increase daily standing time by 3h/d (Cook et al., these proceedings). These data, together with an increased susceptibility to SARA could explain the increase in claw horn lesion development observed in the period from September to November. The two month delay between the peak in heat stress and the peak in lameness appears to reflect the time taken for the sole lesion to develop once an insult occurs at the corium.

- During other abnormal events

Excessive time spent locked up at the feed bunk may have a detrimental effect on daily time budgets. While cows are quite capable of compensating for a 1-2 hour change in routine, if lock up is prolonged and in association with other stressors – such as an overstocked 3-row pen, then the ability of the cow to compensate and 'catch-up' on lying time may be exceeded. It is perhaps unfortunate the cows we most commonly lock up for long periods are the fresh cows, immediately post-partum, at a time when they are most susceptible to changes in total daily standing time.

We believe changes in daily standing time of the order of 2-4 h/d, when enforced by environmental or management circumstances during periods when the cow would rather lie, are biologically significant. This represents 2-4 hours of increased weight bearing, which is potentially damaging to the foot when the change coincides with exposure to one of the trigger factors.

Standing and Walking Surface

In many herds, where cows are predominately exposed to concrete flooring surfaces, white line disease emerges as a problem and rates often exceed that of sole ulceration. Concrete areas that are excessively slippery or rough, especially where cows must make sharp turns, put increased stresses on the white line junction two thirds of the way back from the toe – the area of greatest ground reaction force when the cow stands and walks (Van der Tol et al., 2002). Where cows must walk down inclines greater than 2% and over concrete for more than approximately 200 feet, the issue of wear becomes an important factor making lesions of the claw horn more likely. This may be directly from thinning of the sole, or indirectly via a change in hoof balance and loading, as there is a tendency for cows with shallow rear claw angles to be more susceptible to white line disease and lameness (Wells et al., 1993).

With a focus on preventing slipping, trauma and wear, it is easy to prioritize where alternative flooring surfaces should be sought. Long transfer lanes, parlor holding areas and slippery corners where cows are forced to turn sharply are ideal places for rubber flooring. The decision to use rubber flooring in free stall pens is less clear. Proponents rightly point out rubber flooring improves the locomotion of lame and non-lame cows, increases stride length (Telezhenko and Bergsten, 2005) and allows cows to show improved signs of estrus and mounting activity. However, it is less clear whether this actually impacts herd lameness dynamics. Three studies measuring the time budget of cows in free stall pens fitted with rubber flooring all show increased time spent standing on the rubber alley floor, less time lying in the stalls and an increased likelihood of alley lying – changes which are more likely to be detrimental to foot health (Leonard et al., 1998; Fregonesi et al., 2004; Tucker et al., 2006). Vokey et al. (2001) studied various combinations of sand and mattress freestalls with rubber and concrete flooring and found the optimal combination, with regard to foot health, was a sand stall – rubber alley combination, suggesting we should be cautious over use of rubber flooring in alleys when stall design may be compromised.

Dual Roles of Cow Comfort: Role 2

Once lesions develop and cows become lame, they must be identified and treated as soon as possible. If they are not, then changes in behavior are forced upon them by the pain associated with lameness. This places the cow at great risk for staying lame for a very long period. This is the second role for poor cow comfort in herd lameness dynamics – acting to ensure once a cow becomes lame, she stays lame.

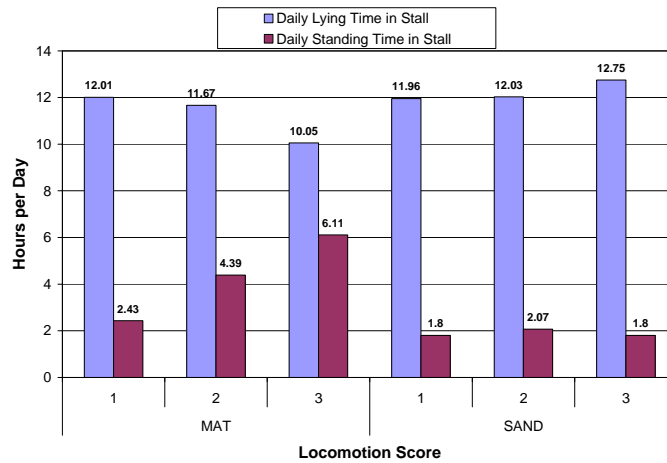
The cow comfort factors discussed previously which increased daily standing times have a role to play in exacerbating the severity and duration of lameness. Consider the greater effect of a poor transition on cows already lame when they leave the far-dry group, the greater effect of heat stress on cows that already have a sole ulcer, and the greater effect of long milking times on cows that are often at the back of the holding area because they were slow to leave the pen due to lameness.

For cows already lame, the interaction of the claw with the walking surface becomes even more important and the pain associated with this interaction is a major reason why gait is modified so we observe lameness as a result of lesion development. For lame cows, concussion is an obvious effect of having to stand and walk on a hard concrete surface.

Stall Design and Standing Time

Lame cows modify their stall use behavior compared to non-lame cows in poorly designed stalls (Cook et al., 2004). The acts of rising and lying become incredibly difficult when cows develop a sore foot, and in poorly designed mattress stalls they spend much longer standing in the stall at the start and during a stall use session than non-lame cows. While normal cows may spend around 2 h/d standing in stalls, slightly and moderately lame cows in poorly designed mattress stalls remain standing in the stall for up to 6 h/d on average, and show a reduction in lying time. In contrast, in deeply bedded, well managed sand stalls, lame cows show no such modification in behavior – they maintain resting times at around 12 h/d and stand in the stall typically less than 2 h/d.

Figure 2. Stall use behavior in non-lame (score 1), slightly lame (score 2) and moderately lame (score 3) cows in barns with deep sand (SAND N=60) and rubber crumb filled mattress (MAT N=60) freestall surfaces.



We believe this difference in lame cow behavior between the two types of stall is related to surface traction and cushion. The rear foot is cushioned and gains traction in a deep loose bed of sand, making standing and lying, even with a sore foot, relatively easy. In contrast on a smooth surface mattress stall, the toe of the weight-bearing rear foot is driven into the surface, making rising much more challenging to a cow with a sore foot.

Figure 3. Compare how the toe of the main weight bearing limb of the cow interacts with the stall surface during rising and lying movements. The cushion and traction of sand (left) is in stark contrast to the small surface area of contact on a mat or mattress stall (right).



We believe these poor environments in which lame cows struggle to gain appropriate periods of rest result in a failure to cure and extended periods of lameness – effectively making sure that if a cow becomes lame, she ‘stays lame’.

Breaking the Cycle of ‘Get Lamé – Stay Lamé’

In addition to reducing the risk factors for each of the triggers of lameness, and improving the identification and treatment of lame cows, improving cow comfort can have a major impact on reducing the effects of the trigger factors (ROLE 1) and improving the rest and recovery of cows already lame (ROLE 2), which ultimately impacts herd lameness dynamics.

Changes we can make to reduce the effects of the trigger factors (ROLE 1) include the following:

1. Exposing heifers to concrete throughout the rearing period and allowing them to learn to use freestalls at a time several weeks before calving (Target at least 60 days pre-partum)
2. Moving heifers to the close-up group at least 30 days before calving

3. Keeping heifer groups split from mature cow groups throughout the transition period

Note: as an alternative to 1-3, heifers may be managed on bedded packs throughout the transition period up to 30 days in milk (DIM) and then introduced to free stalls.

4. Stocking all transition cow groups to provide no less than 30 inches of bunk space per cow and one stall per cow
5. Improving stall design to accommodate large pre-fresh cows, mature cows and first lactation heifers, and ensure resting times in non-lame cows and heifers of around 12 h/d throughout lactation
6. Minimizing the number of pen moves throughout the transition period
7. Minimizing time spent in lock ups, especially within 3 weeks of calving by using sick cow screening systems that do not require a mini-exam of every cow in the pen
8. Using soakers to cool cows at a start temperature of 70°F and increasing soaker frequency with increasing temperature
9. Using recirculation fans over stalls above 70°F to improve stall usage
10. Minimizing time out of the pen during milking by splitting groups and ensuring milking facilities are adequately sized and operating at the number of turns per hour expected
11. Reducing slipping, trauma and wear by strategically using rubber flooring in transfer lanes, holding areas and other high risk surfaces. Similarly, in grazing herds we can improve cow track maintenance.

Currently, there is little evidence to confirm any type of mattress stall can mimic the properties of sand and ensure lame cows can maintain normal time budgets (ROLE 2). In such facilities, the early identification and treatment of lame cows to remove the cause of pain is paramount. Alternative resting areas such as straw bedded packs may be used for lame cow recovery, but since stall use behavior changes are detected even in slightly lame cows, this is not an ideal solution, as most facilities will only have enough space for moderately and severely lame cows.

Sand bedding is, without a doubt, the optimal stall surface for lame cows. Deep beds of sawdust or digested manure solids may behave similarly, but this has yet to be proven and until it is, a deep sand freestall bed remains the gold standard to which we compare everything else. While sand helps cows compensate for many stall design inadequacies, lunge obstructions, high brisket locators and stalls that are too narrow still challenge lame cows more than non-lame cows. For that reason, many sand herds also use a recovery area for lame cows consisting of an open sand bedded area, where cows may rise and lie free of hindrance. Providing cows the option to spend time on an area of pasture close to the free stall barn and a rest from walking on concrete is another option being looked at to improve the comfort of lame cows.

Conclusion

Within this article, I have made the case that cow comfort is the most important factor determining the prevalence of lameness in a dairy herd, by interacting with trigger factors to ensure cows get lame and interacting with the cow once she becomes lame to ensure that she stays lame. We now understand where to impact lameness and break the cycle of 'get lame-stay lame', by focusing on the dual roles of cow comfort and extensive interventions have been economically justifiable based on the increased production achieved by maintaining a herd of more mature, healthier cows that are no longer broken down with chronic claw horn lesions that fail to cure.

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