

THE EFFECTS OF FARM ENVIRONMENT AND MANAGEMENT ON LAMINITIS

Erin Bell and Daniel M. Weary

Animal Welfare Program, Faculty of Agricultural Sciences, University of British Columbia, 2357 Main Mall, Vancouver, BC, V6T 1Z4, Canada

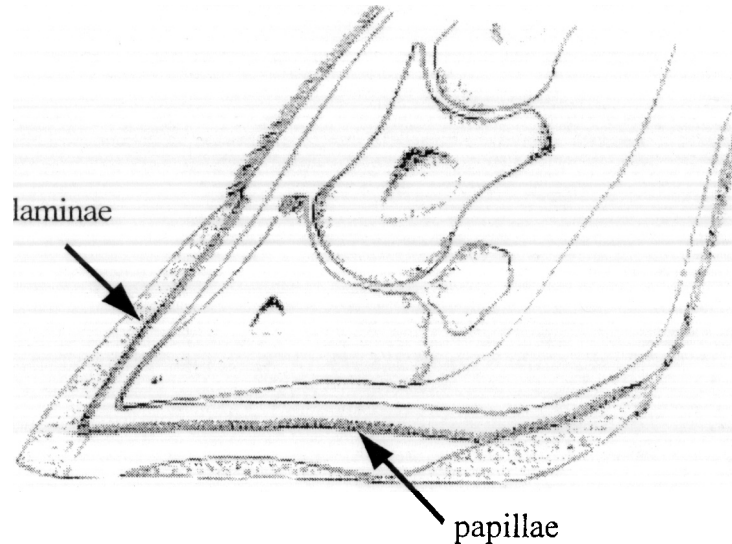
INTRODUCTION

Lameness is an important problem on many modern dairy farms and has been ranked as the third most common disorder, behind mastitis and reproductive failure, contributing to economic losses for farmers (Whitaker *et al.*, 1983; Enting *et al.*, 1997). Costs include treatment, decreased milk production, decreased reproductive performance, and increased culling. Estimates of the total annual cost of lameness range from \$1750 to \$3724 US for a 100-cow herd (Whitaker *et al.*, 1983; Esslemont, 1990; Enting *et al.*, 1997; Borsberry *et al.*, 1999).

One of the leading causes of lameness is laminitis (Collick *et al.*, 1989; Frankena *et al.*, 1992; Ward, W.R., 1994; Bergsten and Herlin, 1996). Estimates of the incidence of lameness range from 5.5 to 65 percent (Russell *et al.*, 1982; Whitaker *et al.*, 1983; Ward, 1994; Murray *et al.*, 1996), but laminitis may be present without showing obvious signs of lameness. Estimates of the number of cows affected by laminitis range from 60 to 90 percent (Mortensen and Hesselholt, 1982; Bradley *et al.*, 1989; Smilie *et al.*, 1996). Many authors believe that laminitis, and specifically subclinical laminitis, is the most important affliction of dairy cattle claws (Vermunt and Greenough, 1994).

Laminitis is an inflammation of the laminae and papillae inside the hoof (Figure 1). These layers of tissue are arranged in folds that act to absorb the impact of the hoof contacting the ground. Another important function of these tissues is the production of the horny tissue of the hoof wall and sole. Anything that disrupts the flow of blood to the laminae or papillae will result in damage to these tissues and impair their ability to absorb shock or produce high-quality horn.

Figure 1. *Laminae and papillae inside the cow's hoof.*



There are three forms of laminitis: acute, subclinical, and chronic. Acute laminitis commonly occurs as a result of a diet high in concentrates and low in effective fibre. A decrease in ruminal and systemic pH leads to vessel wall damage in the hoof, internal haemorrhage, swelling of the laminae and papillae, and severe pain (Nocek, 1997). This stage of laminitis is often associated with sudden lameness.

Subclinical laminitis is the most common form of laminitis in dairy herds (Greenough, 1985; Bergsten, 1994) but often goes undetected because affected animals may not show any obvious signs of lameness. This phase of the disease can result from physical injury to the hoof or from damage sustained during acute laminitis (Nocek, 1997). The damage sustained by these tissues results in production of poor quality horn (Hendry *et al.*, 1997). The wall and sole of the hoof become soft and prone to wear and damage, and the pedal bone may begin to separate from the wall and sole as the laminae and papillae degenerate (Nocek, 1997). Signs of subclinical laminitis include yellowish discoloration of the sole, haemorrhaging and sole ulcers (Hendry *et al.*, 1997).

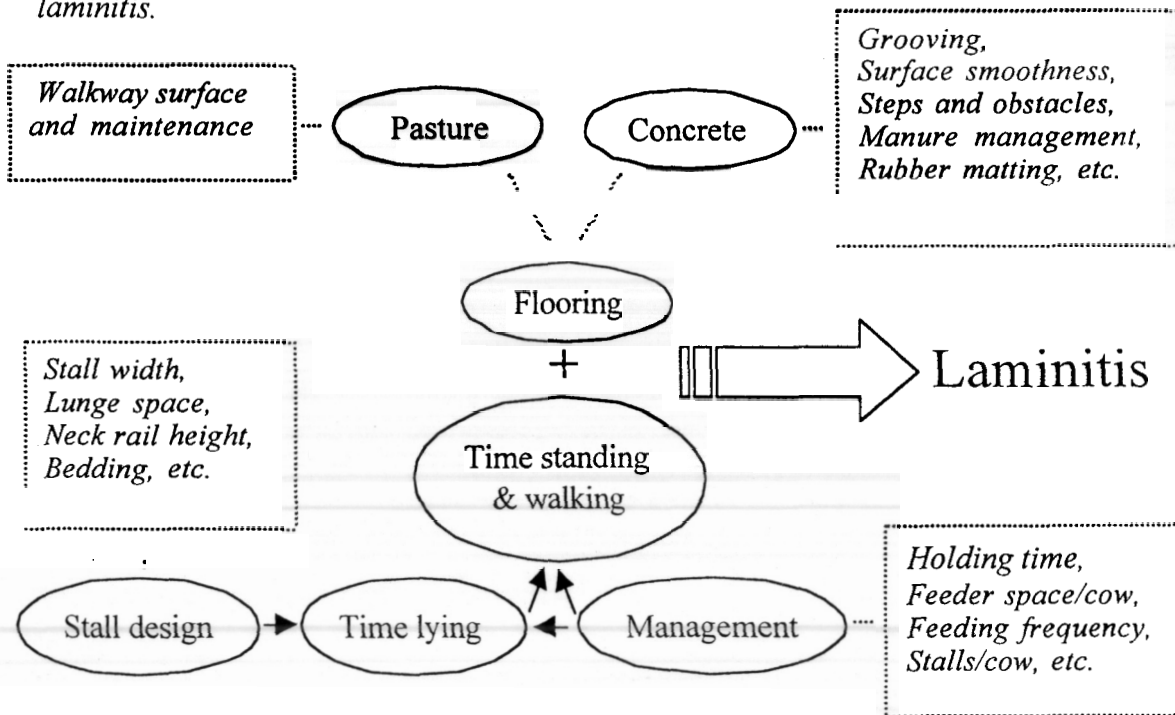
If the disease remains untreated, subclinical laminitis can lead to chronic laminitis. During this stage progressive degeneration of the vascular system and

internal structures of the foot occurs, the final outcome being irreversible damage and lameness (Nocek, 1997).

REVIEW

Although nutritional factors have long been recognised as contributing to laminitis (e.g. Livesey and Fleming, 1984; Peterse *et al.*, 1984; Manson and Leaver, 1989), environmental and management factors may also play important roles in the development of this disease. Housing and management can affect both how long cows spend on their feet and what they are standing upon, and these factors may in turn contribute to laminitis. Figure 2 illustrates some of the proposed links. For example, frequent milking and large group sizes both increase the amount of time cows spend in the holding area waiting to be milked. This increased time standing, together with the type of surface the cows are standing upon, may then affect the incidence of laminitis.

Figure 2. A few of the environmental and management factors that may affect the time cows spend standing or walking or the quality of the surface they are standing upon. Flooring and time spent standing or walking may then interact to result in laminitis.



In some cases the link between environmental and management factors and the time cows spend standing is relatively clear - it takes longer to milk larger groups so, on average, cows spend longer standing in the holding area. In other cases the link is less clear. For example, features of the stall design may influence lying time and thus reduce standing time, but these links need to be established. We also need evidence that time standing and the quality of the surface animals stand and walk upon affect laminitis. Researchers have only recently begun to work in this area, but some progress has been made as we review below.

Herd management and laminitis

The effects of herd management have received very little study to date. Vaarst *et al.* (1998) found large differences among 13 dairy herds in the prevalence of sole ulcers, perhaps resulting from differences in management. Other work has indicated that sudden changes in the physical and social environment may contribute to the development of sole lesions, especially for heifers (Greenough and Vermunt, 1991; Bergsten and Frank, 1996_a; Bergsten and Frank, 1996_b). These authors also suggested that a sudden change of flooring from earth to concrete might be a significant factor in the development of sole hemorrhages. Greenough and Vermunt also found that management factors such as rapid rearing of heifers and sudden introduction to adult cows appeared to contribute to poor claw health. There is also some evidence that the more time cows spend standing the higher the incidence of laminitis (Galindo and Broom, 1993; Leonard *et al.*, 1994), so any practice that increases the time cows spend standing may cause problems.

Flooring and laminitis

Epidemiological work has associated concrete floors with a higher prevalence of laminitis. For example, Bergsten (1994) looked at 22 herds and found that along with some diet and individual cow factors, there was an association between high lesion scores and concrete standing surfaces. Further evidence of the importance of flooring has been provided by experimental work. A study by Bergsten and Frank (1996_a) looked at the effects of diet, flooring and season on laminitis in first lactation cows. They found that the cows on a higher concentrate diet had higher lesion scores than those consuming fewer concentrates, those on concrete flooring had higher scores than those on rubber mats, and that the type of flooring had a greater influence on lesion scores than the type of diet.

Greenough and Vermunt (1991) also suggested that housing on concrete might contribute to the occurrence of sole haemorrhages.

The mechanism by which flooring affects hoof health remains to be understood. Bergsten and Frank (1996_b) looked at the effects of diet and flooring in gestating heifers and failed to find any differences in hoof health in relation to flooring type, suggesting that having calved is an additional risk factor. This view is supported by a recent study (Chaplin *et al.*, 2000) in which lactating heifers had more severe lesions than gestating heifers, despite being kept on identical flooring and under similar conditions.

Bergsten and Herlin (1996) found higher scores for haemorrhages in the white line among cows housed on slatted concrete flooring, but there were other differences between the areas compared, including differences in stall design. An epidemiological study by Philipot *et al.* (1994) found that steps in front of the manger were a risk factor for laminitis, including white line separation. Steps, or any other source of variation in floor level, may cause problems related to the uneven distribution of weight either among hooves or within the hoof.

In summary, concrete flooring and differences in floor height are associated with laminitic injuries. However, there has been little experimental work on effects of flooring, and no work on factors such as the texture of the surface and grooving, wetness, and slurry depth and their possible relationship to laminitis. It is also likely that any negative effects of flooring will be mitigated by management practices that reduce the need for cows to spend long periods walking or standing, or by stall design that provides an attractive place for cows to lie down.

Stall design and laminitis

A number of studies have attempted to link stall comfort, lying times and the prevalence of sole lesions. One study (Colam-Ainsworth *et al.*, 1989) compared two dairy herds with similar management and diet. One herd had a history of lameness problems in replacement heifers while the other herd did not. Moreover, cows in the problem herd spent less time lying down in the stalls, and more time standing and lying half-in the stall, or lying on the concrete outside the stall. The amount of straw bedding was identified as the only obvious difference in the environments of the two herds, with the problem herd receiving 75 % less straw per day than the healthy herd. When the amount of bedding was increased for the problem herd no new cases of laminitis leading to lameness were found.

How much extra straw was added, and whether the lying times improved following the bedding change, was not reported.

In another study focussing on the importance of lying time with respect to lesion severity, Singh *et al.* (1993) studied first lactation cows either kept on pasture or housed in a free-stall barn with concrete stalls. They found fewer and less severe sole lesions in the cows when they were on pasture than when indoors. The authors attributed this finding to longer standing times, shorter lying times and more frequent transitions between lying and standing when the animals were indoors. Unfortunately the change of environment from indoor stalls to pasture was also associated with a change in diet and walking surface, making the results difficult to interpret. In another study (Leonard *et al.*, 1994), two groups of heifers were housed in separate areas of the same barn. One group had access to stalls bedded with rubber mats and the other had stalls without mats. The stalls with mats were also longer and wider than those without mats. Cows using stalls without mats spent less time lying down and their claw health deteriorated more during the two months following calving. The difference in stall design was confounded with a difference in diet, again making the results difficult to interpret. However, the results from these studies suggest that providing a more comfortable lying area that leads to better use can improve claw health.

Stall design and stall use

There has recently been a great deal of producer interest in cow comfort, and how features of stall design can be improved from the cow's perspective. Although this work has not assessed the impacts on hoof health, it has shown how features of stall design can affect stall usage by cows.

Researchers at UBC and Agriculture and Agri-Food Canada have been working together to understand the effects of stall design on cow comfort and stall usage. The results of one recent experiment showed that cows provided with mattresses in tie stalls spent 1.5 h/day more time lying down than did cows provided with only cement to lie upon (Pajor *et al.*, 2000). In another experiment, cows were provided with either a conventional tie stall with cement floors and only small amount of straw bedding, or with a spacious, well-bedded pen (Pajor *et al.*, 2000). Cows in the larger and presumably more comfortable pens spent more time lying down and less time standing inactive.

At UBC we are currently running experiments on free-stall usage in relation to various design features including bedding type. In one series of experiments we have found that cows show a strong preference to lie in sawdust-bedded stalls compared to stalls bedded with sand. Our results to date also suggest that cows spend less time lying down in sand-bedded stalls. We have also performed experiments on the effects of stall length and width, and the results to date show that some cows spend more time lying down in the wider stalls.

In a third series of experiments we have looked at neck rail placement. Interestingly, this work indicates that neck-rail height has little effect on lying time, but does affect how much time cows spend standing in the stall. This effect is not surprising as neck rails were conceived partly as a way of preventing cows from standing in the stall, especially when defecating or urinating. However, it is possible that providing a stall that is comfortable for cows to stand in will also help reduce laminitic injuries by giving the cows an alternative to standing on concrete.

CONCLUSIONS

Laminitis is an important cause of lameness in dairy cattle. The links between this disease and nutrition has long been recognised. We have reviewed work identifying environmental and management factors that may also contribute to the development of laminitis. Environmental and management features that affect how long cows spend on their feet (standing or walking), and the quality of surface they are standing upon, are both associated with laminitis. However, there has been little experimental work in this area, and little is known about how these factors interact with each other and nutrition to result in laminitis.

REFERENCES

- Bergsten, C. 1994. Haemorrhages of the sole horn of dairy cows as a retrospective indicator of laminitis: an epidemiological study. *Acta Vet. Scand.* 35: 55-66.
- Bergsten, C. and Herlin, A.H. 1996. Sole haemorrhages and heel horn erosion in dairy cows: the influence of housing system on their prevalence and severity. *Acta Vet. Scand.* 37: 395-408.

- Bergsten, C. and Frank, B. 1996_a. Sole hemorrhages in tied primiparous cows as an indicator of periparturient laminitis: effects of diet, flooring and season. *Acta. Vet. Scand.* 37:383-394.
- Bergsten, C. and Frank, B. 1996_b. Sole hemorrhages in tied heifers in early gestation as an indicator of laminitis: effects of diet and flooring. *Acta. Vet. Scand.* 37:375-382.
- Borsberry, S., Logue, D., Laven, R., Watson, C.L., Ossent, P. and Livesey, C. 1999. Report on lameness workshop (Harper Adams) "Lameness in the dairy cow". *Cattle Prac.* 7: 307-310.
- Bradley, H.K., Shannon, D., Neilson, D.R. 1989. Subclinical laminitis in dairy heifers. *Vet. Rec.* 125:177-179.
- Colam-Ainsworth, P., Lunn, G.A., Thomas, R.C. and Eddy, R.G. 1989. Behaviour of cows in cubicles and its possible relationship with laminitis in replacement dairy heifers. *Vet. Rec.* 125:573-575.
- Collick, D.W., Ward, W.R. and Dobson, H. 1989. Associations between types of lameness and fertility. *Vet. Rec.* 125: 103-106.
- Enting, H., Kooij, D., Dijkhuizen, A.A., Huirne, R.B.M. and Noordhuizen-Stassen, E.N. 1997. Economic losses due to clinical lameness in dairy cattle. *Livestock Prod. Sci.* 49: 259-267.
- Esslemont, R.J. 1990. The cost of lameness in dairy herds. Proceedings of the Sixth International Symposium on Disorders of the Ruminant Digit. Liverpool, UK. Pp. 237-251.
- Frankena, K., Van Keulen, K.A.S., Noordhuizen, J.P., Noordhuizen-Stassen, E.N., Gundelach, J., De Jong, D.J. and Saedt, I. 1992. A Cross-sectional study into the prevalence and risk indicators of digital haemorrhages in female dairy calves. *Prev. Vet. Med.* 14:1-12.
- Galindo, F.A. and Broom, D.M. 1993. The relationships between social behaviour of dairy cows and the occurrence of lameness. *J. Brit. Cattle Vet. Assoc.* 1:360-364.

- Greenough, P.R. 1985. The subclinical laminitis syndrome. *Bov. Pract.* 20:144-149.
- Greenough, P.R. and Vermunt, J.J. 1991. Evaluation of subclinical laminitis in a dairy herd and observations on associated nutritional and management factors. *Vet. Rec.* 128:11-17.
- Hendry, K.A.K., MacCallum, A.J., Knight, C.H. and Wilde, C.J. 1997. Laminitis in the dairy cow: a cell biological approach. *J. Dairy Sci.* 64:475-486.
- Leonard, F.C., O'Connell, J. and O'Farrell, K. 1994. Effect of different housing conditions on behaviour and foot lesions I Friesian heifers. *Vet. Rec.* 134:490-494.
- Livesey, C.T. and Fleming, F.L. 1984. Nutritional influences on laminitis, sole ulcer and bruised sole in Friesian cows. *Vet. Rec.* 114:510-512.
- Logue, D.N., Lawson, A., Roberts, D.J., Hunter, E.A. 1989. The effect of two different protein sources in the diet upon incidence and prevalence of lameness in dairy cattle. *Anim. Prod.* 48:636 (Abstr.)
- Manson, F.J. and Leaver, J.D. 1988. The influence of dietary protein intake and of hoof trimming on lameness in dairy cattle. *Brit. Soc. Anim. Prod.* 47:191-199.
- Manson, F.J. and Leaver, J.D. 1989. The effect of concentrate:silage ratio and of hoof trimming on lameness in dairy cattle. *Brit. Soc. Anim. Prod.* 49:15-22.
- Murray, R.D., Downham, D.Y., Clarkson, M.J., Faull, W.B., Hughes, J.W., Manson, F.J., Merritt, J.B., Russell, W.B., Sutherst, J.E. and Ward, W.R. 1996. Epidemiology of lameness in dairy cattle: description and analysis of foot lesions. *Vet. Rec.* 138:586-591.
- Nocek, J.E. 1997. Bovine acidosis: implications on laminitis. *J. Dairy Sci.* 80:1005-1028.
- Pajor, E.A., Rushen, J. and de Passille, A.M. 2000. Cow comfort, fear, and productivity. In: *Dairy housing and equipment systems: managing and planning*

- for profitability. Natural Resources, Agriculture and Engineering Service, Ithaca, N.Y. pp.24-37.
- Peterse, D.J., Korver, S., Oldenbroek, J.K. and Talmon, F.P. 1984. Relationship between levels of concentrate feeding and incidence of sole ulcers in dairy cattle. *Vet. Rec.* 115:629-630.
- Philipot, J.M., Pluvinage, P., Cimarosti, I., Sulpice, P. and Bugnard, F. 1994. Risk factors of dairy cow lameness associated with housing conditions. *Vet. Res.* 25: 244-248.
- Russell, A.M., Rowlands, G.J., Shaw, S.R. and Weaver, A.D. 1982. Survey of lameness in British dairy cattle. *Vet. Rec.* 111:155-160.
- Singh, S.S., Ward, W.R., Lautenbach, J.W., Hughes, J.W. and Murray, R.D. 1993. Behaviour of first lactation and adult dairy cows while housed and at pasture and its relationship with sole lesions. *Vet. Rec.* 133:469-474.
- Smilie, R.H., Hoblet, K.H., Weiss, W.P., Eastridge, M.L., Rings, D.M., Schmitkey, G.L. 1996. Prevalence of lesions associated with subclinical laminitis in first-lactation cows from herds with high milk production. *J. Amer. Vet. Med. Assoc.* 208:1445-1451.
- Smit, H., Verbeek, B., Peterse, D.J., Jansen, J., McDaniel, B.T. and Politiek, R.D. 1986. The effect of herd characteristics on claw disorders and claw measurements in Friesians. *Livestock Prod. Sci.* 15:1-9.
- Vaarst, M., Hindhede, J. and Enevoldsen, C. 1998. Sole disorders in conventionally managed and organic dairy herds using different housing systems. *J. Dairy Res.* 65:175-186.
- Vermunt, J.J. and Greenough, P.R. 1994. Predisposing factors of laminitis in cattle. *Brit. Vet. J.* 150: 151-164.
- Vermunt, J.J. and Greenough, P.R. 1995. Lesions associated with subclinical laminitis of the claws of dairy calves in two management systems. *Brit. Vet. J.* 151: 391-399.

Ward, W.R. 1994. Recent studies on the epidemiology of lameness. Proceedings of the Eighth International Symposium on Disorders of the Ruminant digit. Banff, Canada. Pp.197-203.

Whitaker, D.A., Kelly, J.M. and Smith, E.J. 1983. Incidence of lameness in dairy cows. *Vet. Rec.* 113: 60-62.