

PREVALENCE OF LESIONS ASSOCIATED WITH SUBCLINICAL LAMINITIS IN DAIRY CATTLE

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ABSTRACT

Lameness is an important cause of reduced animal welfare and has been shown to cause substantial economical losses in dairy and beef-cattle herds. Lameness is perhaps one of the most important diseases of the modern dairy cow. Laminitis is a diffuse aseptic inflammation of the laminar corium of the hoof wall and, in the bovine definition, also includes the sole corium. There are various forms of laminitis: subclinical, acute or subacute, and chronic. Subclinical laminitis is the most common form of laminitis in dairy cows. For the study, we aimed to determine the prevalence of the lesions associated with subclinical laminitis in 1352 dairy cows from 132 cow barns in Elazig province between 2007 and 2008. Of the 1352 cows selected for the study, lameness was detected in 387 (28.6%). Of these lame cows, 320 (82.7%) had 591 lesions that could be associated with subclinical laminitis. Claw lesions were diagnosed on the basis of macroscopic examination before and after trimming to the correct claw shape. In this study, yellow discolouration and haemorrhage of the white line and the sole, separation of the white line, erosion of the heel, double sole, sole ulcers, flaky or chalky white powder on the sole, abscessed soles were considered lesions associated with subclinical laminitis. The most common lesions were separation of the white line (20.98%) and haemorrhage of the sole (20.31%). Consequently, in this study, it was found that causes of 82.7% of lameness showed in cattle in Elazig region was originated from subclinical laminitis-related lesions.

Keywords: subclinical laminitis, dairy cattle, prevalence

INTRODUCTION

Lameness is one of the most important causes of financial loss and distress in dairy cattle (1-4), and lesions in the claw are the most common visible pathology associated with lameness (5-7). Claw disorders cause over 90% of lameness in dairy cattle (8,9). Lameness is detrimental to animal welfare and is among the three most important diseases in the dairy industry after mastitis and fertility problems (10-12). Several studies in North America, the United Kingdom, and Scandinavia report a wide range in the prevalence of lameness in dairy cattle between herds, typically of the order of 10 to 55% of the herd affected (13-17). Laminitis has been described in many species, but is most common in the equine and bovine. Although bovine laminitis is most common in lactating dairy cows, it has been reported in all ages and both sexes. Laminitis is a diffuse aseptic inflammation of the laminar corium of the hoof wall and, in the bovine also includes the sole corium. There are various forms of laminitis: subclinical, acute or subacute, and chronic. Subclinical laminitis is the most common form of laminitis in dairy cows (18-22).

In cattle, lesions in the sole are usually attributed to laminitis,

include haemorrhages in the horn, double soles, ulcers in the sole and toe, haemorrhage and separation of the white line, as well as deformation of the whole surface ("dropped sole") (23,24). Furthermore, lesions considered by researchers to be associated with subclinical laminitis include an inflamed coronary band, a sunken and rotated distal phalanx (25), abnormal horn formation with reduced hardness and strength (26-29), flaky or chalky white powder on the sole, deformed claws, horizontal grooves in the hoof horn (30), overgrown claws, abscesses of the white line and abscessed soles (31). Other authors used the term claw horn disruption (CHD) (13,32). Usually these lesions occur in the heel, i.e. in zones 3, 4 and 6 (Figure 1).

Claw disorders can be divided into three main categories according to their aetiology; infectious, metabolic, mechanical and traumatic. Infectious and partly infectious claw lesions such as digital dermatitis, heel-horn erosions and interdigital phlegmones are mainly influenced by the environment (30). The causes of CHD or laminitis-like lesions are diverse. The incidence and severity of the lesions are influenced by external mechanical factors such as abnormal claw or limb

configuration, hard surfaces and soft horn. Systemic factors are associated with rumen acidosis, ketosis and endotoxaemia due to e.g. inadequate feeding (24,33-37). Factors that have been associated with claw lesions are individual factors like stage of lactation, parity, weight and genetics (38-40). Herd factors involved are housing, environment, management and nutrition (41-45).

In order to improve preventative regimens, it is necessary to better understand the relative importance of the main factors that influence the prevalence of lameness. In particular, it is necessary to identify whether different causes of lameness have different risk factors. The present study examined the prevalence of subclinical laminitis in Elazig, Turkey.

MATERIALS AND METHODS

We aimed to determine the prevalence of lesions associated with subclinical laminitis in 1352 dairy cows originating 132 cow herds in Elazig province, Turkey, between 2007 and 2008. Heifers were defined as animals more than 1.5 years of age and more than 30 days before their first calving. Most of the animals examined were either close to calving or within 3 months after calving. In all herds, dairy cattle were housed in stalls with concrete floors and, in general, shallow litter bedding material was used. During the summer, the cows were confined to grass. During the winter, when weather permitted, the cows were allowed to use an exercise area around the barn. In general, the animals were fed a total mixed ration.

Claw lesions were diagnosed on the basis of macroscopic examination before and after trimming to the correct claw shape. Each cow was examined while it was restrained in lateral recumbency or in a standing position. The trimming technique included levelling the two claws, aiming for symmetric bulbs. The axial and abaxial walls were both intended to be parts of the bearing surface and the two claws were trimmed flat and balanced with each other. The caudal 2/3 of the axial sole of both claws was dished out. The lateral and medial claws of the fore and hind limbs of each animal were examined after thorough cleaning.

In this study, yellow discoloration and haemorrhage of the white line and the sole, separation of the white line, erosion of the heel, double sole, sole ulcers, flaky or chalky white powder on the sole, abscessed soles were considered lesions associated with subclinical laminitis. The soles of all 8 claws per cow were scored for yellow discoloration, hemorrhage of the white line, separation of the white line, hemorrhage of the sole, erosion of the heel, yellow discoloration of the sole and sole ulcers using an evaluation system described by Greenough and Vermunt (30). The soles were divided into 6 zones (Figure 1). Double sole, yellow discoloration and hemorrhage of the white line and the sole, sole ulcers, separation of the white line and heel-horn erosions were scored either as absent (no notation), mild (1), moderate (2) or severe (3). Definitions in table 1 are adapted from Bergsten (46).

The presence of double sole, flaky or chalky white powder on the sole and abscessed sole was also recorded. The recording protocol did not differentiate between the inner and the outer claw because most lesions occur in the outer hind claw and the inner front claw (9,47).

The herdsmen were interviewed to obtain information about nutrition, housing and trimming intervals of the herd.

RESULTS

The mean incidence of lameness (70%) during the winter (November through April) was higher compared to the summer (30%) during the months May through October. The outside (lateral) claw of the hind legs, and the inside claws of the front legs, were most often affected by laminitis. Of the 1352 cows selected for the study, 387 (28.6%) were lame. Of these lame cows, 320 (82.7%) had 591 lesions that could be associated subclinical laminitis. A total of 591 lesions causing lameness were found in the study group, with 94% of these lesions occurring in the hind feet. Of the lesions occurring in hind feet, 83% occurred in the outside claw, 17% in the inner claw. In forelimbs, 66% of lesions occurred on the inside claw and 34% on the outer.

Table 2 shows the distributions of laminitis-related claw lesions by age. While the lesions related to subclinical laminitis were observed in 4.1% of the cattle aged 1.5-2 year old, it was observed in 14.7% of the cattle aged 6 years old.

In the cows with the laminitis, one or a couple of lesions associated subclinical laminitis were generally observed together in the same claw. The most common lesions were separation of the white line (21.0%) and haemorrhage of the sole (20.3%) (Table 3). Erosion of the heel was observed almost as frequently as separation of the white line and haemorrhage of the sole. In comparison, yellow discoloration of the sole, flaky or chalky white powder on the sole, haemorrhage of the white line, sole ulcer, abscessed sole and double sole were recorded less frequently than hemorrhage of the sole and yellow discoloration of the sole. Most lesions in front and hind claws were mild and heel horn erosions had the highest prevalence of moderate to severe scores.

DISCUSSION

Laminitis-related claw lesions were more prevalent with increasing age. This is partly in agreement with several studies which found lameness increasing with age (16,17,37,48,49). This might be the result of repeated scarring of the corium with irreversible and cumulative damage to claw tissue.

The pathogenesis of laminitis is believed to be associated with a disturbance in the microcirculation of blood in the corium, which leads to breakdown of the dermal-epidermium between the hoof and pedal bone. Rumen (lactic) acidosis is considered to be a major predisposing cause of laminitis and presumably mediates its destructive effects through various vasoactive substances released in coincidence with development of

rumen acidosis. These vasoactive substances initiate a cascade of events in the vasculature of the corium, including increased blood flow, thrombosis, ischemia, hypoxia, and arteriovenous shunting (which directs the flow of blood directly from artery to vein). The end result is oedema, haemorrhage, and necrosis of corium tissues (30,33,34,38).

Many researchers have suggested an association between subclinical laminitis (Pododermatitis aseptica diffusa) and hoof lesions such as white line disease (Pododermatitis zona alba), haemorrhage of the sole, erosion of the heel, yellow discoloration of the sole, double sole, sole ulcers (Pododermatitis circumscripta), and abscesses in the subsole (Pododermatitis septica) (11,30,31,36,39,43,50). The finding that haemorrhages of the sole increased with age is in contrast with many previous studies of dairy cattle (16,22,37,51), which found the highest incidence of haemorrhages of the sole in primiparous cows. Dairy heifers experience major changes in housing conditions, social environment, nutrition and physiological demands, which might lead to increased prevalence of haemorrhages during their first lactation. Stanek *et al.* found that claw condition deteriorated with an increase in body weight, and higher body weight with increasing age might partly explain the relationship between increasing age and more claw lesions (52).

Differences in claw shape, limb conformation, movement and shifting of weight make the hind claws more predisposed (29,47), and hind claws are also more exposed to dirty environment. Sogstad *et al.* found that 13.6% of the hind feet in free-stall herds were affected by haemorrhages of the white line and 20% by haemorrhages of the sole (37). The lower prevalence of haemorrhages in beef-cow herds might be the result of low-intensity feeding. Greenough *et al.* found that high-energy feed increased the prevalence of toe and heel haemorrhages in feedlot calves and of heel haemorrhages in feedlot yearlings (20). External mechanical forces are also considered to cause claw-horn disruption and haemorrhages (12,37,51).

Sole ulcers are the result of haemorrhages and contusions in the corium leading to claw-horn disruption and possible infection (41). Thysen (53) found that the prevalence of sole ulcers observed at claw trimming was not affected by the housing system, which is in agreement with Sogstad *et al.* (37). This suggests that metabolic and hormonal factors are important in the pathogenesis of sole ulcers both in beef and dairy cattle. The prevalence of sole ulcers in the present study was also low compared to most previous studies of dairy cattle (16).

UK studies have reported that sole ulcers and white line lesions are the most common hoof lesions in cows (9,10). Bargai and Levin observed 28.6% sole haemorrhages, 26.7% white line separation and 14.5% sandy soles (54). Belge *et al.* reported 61.4% hemorrhage of the sole, 58.5% yellow discoloration of the sole, 23.9% erosion of the heel, 19% for separation of the white line (5). Smilie *et al.* reported 26.7%

for sole haemorrhages, 36.2% for yellow waxy discoloration, 9.3% for separation of the white line and 13.3% for erosion of the heel (43). In another study (39), 62.1% hemorrhage of the sole, 27.1% erosion of the heel and 15.8% separation of the white line were reported.

This variation may be due to a combination of many factors, including breed types surveyed, genetic selection, conformation characteristics, nutrition and feeding practices, amount of milk production, manure handling systems, presence or absence of certain types of infectious disease, and factors related to the environment in which dairy cows are kept.

The most common lesions in the present study were separation of the white line and hemorrhage of the sole. The prevalence of separation of the white line was 21.0% and the prevalence of haemorrhage of the sole was 20.3%. The other findings recorded were 19.1% for erosion of the heel, 13.2% for yellow discoloration of the sole, 11.3% for yellow discoloration and hemorrhage of the white line, 10.0% for double sole, 2.0% for sole ulcer, 1.7% for flaky or chalky white powder on the sole and 1.3% for abscessed sole. These findings are in agreement with the above descriptions of prevalence of the diseases (39,43,54).

Laminitis-related lesions have a multifactorial aetiology and are influenced by nutrition, feeding routines, hormones around calving and external and internal mechanical forces (30). According to Stokka, laminitis may be the principal cause of foot problems both in dairy and feedlot cattle (55). However, when comparing with feedlots, it should be kept in mind that most of those herds consist of bulls receiving a high-energy diet. The finding of more laminitis-related lesions in hind claws than in front claws is in agreement with previous studies of dairy cattle (9,16,37).

The most common cause of laminitis is known to be a high-energy diet. Feeding high-energy rations to dairy cows is essential to maintain high production. However, the practice of giving large amounts of concentrated food in the absence of roughage could cause a reduction in rumen pH, which is thought to predispose animals to laminitis (19,30,32,34,42).

CONCLUSION

Consequently, in this study it was shown that 82.7% of the lameness found in cattle in the Elazig region of Turkey could be associated with subclinical laminitis-related lesions.

REFERENCES

1. Borderas, T. F., Pawluczuk, B., de Passille, A. M. and Rushen, J.: Claw hardness of dairy cows: Relationship to water content and claw lesions. *J. Dairy Sci.* 87:2085-2093, 2004.
2. Enting, H., Kooij, D., Dijkhuizen, A. A., Huirne, R. B. M. and Noordhuizen-Stassen, E. N.: Economic losses due to clinical lameness in dairy cattle. *Livest. Prod. Sci.* 49:259-267, 1997.
3. Esslemont, R. J., and Kossabati, M. A.: Culling in 50

- dairy herds in England. *Vet. Rec.* 140:36-39, 1997.
4. Whitaker, D. A., Kelly, J. M. and Smith, E. J.: Incidence of lameness in dairy cows. *Vet. Rec.* 113:60-62, 1983.
 5. Belge, A., Bakır, B., Gonenci, R. and Ormanci, S.: Subclinical laminitis in dairy cattle: 205 selected cases. *Turk J. Vet. Anim. Sci.* 29:9-15, 2005.
 6. Somers, J. G. C. J., Schouten, W. G. P., Frankena, K., Noordhuizen-Stassen, E. N. and Metz, J. H. M.: Development of Claw Traits and Claw Lesions in Dairy Cows Kept on Different Floor Systems. *J. Dairy Sci.* 88:110-120, 2005.
 7. Vermunt, J. J.: Subclinical laminitis in dairy cattle. *New Zeal. Vet. J.* 40:133-38, 1992.
 8. Bergsten, C.: Causes, risk factors, and prevention of laminitis and related claw lesions. *Acta Vet. Scand.* 98:157-166, 2003.
 9. Murray, R. D., Downham, D. Y., Clarkson, M. J., Faull, W. B., Hughes, J. W., Manson, F. J., Merritt, J. B., Russel, W. B., Sutherst, J. E. and Ward, W.R.: Epidemiology of lameness in dairy cattle: description and analysis of foot lesions. *Vet. Rec.* 138:586-591, 1996.
 10. Blowey, R. W., Green, L. E., Collis, V. J. and Packington A. J.: The effects of season and stage of lactation on lameness in 900 dairy cows. *Proceedings of the 13th International Symposium on Lameness in Ruminants.* Maribor, Slovenia, 2004.
 11. Bradley, H. K., Shannon, D. and Neilson, D. R.: Subclinical laminitis in dairy heifers. *Vet. Rec.* 125:177-179, 1989.
 12. Espejo, L. A. and Endres, M. I.: Herd-level risk factors for lameness in high-producing holstein cows housed in freestall barns. *J. Dairy Sci.* 90:306-314, 2007.
 13. Clarkson M. J., Downham, D. Y., Faull, W. B., Hughes, J. W., Manson, F. J., Merritt, J. B., Murray, R. D., Russell, W. B., Sutherst, J. E and Ward, W. R.: Incidence and prevalence of lameness in dairy cattle. *Vet. Rec.* 138:563-567, 1996.
 14. Cook, N. B.: Prevalence of lameness among dairy cattle in Wisconsin as a function of housing type and stall surface. *J. Am. Vet. Med. Assoc.* 223:1324-1328, 2003.
 15. Laven, R. A. and Lawrence, K. R.: An evaluation of the seasonality of veterinary treatments for lameness in UK dairy cattle. *J. Dairy Sci.* 89:3858-3865, 2006.
 16. Manske, T., Hultgren, J. and Bergsten, C.: Prevalence and interrelationships of hoof lesions and lameness in Swedish dairy cows. *Prev. Vet. Med.* 54:247-263, 2002.
 17. Wells, S. J., Trent, A. M., Marsh, W. E. and Robinson, R. A.: Prevalence and severity of lameness in lactating dairy cows in a sample of Minnesota and Wisconsin herds. *J. Am. Vet. Med. Assoc.* 202:78-82, 1993.
 18. Bargai, U., Shamir, I., Lublin, A. and Bogin E.: Winter outbreaks of laminitis in dairy calves: aetiology and laboratory and pathological findings. *Vet. Rec.* 131:411-414, 1992.
 19. Boosman, R., Nemeth, F. and Gruys, E.: Bovine laminitis: clinical aspects, pathology and pathogenesis with reference to acute equine laminitis. *Vet. Quart.* 13:163-171, 1991.
 20. Greenough, P. R., Vermunt, J. J., McKinnon, J. J., Fathy, F. A., Berg, P. A. and Cohen, R. D. H.: Laminitis-like changes in the claws of feedlot cattle. *Can. Vet. J.* 31:202-208, 1990.
 21. Lischer, C. J. and Ossent, P.: Pathogenesis of sole lesions attributed to laminitis in cattle. In *Proceedings of the 12th International Symposium on lameness in Ruminants: 9-13 January, Orlando, 2002.*
 22. Midla, L. T., Hoblet, K. H., Weiss, W. P. and Moeschberger, M. L.: Supplemental dietary biotin for prevention of lesions associated with aseptic subclinical laminitis (pododermatitis aseptica diffusa) in primiparous cows. *Am. J. Vet. Res.* 59:733-738, 1998.
 23. Holzhauer, M., Hardenberg, C. and Bartels, C. J. M.: Herd and cow-level prevalence of sole ulcers in The Netherlands and associated-risk factors. *Prev. Vet. Med.* 85:125-135, 2008.
 24. Ossent, P., Greenough, P. R. and Vermunt, J. J.: Laminitis. In: Greenough, P. R. and Weaver, A. D. (Eds.): *In lameness in cattle.* Philadelphia, Saunders Company, pp. 277-292, 1997.
 25. Livesey, C. T. and Fleming, F. L.: Nutritional influences on laminitis sole ulcer, and bruised sole in Friesian cows. *Vet. Rec.* 114:510-512, 1984.
 26. Brandejsky, F., Stanek, C. and Schuh, M.: The pathogenesis of subclinical laminitis in dairy cattle: studies of the hoof status, rumen status and blood coagulation factors. *Deuts. Tierarzt. Wochens.* 101:68-71, 1994.
 27. Cecen C. and Gorgul, O. S.: The evaluation of lameness in a dairy cow herd in the management of Bursa Region. *J. Turk Vet. Surg.* 13:5-10, 2007.
 28. Enevoldsen, C. and Grohn, Y. T.: Sole ulcers in dairy cattle: association with season, cow characteristics, disease and production. *J. Dairy Sci.* 74:1284-1298, 1991.
 29. Fjeldaas, T., Nafstad, O., Fredriksen, B., Ringdal, G. and Sogstad, A. M.: Claw and limb disorders in 12 Norwegian beef-cow herds. *Acta Vet. Scand.* 49:1-11, 2007.
 30. Greenough, P. R. and Vermunt, J. J.: Evaluation of subclinical laminitis in a dairy herd and observations on associated nutritional and management factors. *Vet. Rec.* 128:11-17, 1991.
 31. Peterse, D. J.: Laminitis, interdigital dermatitis and heel horn erosion: a European perspective. *Vet. Clin. North Am. Food Anim. Pract.* 1:83-91, 1985.
 32. Hoblet, K. H. and Weiss, W.: Metabolic hoof horn disease. Claw horn disruption. *Vet. Clin. North Am. Food Anim. Pract.* 17:111-127, 2001.
 33. Cook N. B., Nordlund, K.V. and Oetzel, G.R.: Environmental influences on claw horn lesions associated with laminitis and subacute ruminal acidosis in dairy cows. *J. Dairy Sci.* 87:36-46, 2004.
 34. Donovan, G. A., Risco, C. A., DeChant Temple, G. M.,

- Tran, T. Q. and van Horn, H. H.: Influence of transition diets on occurrence of subclinical laminitis in holstein dairy cows. *J. Dairy Sci.* 87:73-84, 2004.
35. Leach, K. A., Logue, D. N., Randall, J. M. and Kempson, S. A.: Claw lesions in dairy cattle: methods for assessment of sole and white line lesions. *Vet. Jour.* 155:91-102, 1998.
 36. Logue, D.: Lameness, lesions of the claw of the dairy cow and subclinical laminitis. *Br. Vet. J.* 151:343-346, 1995.
 37. Sogstad, Å. M., Fjeldaas, T. and Østerås, O.: Lameness and claw lesions of the Norwegian Red Dairy Cattle housed in free stalls in relation to environment, parity and stage of lactation. *Acta Vet. Scand.* 46:203-217, 2005.
 38. Ossent, P. and Lischer, C. J.: Bovine laminitis: the lesions and their pathogenesis. In *Prac.* 20:415-427, 1998.
 39. Smilie, R. H., Hoblet, K. H., Weiss, W. P., Eastridge, M. L., Rings, D. M. and Schnitkey, G. L.: Prevalence of lesions associated with subclinical laminitis in first lactation cows from herds with high milk production. *J. Am. Vet. Med. Assoc.* 208:1445-1451, 1996.
 40. Vermunt, J. J., and Greenough, P. R.: Structural characteristics of the bovine claw: horn growth and wear, horn hardness and claw conformation. *Br. Vet. J.* 151:157-180, 1995.
 41. Lischer, C. and Ossent, P.: Laminitis in cattle: a literature review. *Tierarztl. Pract.* 22:424-432, 1994.
 42. Sagliyan, A. and Unsaldi, E.: Observation on the Incidence of Foot Diseases of Cattle in Tunceli Region. *Firat Univ. J. Health Sci.* 16:47-56, 2002.
 43. Smilie, R. H., Hoblet, K. H., Eastridge, M. L., Weiss, W. P., Schnitkey, G. L. and Moeschberger, M. L.: Subclinical laminitis in dairy cows: use of severity of hoof lesions to rank and evaluate herds. *Vet. Rec.* 144:17-21, 1999.
 44. Tomlinson, D. J., Mulling, C. H. and Fakler, T. M.: Invited review: formation of keratins in the bovine claw: roles of hormones, minerals, and vitamins in functional claw integrity. *J. Dairy Sci.* 87:797-809, 2004.
 45. Vanegas, J., Overton, M., Berry, S. L. and Sischo, W. M.: Effect of rubber flooring on claw health in lactating dairy cows housed in free-stall barns. *J. Dairy Sci.* 89:4251-4258, 2006.
 46. Bergsten, C.: Workshop report about the documentation of claw diseases. Part 2. In *Proceedings of the 11th International Symposium on the Disorders of the Ruminant Digit*: 3-7 September, 2000.
 47. Toussaint, R. E.: *Cattle Foot Care and Claw Trimming*, Farming Press Books, Ipswich, UK, 1989.
 48. Offer, J. E., McNulty, D., and Logue, D. N.: Observations of lameness, hoof conformation and development of lesions in dairy cattle over four lactations. *Vet. Rec.* 147:105-109, 2000.
 49. Ward, W.R.: Lameness in dairy cattle-an overview. *Cattle Pract.* 7:333-340, 1999.
 50. Vermunt, J. J. and Greenough, P. R.: Predisposing factors of laminitis in cattle. *Br. Vet. J.* 150:151-164, 1994.
 51. Bergsten, C.: Haemorrhages of the sole horn of dairy cows as a retrospective indicator of laminitis: an epidemiological study. *Acta Vet. Scand.* 35:55-66, 1994.
 52. Stanek, C., Frickh, J. J. and Karall, P.: Claw condition and meat quality factors in fattening bulls in two different housing systems. In *Proceedings of the 13th International Symposium and 5th Conference on Lameness in Ruminants*: 11-15 February, Maribor, 2004.
 53. Thysen, I.: Foot and leg disorders in dairy cattle in different housing systems. IN: Wierenga, H. K. and Peterse, D. J. (Eds.): *In Cattle housing systems, lameness and behaviour*. Dordrecht, Martinus Nijhoff, pp. 166-178, 1987.
 54. Bargai, U. and Levin, D.: Subclinical laminitis in dairy cattle in Israel. *Isr. J. Vet. Med.* 48:168-172, 1993.
 55. Stokka, G. L., Lechtenberg, K., Edwards, T., MacGregor, S., Voss, K., Griffin, D., Grotelueschen, D. M., Smith, R. A. and Perino, L. J.: Lameness in feedlot cattle. *Vet. Clin. North Am.: Food Anim. Pract.* 17:189-207, 2001.

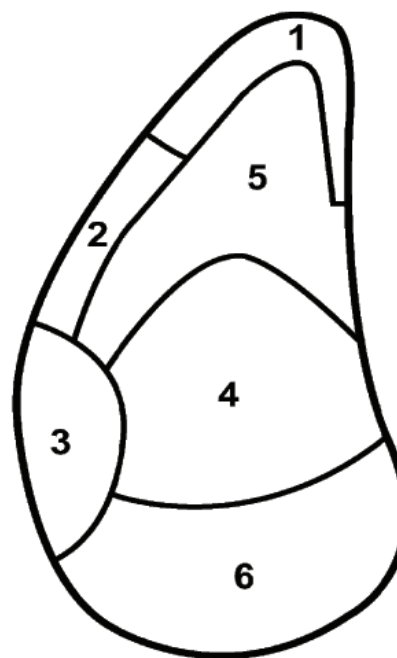


Figure 1. Zones of the Sole Source: VIth Symposium on Diseases of the Ruminant Digit, Liverpool, 1990 (30).

Key for Zones

- Zone 1.** White zone (line) at the toe
Zone 2. Abaxial white zone (line)
Zone 3. Abaxial wall-bulb junction
Zone 4. Sole-bulb junction
Zone 5. Apex of the sole
Zone 6. Bulb (of heel)

Table 1.

Definition of Lameness and Claw Lesions Recorded at Trimming

Lesion	Score*	Definition
Lameness	1 2	Asymmetric gait, bearing weight on all limbs Avoiding weight-bearing on one or more limbs
Heel-horn erosion	1 2 3	Slight defects of the horn integrity, pits and small fissures V-shaped fissures or craters of the heel/bulb not affecting corium V-shaped profound fissures or craters affecting corium of the heel/bulb
Haemorrhages of the white line	1 2 3	Slight haemorrhagic discoloration Moderate haemorrhage on a single spot or several superficial haemorrhages covering >20% of the white line Profound haemorrhage on a single spot or extensive haemorrhagic discoloration covering > 50% of the white line
Haemorrhages of the sole	1 2 3	Slight haemorrhagic discoloration Moderate haemorrhage on a single spot or several superficial haemorrhages covering >20% of the sole surface Profound haemorrhage on a single spot or extensive haemorrhagic discoloration covering > 50% of the sole
Sole ulcer	1 2 3	Exposed, unaffected corium Granulation tissue, necrosis, purulent exudates and separation of the sole horn As score 2 with additional affection of the deeper structures of the claw
White-line fissure and separation of the wall and/or sole	1 2 3	Fissure, which disappear with deep cut beneath normal trimming level Deep fissure perforating next to the corium of sole or wall Corium is affected with purulent exudates, eventually with necrosis, granulation tissue

* Lameness: score 1 = moderate, score 2 = severe. Claw lesions: score 1 = mild, score 2 = moderate, score 3 = severe. Absence of lameness or claw lesions: no notation

Table 2.

Total Prevalence of Laminitis-Related Claw Lesions

Age (years)	1.5-2	3	4	5	6	7	8	9	≥10
Number of animals (n=320)	13	18	24	28	47	43	49	45	53
%	4.1	5.6	7.5	8.7	14.7	13.4	15.3	14.1	16.6

Table 3.

Prevalence (%) of Dairy Cattle with Lameness and Claw Lesions (n=320)

Lesions	Number of lesions	%
Separation of the white line (Fig 2)	124	21.0
Haemorrhage of the sole (Fig 3)	120	20.3
Erosion of the heel (Fig4,5)	113	19.1
Yellow discoloration of the sole (Fig 6)	78	13.2
Yellow discoloration and hemorrhage of the white line (Fig 7)	67	11.3
Double sole (Fig 6,7)	59	10.0
Sole ulcer (Fig 8)	12	2.0
Flaky or chalky white powder on the sole (Fig 2)	10	1.7
Abscessed sole (Fig 9)	8	1.3
Total	591	100

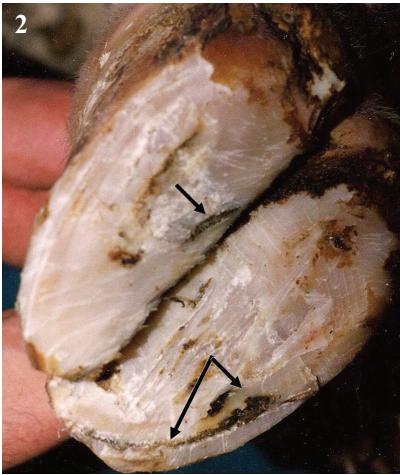


Fig. 2: White line separation can be seen in zone 2 and 4 on both digits and chalky or flaky powder sole in zone 4.

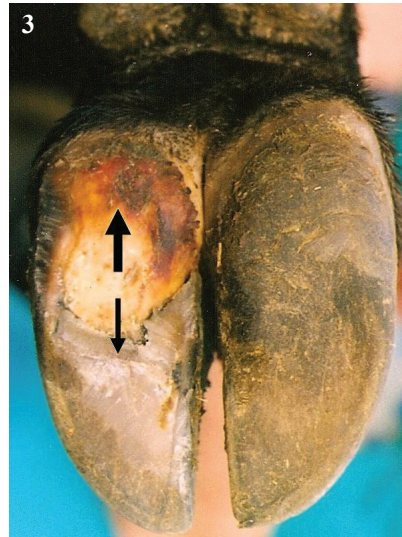


Fig. 3: Solar hemorrhage (large black arrow) in zone 4 and 6 on the lateral claw and double sole (small black arrow).



Fig. 4: There are deep and irregular heel erosions (black arrow) in zone 6 and white line separation (white arrow) in zone 1 on both digits of the hind limb.



Fig. 5: Diffuse white line separation (black arrow) can be seen in zone 3 and heel erosions (white arrow) in zone 6.

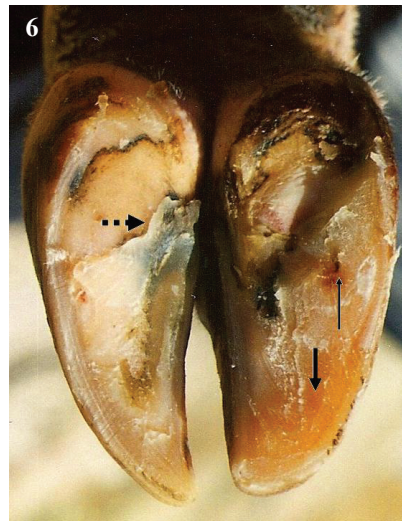


Fig. 6: Yellow discoloration (large black arrow) and hemorrhage (small black arrow) of the sole can be seen in zones 1, 2 and 4 on the medial claw and double sole on the medial and lateral claws of the hind limb



Fig. 7: Yellow discoloration (small black arrow) and hemorrhage (large black arrow and white arrow) of the sole and white line can be seen in zones 1, 2, 3, 4, and 5 on both digits.

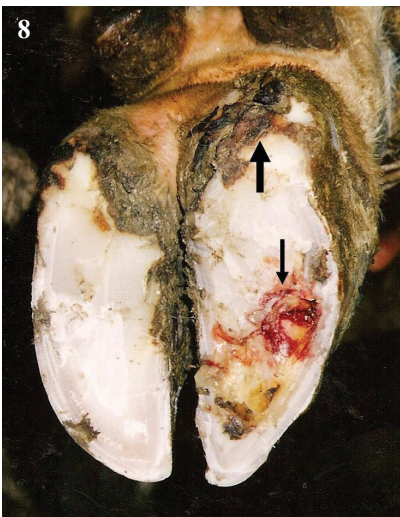


Fig. 8: There are deep and irregular heel erosions (large black arrow) in zone 6 on both digits and sole ulcer (small black arrow) on the lateral claw of the hind limb.

Fig. 9: Abscessed sole (small black arrow) and white line separation (large black arrow) can be seen on the lateral claw.

