Acta vet. scand. 1996, *37*, 383-394.

Sole Haemorrhages in Tied Primiparous Cows as an Indicator of Periparturient Laminitis: Effects of Diet, Flooring and Season

By *C. Bergsten* and *B. Frank*

Experimental Station, Swedish University of Agricultural Sciences, Skara and Department of Agricultural Biosystems and Technology, Swedish University of Agricultural Sciences, Alnarp, Sweden.

Bergsten, C and B. Frank: Sole haemorrhages in calving heifers as an indicator of periparturient laminitis: Effects of diet, flooring and season. Acta vet. scand. 1996, 37. 383-394. – Fifty-six tied heifers calving in autumn (trial I) and 21 tied heifers calving in late spring (trial II) were fed either a high or a low concentrate diet from 3 weeks before expected calving until 13 weeks after calving. Half the heifers in trial I were kept on concrete floors and the others were kept on rubber mats; all the heifers in trial II were on concrete floors. The hooves were trimmed and the soles were photographed 3 weeks before expected calving and again 13 weeks after calving. The photographs were evaluated, each claw was scored for sole haemorrhages, and the total score for all 8 claws was calculated. Before calving there were no differences between the groups of heifers within trial I or trial II, but the heifers in trial II had higher scores than those in trial I. Thirteen weeks after calving the scores had increased in both trials. In trial I the animals fed the high concentrate diet and kept on concrete floors had the highest score, and the type of floor had a greater influence than the level of concentrates fed. The heifers calving in the autumn had higher scores than those calving in the spring. The sudden change from being at pasture to being housed, and the events related to the periparturient period were the most significant factors for the development of sole haemorrhages.

concentrates; concrete floor; dairy cow; foot disease; rubber mat.

Introduction

Laminitis *(Pododermatitis aseptica diffusa)* is a diffuse non-infectious inflammation of the hoof corium *(Espinasse et al.* 1984). The disease has a degenerative effect on the keratocytes which produce poor quality horn with blood serum, erythrocytes and debris incorporated into the keratin *(Andersson & Bergman* 1980, *Kempson & Logue* 1993). The haemorrhages become visible in the sole surface at trimming from about 2 months after the onset of the inflammation of the corium, and at that time the clinical signs of chronic laminitis may appear; however, quite often no clinical signs are observed *(Peterse* 1980, *Greenough* 1985, *Kempson & Logue* 1993). In some cases acute or subacute signs of laminitis may have been observed when the corium first became inflamed, and in some cases the laminitis may have been subclinical throughout the whole period.

Subclinical laminitis, indicated only by small or moderate haemorrhages of the sole at trimming, is most common in heifers at calving *(Peterse* 1980, *Smits et al.* 1992, *Bergsten* 1994) whereas severe lesions of the sole horn, with sole ulcer *(Pododermatitis circumscripta)* and white line disease *(Pododermatitis zona alba)*

are at least as common in multiparous cows as in heifers *(Livesey & Fleming* 1984, *Rowlands et al.* 1985, *Greenough & Vermunt* 1991).

Laminitis is most often manifested as a herd problem and is strongly associated with the periparturient period, and with being housed during the winter *(Andersson* 1980, *Edwards* 1982). The most important risk factors are considered to be housing, feeding, management, stress and behaviour *(Peterse* 1980, *Bazeley & Pinsent* 1984, *Colam-Ainsworth et al.* 1989, *David* 1989, *Bergsten* 1994, *Leonard* 1994).

The economics of the dairy industry determine that the majority of heifers calve in the autumn, when they are subjected to a number of risk factors: the change in diet from fresh grass to winter fodder and, shortly after, the introduction of an intensive lactation diet, the change from soft pasture to hard concrete floors, and the change from regular exercise to a less active life. At the same time they are undergoing profound hormonal changes in relation to calving and the initiation of lactation. All these changes occur within a few weeks and their interrelationships make the aetiology of laminitis potentially very complex. Experimental studies are needed in which the number of variable factors is restricted so that the relative importance of each can be evaluated; the results would complement the results of multifactorial epidemiological studies.

The fact that haemorrhages of the sole horn are revealed retrospectively at trimming 2 to 4 months after calving *(Peterse* 1980, *Bergsten et al.* 1986) makes it possible to make more detailed studies of the risk factors for laminitis during the periparturient period. The aim of the present study was to evaluate the influence of the diet and the nature of the stall floors on the incidence of haemorrhages of the sole horn in tied heifers calving either in the autumn or in the spring.

Materials and methods

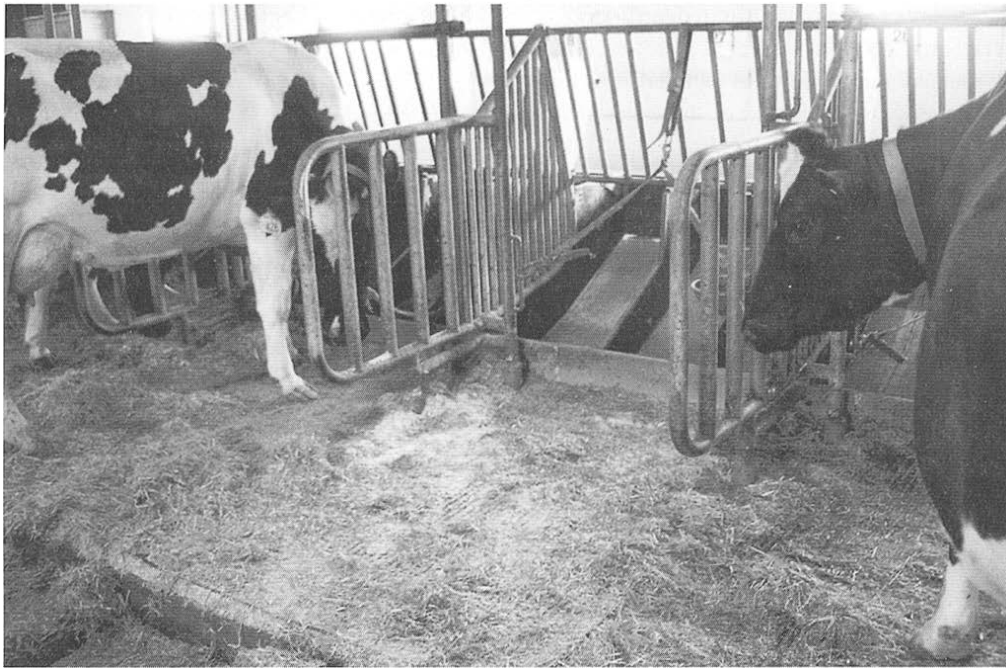
Environment and animals

The study was made at the University of Agricultural Sciences Research Station at Alnarp during the period of housing from autumn 1987 to spring 1988. The barn was divided into a section with tie-stalls, and a section with cubicles. The tie-stall section had 2 rows of short stalls (1.8 m×1.3 m) with concrete floors, one on each side of a common centre alleyway, with a partition between each animal (Fig. 1). One of the rows of stalls was fitted with rubber mats. Sawdust and chopped straw were provided twice a day as bedding. The cubicles, used during the precalving period in trial II, had a concrete floor with an edge 10 cm high at the back to retain the sawdust provided as bedding. The alley ways had concrete slatted floors.

The heifers were Swedish Friesians sired by 8 bulls and born in the herd between July 1984 and November 1985.

The experimental period lasted 16 weeks, from 3 weeks before calving until 13 weeks after calving.

Trial I used 56 heifers which were expected to calve from August to December 1987. When they were between 24 and 30 months old they had taken part in a study of laminitis which has been described by *Bergsten & Frank* (1995). Their mean age at calving was 36 months (range 33-41). Their mean weights 3 weeks before calving, 2 days after calving and 12 and 16 weeks after calving were 671 kg (range 581-754), 616 kg (range 523-725), 596 kg (range 472-686) and 605 kg (range 515-700) respectively. The heifers were at pasture from the end of May to the end of September, except for those expected to calve in August and September, and they were housed in the tie-stalls at least 4 weeks before they were expected to calve. The animals were assigned to 4 groups, balanced as far as possible with respect to sire, bodyweight and expected calving date and then



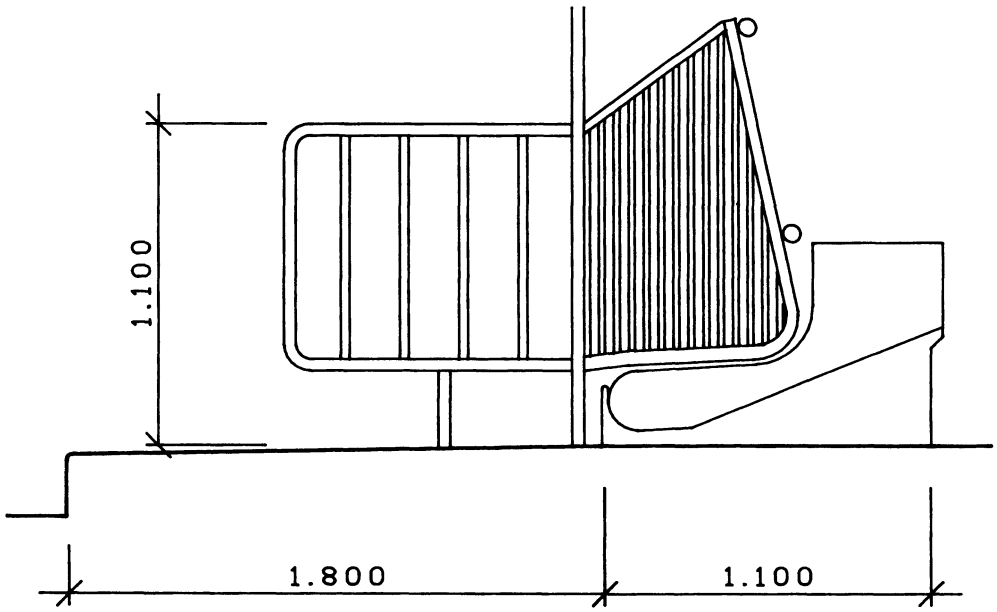


Figure 1. The design of the tie-stalls.

allotted at random to 4 treatments. Two of the groups were housed in the concrete-floored tie-stalls and the other 2 in the stalls with rubber mats; one of each pair of groups was fed a high concentrate diet and the other a low concentrate diet.

Trial II used 21 heifers which were expected to calve in April or May 1988. Their mean age at calving was 32 months (range 30-33). Their mean weights 2 days, 12 weeks and 16 weeks after calving were 572 kg (range 517-634), 562 kg (range 487-620) and 565 kg (range 502-640), respectively. In November all the animals were removed from pasture and housed in the cubicle section. During the winter they were fed a diet of 2.2 kg of concentrates and 2.8 kg dry matter (DM) silage, and they had free access to straw. Four to 5 weeks before they were expected to calve all the animals were tied up in the stalls with concrete floors. They were divided into 2 groups, which were balanced as far as possible with respect to sire and bodyweight, and one of the groups was fed a high concentrate diet and the other a low concentrate diet.

Diets, feeding regimens and management

The diets fed to the animals during the trials are presented in Table 1. From the third week after calving both diets were calculated to provide for the production of 30 kg fat-corrected milk (FCM). The concentrates were offered 4 times daily (6 and 9 am, and 2 and 5 pm) and the roughages twice daily (6 am and 2 pm) from computer-controlled feed carriers.

The animals were milked twice daily and the milk yields were recorded on 3 days a week. The general health of the animals was observed daily.

Records of haemorrhages of the sole horn

The hooves of all the animals were trimmed by a professional hoof trimmer at approximately 3 weeks (± 1 week) before they were expected to calve and approximately 13 weeks (± 1 week) after they had calved. The surface of the sole horn was photographed by the method described by *Bergsten* (1993) and the photographs were all evaluated together after the trial by 2 people who had no knowledge of the groups to which the animals had belonged. Each claw was assigned a score for haemorrhages on a 6-point scale which was related to both the severity and the extent of the lesions:

0 = no haemorrhages
1 = slight haemorrhages covering a small area
2 = slight haemorrhages covering a large area or moderate haemorrhages covering a small area
3 = moderate haemorrhages covering a large area
4 = severe haemorrhages covering a small area
5 = severe haemorrhages covering a large area, or exposed corium (sole ulcer)

The sum of the scores for each animal was calculated and a median score with 10% and 90% quantiles was calculated for each group.The difference between the median scores observed at the first and second trimming was termed the net score.

Statistical analysis

All the analyses were done by using Statistical Analysis Systems software *(SAS Institute Inc.* 1987). The differences between the median scores of the dietary groups and of the groups on different floor surfaces at each trimming, and between the net scores of these groups, were analysed by the Kruskal-Wallis test *(Kruskal & Wallis* 1952); the pair-wise comparisons between the 4 sub-groups in trial I were made by means of Duncan's multiple range test *(Duncan* 1955). Within each trial linear regression analysis was used to test the association between the individual animals' haemorrhage scores and their bodyweight, sire and age, and in trial I, also date of calving.

Table 1. High and low daily concentrate diets 3 weeks before calving, at calving, one week after calving and 3 weeks after calving in trial I and II. The change-over between periods was made gradually. ME = metabolizable energy. DCP = digestible crude protein. DM = dry matter.

	Diet	High concentrate	Low concentrate
Three weeks before calving	Hay, kg DM	1.7	3.5
	Alfalfa silage, kg DM	3.5	3.5
	Beet pulp silage, kg DM	1.5	1.5
	Barley/Oats/Beet*, kg DM	1.4	0.9
	Protein feed**, kg DM	0	0
	Total	83 MJ ME	92 MJ ME
		932 g DCP	965 g DCP
		8.1 kg DM	9.4 kg DM
At calving	Hay, kg DM	1.7	3.5
	Alfalfa silage, kg DM	3.5	3.5
	Beet pulp silage, kg DM	1.5	1.5
	Barley/Oats/Beet*, kg DM	5.3	1.8
	Protein feed**, kg DM	0	0
	Total	134 MJ ME	104 MJ ME
		1280 g DCP	1094 g DCP
		12.0 kg DM	10.3 kg DM
One week after calving	Hay, kg DM	1.7	3.5
	Alfalfa silage, kg DM	3.5	5.2
	Beet pulp silage, kg DM	1.5	2.5
	Barley/Oats/Beet*, kg DM	7.6	3.8
	Protein feed**, kg DM	0.3	0
	Total	168 MJ ME	157 MJ ME
		1628 g DCP	1620 g DCP
		14.3 kg DM	15.0 kg DM
Three weeks after calving	Hay, kg DM	1.7	3 5
	Alfalfa silage, kg DM	3.5	7.0
	Beet pulp silage, kg DM	1.5	3.0
	Barley/Oats/Beet*, kg DM	10.4	6.5
	Protein feed**, kg DM	1.1	0
	Total	214 MJ ME	213 MJ ME
		2194 g DCP	2187 g DCP
		18.2 kg DM	20.0 kg DM

* Barley 45%, oats 45%, dried molassed beet pulp 10%, ** soya bean meal 50%, rape seed meal 50%.

When considering the effect of season, the scores of the 28 animals in trial I, which calved in the autumn and were housed on concrete floors, were compared with the scores of the 21 animals in trial II, which calved in the spring and were also housed on concrete floors.

Results

The results of trial I are presented in Tables 2, 3 and 4. The haemorrhage scores before the heifers calved were low, and no significant differences were observed between the groups. Thirteen weeks after calving the scores were all significantly higher ($p<0.001$) and there were differences between the groups; the cows fed the high concentrate diet and housed on concrete floors had the highest score (Table 2). The score of the cows fed the high concentrate diet was higher after calving than that of the group on the low concentrate diet, but the difference was not statistically significant (Table 3). However, the score of the cows on the concrete floor was significantly higher after calving than the

Table 2. Trial I. Median score (10% and 90% quantile) of haemorrhages of the sole horn in primiparous cows (N = number of animals) at trimming 3 weeks before calving, 13 weeks after calving, and the difference between trimmings (net score) in relation to high (H) or low (L) concentrate diet, and on concrete floor (C) or rubber mats (R). All calvings in autumn (August to December). Groups with different letters within columns are significantly different from each other ($p< 0.05$, Duncan's Multiple Range test)

	N	Prepartum			Postpartum			Net score		
		Median	10%	90%	Median	10%	90%	Median	10%	90%
H C	14	1.0[a]	0	3	9.6[a]	1	15	8 5[a]	−1	14
L C	14	1.0[a]	0	3	8.5[a]	2	12	7 5[a]	1	10
H R	14	1.0[a]	0	3	4.0[ab]	1	13	3.0[ab]	0	12
L R	14	1.0[a]	0	2	4.0[b]	0	8	3.0[b]	0	7

Table 3. Trial I. Median score (10% and 90% quantile) of haemorrhages of the sole horn in primiparous cows (N = number of animals) at trimming 3 weeks before calving, 13 weeks after calving, and the difference between trimmings (net score) in relation to high (H) or low (L) concentrate diet. (NS = not significant ($p>0.05$), Kruskal-Wallis test).

	N	Prepartum			Postpartum			Net score		
		Median	10%	90%	Median	10%	90%	Median	10%	90%
High	28	1.0	0	3	7 0	1	15	7.0	−1	13
Low	28	1.0	0	3	6.0	0	11	5.0	0	10
Significance			NS			NS			NS	

Table 4. Trial I. Median score (10% and 90% quantile) of haemorrhages of the sole horn in primiparous cows (N = number of animals) at trimming 3 weeks before calving, 13 weeks after calving, and the difference between trimmings (net score) in relation to concrete or rubber mats. (NS = not significant ($p>0.05$), * = $p<0.05$, ** = $p<0.01$, Kruskal-Wallis test).

	N	Prepartum			Postpartum			Net score		
		Median	10%	90%	Median	10%	90%	Median	10%	90%
Concrete	28	1.0	0	3	9.0	1	15	8.0	0	14
Rubber	28	1.0	0	3	4.0	0	11	3.0	0	6
Significance			NS			NS			NS	

Table 5. Trial II. Median score (10% and 90% quantile) of haemorrhages of the sole horn in primiparous cows (N = number of animals) at trimming 3 weeks before calving, 13 weeks after calving, and the difference between trimmings (net score) in relation to high or low concentrate diet All animals stalled on concrete floor and all calvings in late spring (April to May). (NS = not significant (p>0.05), Kruskal-Wallis test).

	N	Prepartum			Postpartum			Net score		
		Median	10%	90%	Median	10%	90%	Median	10%	90%
High	10	2.0	0	4	4 0	1	9.5	2.5	–1.5	8
Low	11	2.0	1	4	5.0	0	8	2 0	–3	7
Significance			NS			NS			NS	

Table 6. Trial I and II Median score (10% and 90% quantile) of haemorrhages of the sole horn in primiparous cows (N = number of animals) at trimming 3 weeks before calving, 13 weeks after calving, and the difference between trimmings (net score) in animals stalled on concrete floor and calving in autumn (trial I) or spring (trial II). (Significance levels are * = p<0 05, ** = p<0.01, *** = p<0.001 (Kruskal-Wallis test))

	N	Prepartum			Postpartum			Net score		
		Median	10%	90%	Median	10%	90%	Median	10%	90%
Autumn	28	1 0	0	3	9.0	1	15	8.0	0	14
Spring	21	2 0	0	4	4 0	1	9	2.0	–2	7
Significance			*			**			***	

score of the cows on rubber mats, and they also had a significantly higher net score (Table 4).

The results of trial II are shown in Table 5. There was no significant difference between the groups at either of the trimmings, but the scores of both groups had increased after calving ($p<0.01$). After calving the median score of the group fed the low concentrate diet was higher than that of the high concentrate group, but the group fed the high concentrate diet had a higher net score.

The results of the comparison between calving in the autumn or spring are shown in Table 6. Before calving the haemorrhage score was significantly higher in the spring calving heifers, but after calving the score was significantly higher in the autumn calving heifers. The net score of the autumn calving heifers was 4 times that of the spring calving heifers.

In trial I there was a significant ($p<0.05$) positive association between the live weight of the heifers 3 weeks before they were expected to calve and their sole haemorrhage scores at the first trimming. Furthermore, the time of calving affected the haemorrhage score at the first trimming, with the effect that animals that calved late had significantly higher scores ($p<0.01$). There were no other significant regressions between the sole haemorrhage scores, either before or after calving, and the age, bodyweight or sire of any of the heifers in trials I or II.

Discussion

Confounding factors

Regular hoof trimming to keep the claws in their optimal shape is probably the most important preventive measure against laminitis and its secondary affections of the hoof horn. In these trials, in order to prevent any confounding

effect of overgrown or uneven claws, the feet of all the heifers were carefully trimmed 3 weeks before calving by the same professional hoof trimmer.

Investigations of laminitis are subject to several other confounding factors. For example, it is known that a cow's parity affects the likelihood of its suffering sole haemorrhages, laminitis and sole ulcers *(Peterse* 1980, *Andersson & Lundström* 1981, *Mortensen & Hesselholt* 1982, *Rowlands et al.* 1985, *Bergsten & Herlin* 1995); for this reason only heifers were used in these trials.

The results of trial I were subject to the possible confounding effects of the previous use of the same heifers, early in their pregnancy, in a similar experiment in which they were fed different diets and housed on different floor surfaces *(Bergsten & Frank* 1995). However, the effects of this earlier experiment were likely to have been small, partly because only low haemorrhage scores were recorded, and partly because there was an interval of at least 5 months, including a pasture season, between the 2 experiments.

The possible confounding effects of herd, breed and management were avoided completely in the present trials, and the possible variations due to sire were minimized by distributing the progeny of the 8 sires randomly among the different treatment groups. Variations in the incidence of laminitis have been reported with both breed *(Peterse* 1980, *Andersson & Lundström* 1981, *Bergsten* 1994) and sire *(Peterse* 1980, *Russell* 1986).

The incidence of sole haemorrhages and laminitis has been reported to increase with the animals' body weight *(Rowlands et al.* 1985, *Enevoldsen et al.* 1991, *Greenough & Vermunt* 1991); in trial I there was a significant positive relationship between the live weight of the heifers 3 weeks before they were expected to calve and their haemorrhage scores at that time, but the relationship was not observed at other times in either of the trials.

Effects of calving

In both trials the haemorrhage scores recorded a few months after calving were higher than those recorded before calving, in agreement with the results of several earlier investigations in dairy cows *(Peterse* 1980, *Bergsten et al.* 1986, *Logue et al.* 1994). These results clearly indicate that events related to the periparturient period are very important for the aseptic inflammation of the hoof corium. Indirect evidence for the importance of this period is provided by the observations that a high concentrate diet and different floor surfaces had no significant effect on the incidence of sole haemorrhages in heifers in early pregnancy *(Bergsten & Frank* 1995), and that different diets fed from 5 to 6 weeks after calving similarly had no effect *(Logue et al.* 1994). In contrast, *Boosman* (1990) did not find any clinical or histopathological signs of laminitis at calving in beef cows, and *Kempson & Logue* (1993) observed a relationship between haemorrhages of the sole horn recorded 10 to 20 weeks after calving and the quality of the white line horn observed one month before calving. Furthermore, *Greenough & Vermunt* (1991) and *Stanek* (1994) observed haemorrhages of the sole horn of heifers a few months before they calved; they reached their highest prevalence at calving and were much less severe 2 months later; the development of the haemorrhages appeared to be related to the sudden introduction of the heifers to concrete floors.

These apparently contradictory results suggest that further studies of the importance of calving itself, and of the period of risk associated with calving, are required. The influence of the changes in hormonal patterns in the periparturient period requires particular study. It seems possible that the softening of the tissues at calv-

ing could predispose the claw corium to haemorrhages, because oedema and diffuse haemorrhages have been observed around the ileosacral joints of periparturient cows, and of non-parturient cows injected with oestrogen and relaxin *(Jönsson & Pehrson* 1969).

Effects of diet

Peterse et al. (1984) reported that the incidence of sole ulcers in dairy cows increased as they were fed larger amounts of concentrates, and *Manson & Leaver* (1988) observed a higher incidence of lameness due to laminitis in calving heifers fed large amounts of concentrates. Furthermore, *Livesey & Fleming* (1984) reported that when cows were fed a diet containing little crude fibre and large amounts of starch after calving they suffered a high prevalence of clinical laminitis in early lactation and an exceptionally high prevalence of sole ulcer about 3 months later.

In the present study the diets fed differed principally in the amounts of starch derived from grain, and in the amounts of fibre derived from hay and silage. It is well known that easily digestible starch is rapidly fermented in the rumen, and that in large quantities it can reduce the rumen pH and give rise to rumenitis, a condition which can lead to the absorption of toxic agents into the blood. This effect might be increased by a ration containing small amounts of fibre, thus reducing the chewing time and the alkaline buffering effect provided by saliva. The importance of a balanced ration and regular feeding has been observed in earlier studies by *Bergsten* (1994) in which the incidence of sole haemorrhages was observed to be higher in animals which were fed fewer than 4 times a day, or had access to fodder for only a short time, or were fed concentrates before they were fed roughage. In the present study the heifers had free access to straw, the automatic feed carriers offered the roughage and the concentrates simultaneously and the concentrates were given 4 times a day. This careful feeding regimen probably contributed to the small differences observed between the incidences of sole haemorrhages in the heifers fed the high and low concentrate diets.

Effects of housing and floor surfaces

In trial I the late calving heifers had higher haemorrhage scores at the first trimming than those calving earlier. This difference can be related to the fact that the early calving heifers – in contrast to the late calving animals – were housed in close connection to their first trimming.

In trial I the heifers in the stalls with concrete floors had significantly higher haemorrhage scores postpartum than those in the stalls with rubber mats. In an epidemiological study of cows in tie-stalls *Bergsten* (1994) similarly observed that subclinical laminitis occurred less commonly in the animals on rubber mats than in those on concrete floors. *Thysen* (1987) reported a higher incidence of clinical lameness (treated by a veterinary surgeon) in cows in tie-stalls with concrete floors than in cows in stalls with rubber mats, but in contrast with the present results, did not find any difference between the incidence of subclinical claw lesions among the cows on the 2 different types of floor. In investigations of dairy cows in cubicle systems *Rowlands et al.* (1983) and *David* (1989) observed a higher incidence of sole ulcers and white line disease among cows on concrete floors than among cows in straw yards. In an investigation of intensively reared beef cattle *Murphy & Hannan* (1986) recorded twice as much lameness among animals on concrete slats than among those on a softer type of flooring.

It has been shown that when a cow is provided with a soft comfortable lying area it will spend longer time lying down *(Cermac* 1988). This behaviour should help to prevent laminitis-re-

lated lesions, because significant correlations have been reported between the time spent by cows standing on a concrete floor and the incidence of haemorrhages of the sole, sole ulcer and white line disease *(Galindo & Broom* 1993, *Singh et al.* 1993, *Leonard* 1994). Also, when a cow stands on a soft surface the weight is distributed more evenly; and when the animal gets up, lies down or moves about the impact on the hoof corium is more likely to be absorbed smoothly. Moreover, on soft yielding ground the action of turning the toe over is facilitated, and the moment applied to the point of insertion of the deep flexor tendon into the rear palmar/plantar part of the distal phalanx is reduced, because the toe can penetrate into the ground and grip it. As a result the tension on the deep flexor tendon, and the biomechanical forces on the corium of the hoof, are both substantially reduced.

Effects of season

At the trimming before calving the spring calving heifers had slightly, but significantly, higher haemorrhage scores than the autumn calving heifers. This difference was clearly due to the fact that the autumn calving heifers had been on pasture less than 3 months before the hoof trimming, whereas the spring calving heifers had been housed in cubicles with concrete slats for at least 3 months. A similar result was observed in pregnant heifers *(Bergsten & Frank* 1995). For the same reason, the autumn calving heifers had much larger net increases in their haemorrhage scores after calving than the spring calving heifers, the median increases in the net scores being 8.0 and 2.0 respectively. The spring calving heifers had had a considerably longer period in which to become relatively well adapted to the concrete floors. These results agree with the results of a number of other experiments in which a high prevalence of laminitis has been associated in autumn calving heifers with the abrupt change from relatively soft pasture to hard indoor surfaces *(Andersson* 1980, *Peterse* 1980, *Bazeley & Pinsent* 1984, *Livesey & Fleming* 1984, *David* 1986, *Potter & Broom* 1987, *Colam-Ainsworth et al.* 1989, *Bergsten* 1994). The observation by *Andersson & Lundström* (1981) that cows slaughtered in the spring were more often affected by sole ulcer and chronic laminitis than cows slaughtered at other times of the year is in agreement with these observations, if it is assumed that these diseases were late consequences of laminitis in the autumn. *Peterse* (1980) reported that cows at pasture had a low risk of developing laminitis, and *Smits et al.* (1992) found that well managed zero-grazed cows also had a low risk of developing sole haemorrhages; in neither of these studies did the animals have to cope with a sudden change from a soft to a hard ground surface. When considering preventive measures against laminitis it is clear that the season of calving is an important factor; the animals should have as long a period as possible before they calve to become accustomed to stalls with concrete floors.

Conclusions

The results of these trials clearly indicate that laminitis is a disease in which many factors are involved. The highest haemorrhage scores were recorded in the heifers which calved in the autumn, and which were housed in stalls with concrete floors and fed a high concentrate diet. Animals appear to be particularly at risk of developing laminitis during the periparturient period, and the type of floor appears to be more important than the level of concentrates if fed in an appropriate way.

Acknowledgement

The investigation was supported by the Swedish Council for Forestry and Agricultural Research and by the Swedish Farmers' Foundation for Research.

References

Andersson L. Frekvensstudier och kliniska observationer vid fång hos nötkreatur. (Frequency studies and clinical observations in bovine laminitis). Nord. Vet.-Med. 1980, *32,* 301-307 (In Swedish).

Andersson L, Bergman A: Pathology of bovine laminitis especially as regards vascular lesions. Acta vet. scand. 1980, *21,* 559-566.

Andersson L, Lundström K· The influence of breed, age, body weight and season on digital diseases and hoof size in dairy cows. Zbl. Vet. Med. A 1981, *28,* 141-151.

Bazeley K, Pinsent PJN· Preliminary observations on a series of outbreaks of acute laminitis in dairy cattle. Vet. Rec. 1984, *115,* 619-622.

Bergsten C· A photometric method for recording hoof diseases in cattle, with special reference to haemorrhages of the sole. Acta vet. scand. 1993, *34,* 281-286.

Bergsten C. Haemorrhages of the sole horn of dairy cows as a retrospective indicator of laminitis: An epidemiological study. Acta vet. scand. 1994, *35,* 55-66.

Bergsten C, Andersson L, Wiktorsson H: Effect of feeding intensity at calving on the prevalence of subclinical laminitis. Proc. V Int. Symp. Disord. Ruminant Digit, Dublin, Ireland, 1986, pp. 34-38.

Bergsten C, Frank B. Sole haemorrhages in tied heifers in early gestation as an indicator of laminitis: Effects of diet and flooring. 1995, *in manuscript.*

Bergsten C, Herlin AH Haemorrhage of the sole and heel horn erosion in dairy cows: The influence of housing system on their prevalence and severity. 1995, *in manuscript*

Boosman R The influence of calving and puerperium on clinical and histopathologic changes associated with laminitis and sole ulceration in a group of first-calving cows. J. Vet. Med. A 1990, *37,* 513-519.

Cermac J: Cow comfort and lameness – design of cubicles. Bovine Pract. 1988, *23,* 79-83.

Colam-Ainsworth P, Lunn GA, Thomas RC, Eddy RG. Behaviour of cows in cubicles and its possible relationship with laminitis in replacement heifers. Vet. Rec. 1989, *125,* 573-575.

David GP: The influence of building design and management practices on lameness in heifers and cows. Proc. Brit. Cattle Vet. Assoc. 1984-85, Windermere, UK, 1986, pp. 155-159.

David GP Epidemiological factors associated with a high incidence of sole ulcer and white line disease in dairy cattle. Proc. Soc. Vet. Epidem. Prev. Med., Exeter, UK, 1989, pp. 149-158.

Duncan DB: Multiple range and multiple F tests. Biometrics 1955, *20,* 1-42.

Edwards GB Acute and subacute laminitis in cattle. Vet. Ann. 1982, *22,* 99-106.

Enevoldsen C, Gröhn YT, Thysen I: Sole ulcers in dairy cattle: Association with season, cow characteristics, disease, and production. J. Dairy Sci. 1991, *74,* 1284-1298.

Espinasse J, Savey M, Thorley CM, Toussaint Raven E, Weaver AD· Atlas en couleur des affections du pied des bovins et des ovins. Terminologie internationale. (Colour atlas on disorders of cattle and sheep digit. International terminology). Editions du Point Vétérinaire, Maisons-Alfort, France, 1984. (In French, English, Spanish).

Galindo FA, Broom DM. The relationships between social behavior of dairy cows and the occurence of lameness. J. Brit Cattle Vet. Ass. 1993, *1,* 360-364.

Greenough PR· The subclinical laminitis syndrome. Bovine Pract. 1985, *20,* 144-149.

Greenough PR, Vermunt JJ· Evaluation of subclinical laminitis in a dairy herd and observations on associated nutritional and management factors. Vet. Rec. 1991, *128,* 11-17.

Jönsson G, Pehrson B. Studies of the downer syndrome in dairy cows. Zbl. Vet Med. A 1969, *16,* 757-784.

Kempson SA, Logue DN· Ultrastructural observations of hoof horn from dairy cows: changes in the white line during the first lactation. Vet. Rec. 1993, *132,* 524-527.

Kruskal WH, Wallis WA· Use of rankings on one criterion variance analysis. J. Am. Stat. Ass. 1952, *47,* 583-621 (corrections appear in *48,* pp. 253-265).

Leonard FC. Effect of different housing on behaviour and foot lesions in Friesian heifers. Vet. Rec. 1994, *134,* 490-494.

Livesey CT, Fleming FL Nutritional influences on laminitis, sole ulcer and bruised sole in Friesian cows. Vet. Rec. 1984, *114,* 510-512.

Logue DN, Offer JE, Hyslop JJ: Relationship of diet, hoof type and locomotion score with lesions of the sole and white line in dairy cattle. Anim. Prod. 1994, *39,* 173-181.

Manson FJ, Leaver JD· The influence of concentrate amount on locomotion and clinical lameness in dairy cattle. Anim. Prod. 1988, *47,* 185-190.

Mortensen K, Hesselholt M: Laminitis in Danish dairy cattle – an epidemiological approach. Proc.

IV Int. Symp. Disord. Ruminant Digit, Paris, France, 1982, pp. 295-311.

Murphy PA, Hannan J: Effects of slatted flooring on claw shape in intensively housed fattening beef cattle. Proc. V Int. Symp. Disorders Ruminant Digit, Dublin, Ireland, 1986, pp. 2-7.

Peterse DJ. De beoordeling van de runderklauw op basis van het optreden van zoollaesies (Judgement of bovine claws by the occurrence of sole lesions). Thesis, Rijksuniv., Utrecht, the Netherlands, 1980. (In Dutch).

Peterse DJ, Korver S, Oldenbroek JK, Talmon FP: Relationship between levels of concentrate feeding and incidence of sole ulcers in dairy cattle. Vet. Rec. 1984, *115,* 629-630.

Potter MJ, Broom DM: The behaviour and welfare of cows in relation to cubicle house design. In: Cattle housing systems, lameness and behaviour. Eds. HK Wierenga and DJ Peterse. Martinus Nijhoff Publishers, Dordrecht, the Netherlands, 1987, pp. 159-165.

Rowlands GJ, Russell AM, Williams LA: Effects of season, herd size, management system and veterinary practice on the lameness incidence in dairy cattle. Vet. Rec. 1983, *113,* 441-445.

Rowlands GJ, Russell AM, Williams LA: Effects of stage of lactation, month, age, origin and heart girth on lameness in dairy cattle. Vet. Rec. 1985, *117,* 576-580.

Russell AM. The influence of sire on lameness in cows. Proc. Brit. Cattle Vet. Assoc. 1984-85, Windermere, UK, 1986, pp. 213-219.

SAS Institute Inc: SAS/STATTM. Guide for personal computers. Version 6. Edition, Cary, NC, USA, 1987.

Singh SS, Ward WR, Lautenbach K, Murray RD: Behaviour of first lactation and adult dairy cows while housed and at pasture and its relationship with sole lesions. Vet. Rec. 1993, *133,* 469-474.

Smits MCJ, Frankena K, Metz JHM, Noordhuizen JPTM: Prevalence of digital disorders in zero-grazing dairy cows. Livest. Prod. Sci. 1992, *32,* 231-244.

Stanek C: Does the claw trimming procedure affect milk yield and milk quality factors? Proc. VIII Int. Symp. Disord. Ruminant Digit & Int. Conf. Bovine Lameness, Banff, Canada, 1994, pp. 306-317.

Thysen I: Foot and leg disorders in dairy cattle in different housing systems. In: Cattle housing systems, lameness and behaviour. Eds. HK Wierenga and DJ Peterse. Martinus Nijhoff Publishers, Dordrecht, the Netherlands, 1987, pp. 166-178.

Sammanfattning

Blödningar i sulhornet som indikation på fång hos förstakalvande kvigor under perioden kring kalvning: inverkan av utfodring, båsplatsunderlag och kalvningssäsong

Femtiosex uppbundna, höstkalvande förstakalvare (Försök I) och 21 uppbundna, vårkalvande, förstakalvare (Försök II) gavs en foderstat som var baserad på endera en stor eller liten kraftfodergiva med successiv början från tre veckor före beräknad kalvning. Hälften av djuren i Försök I uppstallades på gummimatta medan övriga djur i Försök I och samtliga djur i Försök II ställdes på betongbåspall. Klövarna på samtliga djur verkades och klövsulorna fotograferades tre veckor före beräknad kalvning och 13 veckor efter kalvning. Klövbilderna bedömdes och sulblödningar på varje klövhalva poängsattes varefter poängen från de åtta klövhalvorna summerades och angavs som sulblödningspoäng. Före kalvning förekom ingen skillnad mellan djurgrupperna inom något av försöken men alla grupper med förstakalvare i Försök I hade lägre sulblödningspoäng än de i Försök II. Tretton veckor efter kalvning hade sulblödningarna ökat i båda försöken. I Försök I hade de djur som fått hög kraftfodergiva och som stod på betongunderlag den högsta sulblödningspoängen. Båspallsunderlaget hade större inverkan än foderstaten. De höstkalvande förstakalvarna (Försök I) hade högre blödningspoäng än de som kalvade på våren (Försök II). De mest sannolika orsakerna till utvecklingen av sulblödningar var installningen från mjukt bete till ett hårdare båspallsunderlag samt faktorer relaterade till perioden kring kalvningen.

(Received June 26, 1995; accepted June 14, 1996).

Reprints may be requested from: C. Bergsten, Experimental Station, Swedish University of Agricultural Sciences, P.O.Box 234, S-532 23 Skara, Sweden. Fax: +46 (0) 511 67134, e-mail: christer.bergsten@fg.slu.se