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Relationships of individual animal traits and sole haemorrhage scores in fresh heifers

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Summary

An experiment with two treatment factors in two levels (four treatments) pointed out that restricted cubicle access did not influence the occurrence or severity of sole haemorrhages in fresh heifers, probably because the animals were able to maintain their overall lying time. This was not influenced by the floor on which they were kept. Heifers kept in a barn compartment with concrete alley floors the first 2 months after calving showed more sole haemorrhages 14 weeks after calving than heifers kept in a barn compartment with rubber topped alley floors. Effects of flooring were such that in each treatment group considerable variation existed in the sole haemorrhage score. In this study it was investigated if animals with high haemorrhage score showed different patterns of development of behavioural variables and lower social rank than animals with low scores. Only subtle differences were found, animals with high scores had fewer lying and standing bouts and tended to have lower speed of feed intake. No indications were found for relationships between percentage of time standing or social rank and sole haemorrhage score.

Introduction

Claw disorders in dairy cattle are an important issue, both for the dairy industry and society. Claw disorders occur frequently (Holzhauer, 2006; Manske et al., 2002) and have a negative effect on milk production and fertility. Although locomotory problems are not always due to feet and leg problems, these are responsible for the majority of lameness cases (Berry et al., 1998; Blowey, 2005) and tend to increase the risk of involuntary culling (Booth et al., 2004). As a result, these disorders cause substantial economic losses (Bruijnis et al., 2010). Moreover, they seriously impair animal welfare (Rushen, 2001). Although part of the disorders have an infectious origin, this study focuses on non infectious disorders and sole haemorrhages in particular.

Traditionally the development of haemorrhages in the claw horn was subscribed to metabolic factors (Bergsten and Mülling, 2004) and regarded as an indicator of laminitis. In contrast to horses, the majority of affected cows is not clinically lame (Flower and Weary, 2006; Sogstad et al., 2005) and the onset seems to be chronicle instead of acute, therefore the term subclinical laminitis is customary. Attempts to invoke laminitis through metabolic disturbance were not successful (Boosman, 1990). Several studies have indicated that different feeding did not significantly affect the development of sole lesions (Knott et al., 2007, Olsson et al., 1998), although other researchers reported negative effects of energy rich diets on claw health (Donovan et al., 2004; Livesey et al., 1998). More recently it was reported that haemorrhages were not necessarily coincided with inflammatory changes (Knott et al., 2007), despite that these cause similar symptoms. Epidemiological studies have indicated that heifers are more at risk than older cows (Donovan et al., 2004; Sogstad et al., 2005), and parturition is mentioned as an event that increases susceptibility for development of haemorrhages in hoof horn. Housing is identified as an important risk factor (Knott et al., 2007; Laven and Livesey, 2004; Webster, 2001), but underlying mechanisms are not fully understood. It is hypothesized that sole haemorrhages partly result from mechanical overload due to repeated trauma from solid flooring (Holzhauer, 2006), but quantification of mechanical load is complicated. Comparison of straw yard barns and cubicle barns revealed substantially better claw health in straw yards (Knott et al., 2007; Laven and Livesey, 2004, Webster, 2001) and lower incidence of haemorrhages. Straw yards and cubicle barns differ in multiple aspects that could be relevant with regard to mechanical load of the claws.

Although straw yard barns often have concrete flooring in the feeding area the animals can spend most of their time lying or standing on soft substrate in the bedding area. Generally cubicle barns are equipped with hard concrete flooring in the alleys, and often have mattresses in the cubicles as bedding material. Empirical evidence that alley floor hardness in cubicle barns affects the development of sole haemorrhages is presented in numerous papers (e.g. Vanegas et al., 2006; Vokey et al., 2001), and it is obvious that softer flooring reduces mechanical load although the magnitude is not easy to quantify. However, the differences observed between straw yards and cubicle barns can only partly be explained through softer alley flooring. The study of Ito et al. (2010) showed that stall surfaces also affect claw health and lying and standing behaviour. Often cubicle bases provide insufficient grip and/or poor lying comfort, this does affect lying and standing behaviour (Cook et al., 2004). Increased standing and reduced lying times are expected to increase the mechanical load of cattle claws, particularly on hard floors, and increases the time the hooves are exposed to risk factors for sole and soft tissue lesions (Galindo et al., 2000). Moreover, it is often mentioned that cubicle dimensions are such that they restrict cows when lying down or getting up (Faull et al., 1996). Cows use significantly less time for lying down and getting up in straw yards and on pasture than in cubicles (Smolders, 2010), and they may have different bout lengths even when maintaining overall time budgets. It is unclear to what extent reduced lying times could contribute to differences between cubicle barns and straw yards in claw disorders. Reduced overall lying times particularly will occur when resources, such as feed or cubicles, have limited availability. We have found lower standing times for cows on pasture than for housed cows (unpublished results), this agrees with results of (Hernandez-Mendo et al., 2007) who compared grazing and cubicle housing. Despite this, grazing coincided with better claw health. It can however be speculated that besides overall time budgets for lying and standing the alternation of these two is relevant for claw tissues. Another difference between straw yards and cubicle barns is that straw yards usually have more space per animal, thus low ranked animals may have more opportunities to avoid confrontations with higher ranked herd mates. If confrontations occur in the bedding area the chances of slipping are low.

Even under the same environmental circumstances animals of similar age and lactation stage differ in susceptibility to experience overload and locomotory problems (Galindo et al., 2000). Housing and keeping circumstances are not the only determinants of lameness, other factors like social rank and behaviour (Galindo et al., 2000) and conformation and body weight (Knott et al., 2007) have been suggested in literature as individual parameters. It was our aim to investigate differences in behavioural traits, body weight and milk yield and indicators for rank between animals with relatively high and low sole haemorrhage score but kept under controlled circumstances. It was hypothesized that animals with higher sole haemorrhage score have lower rank and different development of behaviour than animals with lower score.

Material and methods

Data for this study were obtained from an experiment with 44 heifers during the first 3 months after their first calving in a cubicle barn with one cubicle per animal. The animals were subjected to one of 4 experimental conditions during the first 2 months after calving and kept under standardized conditions during the third month. Experimental conditions were characterized by overnight access to the cubicles (yes or no) and alley flooring (concrete or rubber topped concrete), each combination of these factors was a treatment. During the third month the animals were kept in a compartment with concrete alley flooring and unrestricted access to the cubicles. All animals were equipped with Icetags (version 2.004 and 3.001, IceRobotics Ltd, Roslin, Midlothian, Scotland) and feed intake was recorded with an automated RIC system (Insentec, Marknesse, The Netherlands). The experimental setup and effects of the treatments on behaviour and claw health are described in detail elsewhere (Ouweltjes et al., 2010), but the results in summary indicated that hard flooring caused more sole haemorrhages than soft flooring, whereas restricted cubicle access did not affect claw health. The effect of flooring again suggests the contribution of mechanical load to development of sole haemorrhages. Within all treatment groups considerable variation existed in the seriousness of the sole haemorrhages of individuals. In this paper differences in development of behaviour, feed intake, body weight, milk yield and displacement at the feeders between animals that showed various degrees of sole haemorrhages at the end of the study were investigated. These could be useful for early detection and prevention. For this analysis, the animals were classified into four classes of sole haemorrhage score after the experiment: score_sh 0 – 6 (class 1), score_sh 7 - 9 (class 2), score_sh 10-14 (class 3) and score_sh >14 (class 4). The numbers of animals per class were 9, 11, 12 and 12 respectively. The following traits were analyzed for the treatment period: %standing, #bouts (both recorded with IceTags), feed intake speed, #meals and %displacements at the feeders. Percentages of displacement were calculated from the feeder data: each time a visit of a cow was followed by that of another cow within 15 seconds the first cow was considered to be displaced by the other. Thus for all animals the number of times being displaced (**#displace1**) and the number of times displacing another cow (**#displace2**) were calculated per day, and from these figures three indices were calculated: 100*#displace1/#feeder visits (**%displace1**), 100*#displace2/#feeder visits (**%displace2**) and 100*(#displace1 +#displace2)/#feeder visits (**%displace3**). In this paper only results for %displace1 are reported. Data (daily averages) were analyzed with ASREML (Gilmour et al., 2004) with the following model:

$$Y_{ijklmnop} = \mu + F_i * Lr_j + C_k.D_l + Bl_m + spl(Wk_n) + e_{ijklmno}$$

where $Y_{ijklmno}$ is the variable recorded for floor i, restricted cubicle access j, class of sole haemorrhage score in week 14 k, day l in lactation or in control period, block of entry m, day n during the experiment and repeated observation o. μ is the overall mean, F_i is the type of floor on which a cow was kept during the treatment period (concrete, rubber), Lr_j represents restricted cubicle access (yes, no), C_k represents sole haemorrhage class in week 14 (k = 1 – 4), D_l represents day of lactation (l = 1 – 56), Bl_m represents the block of entry (m = 1 - 11) and $spl(Wk_n)$ represents daily environmental fluctuations throughout the experiment (n = 1 – 175). Bl_m, $spl(Wk_n)$ and the error term are the random components of the model. A correction for animal was not applied because we were primarily interested in predictions of class-effects and interactions of class and day in lactation. Predictions for overall class effects were obtained from the estimated parameters.

Results

There was substantial variation between animals in all traits, see table 1.

Table 1 Variation of animal averages per trait for treatment period

trait	unit	Mean	Sdev	Min	Max
%standing		60.7	4.9	50.4	70.5
#bouts	/hour	0.69	0.19	0.42	1.33
intake speed	gr/sec	3.05	0.63	1.90	5.83
#meals	/day	40.5	14.1	22.0	77.5
Displace1		8.6	3.2	3.0	15.0

Overall predicted means ± se for sole haemorrhage classes and significances of patterns over days in lactation per haemorrhage class are presented in table 2.

Table 2 Predicted sole haemorrhage class means ± se and P-values for day in lactation patterns per haemorrhage class

trait	unit	class 1	class 2	class 3	class 4	P-value
%standing		61.1 ± 1.3	61.5 ± 1.3	63.1 ± 1.3	63.0 ± 1.3	<.001
#bouts	/hour	0.73 ± 0.02	0.72 ± 0.02	0.57 ± 0.02	0.56 ± 0.02	<.001
intake speed	gr/sec	3.42 ± 0.12	3.32 ± 0.12	3.20 ± 0.12	3.00 ± 0.12	<.223
#meals	/day	40.0 ± 2.5	41.1 ± 2.5	40.8 ± 2.4	37.6 ± 2.4	0.233
Displace1		6.9 ± 0.5	8.0 ± 0.5	7.8 ± 0.5	8.2 ± 0.5	0.251

Table 2 indicates that differences between classes in %standing were limited, but classes 3 and 4 had slightly but non-significantly higher %standing and significantly less standing bouts than classes 1 and 2. Patterns over days in lactation were significantly different for all traits derived from IceTags. Patterns for these traits are presented in figure 1.

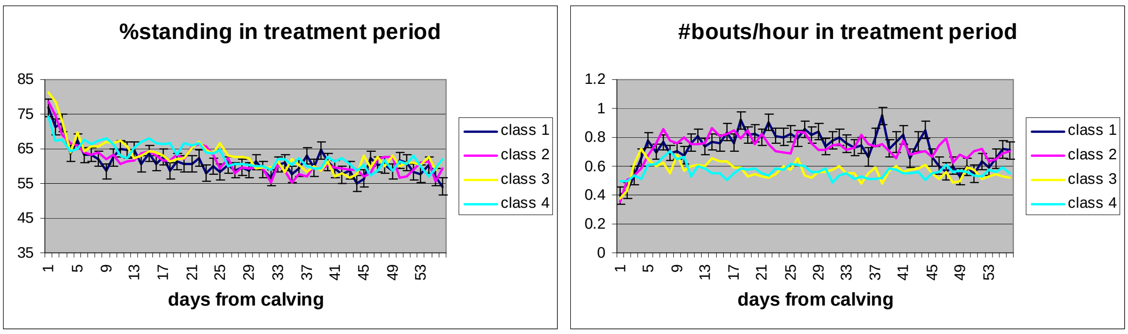

Figure 1 Estimates of daily averages per haemorrhage class during the experimental phase for %standing and #bouts/hour (se are presented for class 1 only, but are similar for the other classes)

Figure 1 shows that patterns for %standing were similar for all classes, showing a rapid decline in the first week after calving and a very small decline thereafter. The development of #bouts differed for class 1 and 2 from that of class 3 and 4, but initially there was no difference between classes. From 5 days after calving onwards the animals in classes 3 and 4 had a lower #bouts than the animals in classes 1 and 2.

Patterns for feed intake speed are presented in figure 2.

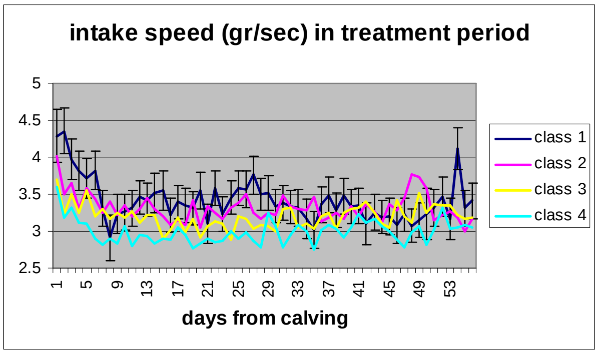

Figure 2 Estimates of daily averages per haemorrhage class during the experimental phase for feed intake speed (se are presented for class 1 only, but are similar for the other classes)

Average feed intake of class 3 was higher than that of the other 3 classes (data not shown). These had very similar averages. Figure 2 shows that feed intake speed tended to decrease with increasing sole haemorrhage score. Patterns for feed intake speed were not significantly different between classes. In the first week after calving feed intake speed declined, and thereafter more or less stabilized.

Table 2 indicates that overall differences between classes in %displacements were not significant. Moreover, the day to day variation within classes was substantial, and figure 3 illustrates that for this definition of displacements patterns for the four sole haemorrhage classes were not significantly different.

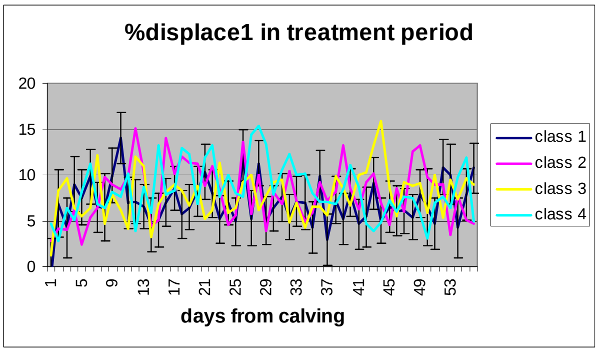

Figure 3 Estimates of daily averages per haemorrhage class during the experimental phase for displacement variables (se are presented for class 1 only, but are similar for the other classes)

There were also no indications for systematic changes of displacement during the experimental period.

Discussion

For this study the animals were categorized into one of four classes for haemorrhage score in week 14 after calving, regardless of treatment group. This despite the significant effect of alley flooring on sole haemorrhage score. In the meantime an analysis is also performed with classes defined within flooring, and this gave quite similar results for the traits reported here. We assume that the week 14 observation revealed the majority of tissue damage that originated in the treatment period. It was noticed that the sole haemorrhages we observed in our study were relatively small and mild (Ouweltjes et al., 2010). This implies that the contracts between haemorrhage classes are limited. Moreover, the definition of class ranges is arbitrary and basically determined by cow numbers per class. These constraints have to be kept in mind when interpreting the results of this study.

The absence of significant differences between animals with relatively high and low sole haemorrhage scores in overall means for behavioural and other traits does not necessarily imply that these traits are unrelated to occurrence of haemorrhages. Cook et al. (2007) reported that lameness affects time budgets, this could also occur for sole haemorrhages. Cause and effect could be interrelated, e.g. initially more active animals could be at increased risk for haemorrhages and once having bruises lower their activity due to discomfort in their feet. Therefore patterns in time for each trait were studied per sole haemorrhage class instead of overall differences. However, other than for number of lying and standing bouts, differences in patterns between classes were small.

Despite effects of flooring on occurrence of sole haemorrhages (Ouweltjes et al., 2010), within all treatment groups a considerable variation between animals in sole haemorrhage scores was found. Environmental circumstances within treatments were equal and all animals were heifers in the first 3 months after calving. Galindo et al. (2000) suggested that individual differences in susceptibility for foot lesions are influenced by social and individual behaviour. Because in our study several aspects of behaviour as well as weight changes and milk yield were monitored in detail we were able to study their relationships with occurrence of sole haemorrhages retrospectively. The analysis showed no significant relationships between occurrence of sole haemorrhages and %standing, feed intake and percentage of displacements at the feeders. The groups of animals with highest sole haemorrhage scores (class 3 and 4) had fewer lying and standing bouts than classes 1 and 2. This suggests that relatively infrequent alternation of lying and standing increases the risk of sole haemorrhages. It is less likely that the haemorrhages detected in week 14 after calving were already present as tissue damage one week after calving and were a cause of the lower number of bouts instead of an effect thereof. Furthermore, the results suggest that animals with faster feed intake have a reduced risk to develop sole haemorrhages, although the differences between classes were not significant.

Several authors have stressed the relevance of standing time for claw health (Cook et al., 2007; Galindo et al., 2000). In their studies a distinction was made between standing in the alleys and standing in the cubicles, and is was reported that animals with impaired locomotion spent more time standing in the cubicles. We have not subdivided standing time, but it could be that individual differences exist in the subdivision of time standing over cubicles and alleys. Despite that we have not observed lameness during the experiment, it could be that the relevance of standing time as a risk factor for sole haemorrhages is underestimated in our study. Cook et al. (2007) suggested that reduced lying time due to heat stress contributes to claw lesions at the end of the summer, but our results indicate that overall %standing per animal is not a good predictor for the individual risk to develop sole haemorrhages.

The clearest relationship of lying and standing behaviour with sole haemorrhage score was found for the number of standing bouts. Animals with on average lower numbers of bouts had higher haemorrhage scores. Because there was no relationship between standing time and haemorrhage score, this also implies that animals with longer bouts had more haemorrhages. This was not expected, because restricted cubicle access also caused fewer and longer bouts but did not affect sole haemorrhage score. This suggests that within treatment groups animals with relatively low numbers of bouts are susceptible for sole haemorrhages.

Galindo et al (2000) argued that differences in social behaviour could determine individual variation in susceptibility for claw lesions. They presented an index of displacement that was considered to be indicative for rank, with high values for high ranked cows and vice versa. Because we did not have visual observations or video recordings of the animals in their home environment, we have used the data from the feeders to obtain inferences about social status of individuals. Our definition of displacement was arbitrary, but it seems reasonable to assume that when the next cow starts feeding within 15 seconds after the previous cow she has forced the first cow to move away. Shortening the timeframe will increase the likelihood that involuntary displacements are not being counted as such, whereas prolonging the timeframe has the opposite effect. Due to our definition of displacements, the small experimental groups with heifers only and the ad lib availability of feed (mixed ration) throughout the day, displacements were relatively rare, i.e. most meals did not start with a displacement. As a consequence, zero displacements (both active and passive) were calculated regularly for individual cow days. Therefore we calculated displacement variables as percentages of displacements relative to the number of meals per cow per day. We have tried other definitions (displacement within 10 or 30 seconds), and these gave similar results in the sense that again no clear relationships were found between sole haemorrhage class and displacements. Social status could have been influenced by the fact that composition of experimental groups was variable and animals entered individually. However, figure 3 shows no clear patterns over days in lactation for any of the displacements, therefore we conclude that under circumstances of the study effects of social status on the occurrence of sole haemorrhages did not seem significant.

High mechanical load is often mentioned as an important factor for development of sole lesions. Therefore it was expected that besides social rank both the percentage animals are standing and body weight would be related to occurrence of sole haemorrhages. Our analyses do not support the existence of such relationships, and it seems that individual differences in occurrence of haemorrhages can not simply be explained by behavioural variables. Anatomical differences between animals as suggested by Knott et al. (2007), that might not be readily visible from outside, could also affect the threshold for overload and thus complicate relationships between load and tissue damage.

Conclusions

This study revealed no indications for effects of social rank on occurrence of sole haemorrhages under the circumstances of the study. The groups of animals with highest sole haemorrhage scores (class 3 and 4) had fewer lying and standing bouts than classes 1 and 2 from week 2 after calving onwards. Furthermore, the results suggest that animals with faster feed intake had a reduced risk to develop sole haemorrhages. Overall %standing per animal was not a good predictor for the individual risk to develop sole haemorrhages.

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