ALLEY-FLOOR DESIGN, CLAW LESIONS AND LOCOMOTION IN SWEDISH LOOSE-HOUSED DAIRY CATTLE

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SUMMARY

Effects on claw lesions and lameness of rubber vs. mastic-asphalt flooring in solid alleys, scrapers vs. no scrapers on top of slatted concrete alleys, and feed stalls vs. no feed stalls were studied in a 2-yr 2x2 factorial experiment, using 183 Swedish Holstein cows in a research cubicle herd. Most cows were scored as mildly lame at least once, but at the majority of weekly scorings cows were non-lame. Scrapers, as well as rubber comparing with mastic asphalt, reduced the risk of lameness. We found no effects on the risk of claw lesions at the end of the study.

Keywords: claw lesion; dairy cattle; feed stall; lameness; locomotion; mastic asphalt flooring; rubber flooring; scrapers

INTRODUCTION

Concrete is a common material in alleys for loose-housed dairy cattle, presumably due to its durability, low cost and ease of cleaning. However, alley flooring design affects cow behaviour and the risk of claw lesions and lameness. For instance, dairy cattle are able to distinguish walking surfaces differing in traction (Phillips and Morris, 2002) and rubber flooring in front of the feed bunk increases the time cows spend standing in concrete alleys (Fregonesi et al., 2004). Unfortunately, concrete walking surfaces have a negative effect on locomotion (Telezhenko and Bergsten, 2005) and may increase the risk of claw disease and lameness (e.g. Bergsten and Frank, 1996), comparing with more yielding surfaces such as rubber and mastic asphalt. Mastic asphalt is made of acid-resistant bituminous compounds and fine siliceous sand, particle size ≤0.5 mm (BINAB, NCC Roads AB, Stockholm, Sweden), with a relatively high coefficient of friction. Scrapers of various types are commonly used to clean solid loose-housing alleys. They have also been installed on top of slatted flooring to improve cleanliness further and reduce ammonia emission. Theoretically, scrapers would decrease the risk of infectious claw disease in cows on slatted alleys but, to our knowledge, such an effect has not been studied previously.

Cattle often displace each other while feeding by butting with their heads. Bouissou (1970) tested different partitions between dominant and subordinate cows and found that partitions separating the heads and bodies of the cows increased the feeding time of subordinate individuals. However, studied animals were horned and the results cannot be extrapolated to larger and socially more complex cow groups. Kongaard (1983) suggested that cows might feel more protected when there is a physical barrier between the animals during feeding. In practice, feed stalls are used to reduce social stress and the consequences of agonistic behaviour at the feed-bunk, thus presumably securing feed intake and milk production, but also to improve standing comfort, foot cleanliness and claw health. DeVries and von Keyserlingk (2006) showed that feed stalls reduce competition at the manger and improve access to feed, especially in subordinate cows. However, we found no previous scientific study of the influence of feed stalls on claw health.

The objective of the present experiment was to study the effect of solid rubber vs. mastic-asphalt flooring in alleys, of scrapers on top of slatted concrete flooring in alleys, and of feed stalls, on claw lesions and lameness in dairy cows housed in cubicle systems.

MATERIAL AND METHODS

The study was conducted as a double 2x2 factorial experiment during two consecutive housing seasons (2002–2004) at a university dairy farm in southern Sweden. Claw lesions were observed in 75 (year *1*) and 115 (year *2*) cows of the Swedish Holstein breed, parity 1–5; 30 of the cows participated both years. Locomotion was observed in 96 (year *1*) and 121 (year *2*) cows; 34 of the cows contributed both years. Seventy-two (year *1*) and 92 (year *2*) cows were observed for both lesions and locomotion.

All cows were loose-housed in a cubicle system with four equally-sized pens, each subjected to a separate treatment but otherwise identical. In each pen there were 21 cubicles in two rows parallel to the manger, and one computer-controlled concentrate feeding station along the outer wall. The cubicles measured 1.2 x 2.4 m and were equipped with cubicle partitions (Solid, DeLaval, Tumba, Sweden) and 30-mm polymeric mats (Cow Mat CM30L, DeLaval). They were littered with sawdust, providing new litter material twice a week. Alleys between cubicle rows were 2.2 m wide. In each pen there were four water bowls, placed in the cross passages between alleys. The cows were milked twice daily in a 2x9 herringbone parlour. The holding area had solid concrete floor and a mechanical crowd gate, and room for a maximum of 50 cows. The cows walked approximately 30 to 50 m on slatted concrete from their pens to the milking centre. The cows were fed concentrates (grain, soya and supplements) partly in feeding stations, and partly together with roughage (grass-clover silage) in a mix given *ad libitum* at the manger twice daily. Additional hay was fed during a 60-d period in the spring of 2003, when several cows exhibited loose faeces. All cows were grazed daily from beginning of May to beginning of September between the two housing seasons. Claw trimming was performed at the beginning and end of the observation period (in September-January and in January-May). Trimming was done by a third author or a professional claw-trimmer using an electrical grinder and a hydraulic trimming chute.

In year *1*, the alley floor was newly installed slatted concrete (single 125-mm concrete beams divided by 40-mm slots) and the treatments were: scrapers (Delta Master DM II automatic hydraulic scrapers with rubber blades, DeLaval, installed on top of the slats) and feed stalls, no scrapers but feed stalls, scrapers but no feed stalls, and neither scrapers on the slats nor feed stalls. In year *2*, the alley floor was solid and the treatments were: rubber mat flooring (KURA-P, Gummiwerk Kraiburg Elastik GmbH, Tittmoning, Germany) and feed stalls, 25 mm mastic asphalt flooring and feed stalls, rubber mats but no feed stalls, and mastic asphalt but no feed stalls. To render a comparison between years possible, a fifth treatment (23 cows) in year *2* had concrete slats (4 years old) without scrapers or feed stalls. If present, there were 20 feed stalls per pen, measuring 0.8 x 1.6 (2003–2004) to 1.7 (2002–2003) m, equipped with a standard hard rubber mat (Gummimattan Marianne Larson AB, Gothenburg, Sweden). The alley behind feed stalls was 2.2 to 2.3 m wide, and the alley along the manger without feed stalls was 3.9 m wide.

Treatments were expressed by three dichotomous variables representing scrapers (*No*; *Yes*) in year *1*, type of solid flooring (*Mastic asphalt*; *Rubber mats*) in year *2* and feed stalls (*No*; *Yes*) in both years. Cow group (1 group per pen each year) was expressed by a categorical variable. The cows were allocated to treatments (18–23 cows in each pen) in early autumn each year by blocked randomization in order of expected calving (every fourth cow going into a given pen, random order of pens) within parity (primiparous and multiparous), and introduced 4 to 90 d before calving; however, 62 cows that calved before the observation period (<113 d) were allocated in order of observed calving. No cows changed pen during the housing season.

Claw-lesions were recorded in connection with claw trimming at the beginning and end of observations, originally scored on 4-level ordinal or dichotomous scales. One trained recorder performed all examinations. All feet were immobilized at a convenient height and the trimming area was well lit-up to facilitate the assessment of lesions. Clinical diseases and therapeutic measures were recorded successively. Claw-lesion records at second trimming were recoded into four binary outcome traits with a sufficient number of cases and non-cases, representing heel-horn erosion, haemorrhage in the sole or white line (including sole ulcer), dermatitis, and separation in the white line or double sole (*0* for score 0 and as *1* for scores >*0*). Lameness data were collected at 31 and 34 weekly sampling occasions, from September to May. At each occasion, all cows were scored once for lameness by one of three persons (year *1*, *n*=1375, 435 and 315 records, and year *2*, *n*=1618, 557 and 79 records, respectively) as the animals walked a 30-m alley (slatted concrete with 125-mm slats and 40-mm slots) from the milking parlour to the cubicle area and while they were standing in front of the manger. Lameness score *0* denoted normal (level-back) posture; cows with score *1* stood with a level-back posture but walked with an arched back; cows with score *2* both stood and walked with an arched-back posture (Sprecher et al., 1997, modified). Lameness score was transformed into a binary trait representing lameness status by changing records with scores ≥*1* to *1*.

Analyses were done using generalized linear mixed models in the GLIMMIX procedure of SAS 9 (SAS for Windows, SAS Institute Inc., Cary, NC, USA), assuming a binomial distribution and including group as a random effect. Lesion traits were modeled at the foot level, specifying repeated measures within cow by a compound-symmetry correlation structure (different years within cow assumed independent). Only cows that were exposed for treatment until at least 85 days after calving were used, excluding 104 cows year *1* and 16 cows year *2*; cows were exposed for between 107 and 245 days (median 190 days) before lesion assessment at second trimming. In total, 648 observations in 141 cows were used. Lameness was analysed by two different strategies. First, lameness status at each occasion was modeled as separate observations, specifying a first-order auto-regressive correlation structure for repetitions within cow, assuming observations to be decreasingly correlated over time within cow (different years within cow assumed independent). In total, 4359 observations in 168 cows were used. By the second analytical strategy, the portion of observation time lame was modelled. A binary outcome trait was coded as *1* if the percentage of occasions scored as lame was ≥50%, otherwise as *0*. In this model, different years in the same cow were assumed independent. Totally 193 observations in 167 cows were used.

Tested fixed-effect predictors at the group level represented year (*1*; *2*) and studied treatments (scrapers [year *1*] or solid flooring type [year *2*], and feed stalls). Cow-level predictors represented parity, calving season, days in milk at the start of the observation period, days in milk at lesion scoring, days in milk at lameness scoring. Foot-level predictors of lesions represented pair of feet (*hind*; *front*) and lesion status at first trimming regarding the same type of lesion (*0*; *1*). Occasion-level predictors of lameness (1^{st} strategy) tested represented days in trial, days since last claw trimming, and rater. The final models were built by a manual stepwise procedure, starting with full models. Predictors representing year, either scrapers or solid flooring type (nested within year) and feed stalls were forced into all models; among remaining predictors, only those associating statistically significantly with the outcome (Type 3 P≤0.05) or confounding a treatment effect were retained in the models. Thereafter, biologically plausible 1st-order interactions were tested and included if statistically significant (Type 3 P≤0.05). Differences between predicted population margins (least-squares means) of treatments and interacting factors were computed, and corresponding odds ratios and their 95% confidence intervals were calculated.

RESULTS

Most prevalent lesions were haemorrhage of the sole (67 and 84%), haemorrhage of the white line (43 and 62%), dermatitis (24 and 32%), and white-line separation (21 and 23% of cows affected in one or more feet at the end of the observation period in year *1* and *2*, respectively). The prevalence of most lesions was higher in year *2* than in year *1*; there were however only two cases of sole ulcer, in year *1*. There was no need for any emergency treatments of claw diseases during the study. Most of the cows (58% in year *1* and 70% in year *2*) were scored as mildly lame at least once, but the majority of scorings (55% in year *1* and 65% in year *2*) were *0*. Forty-eight percent of the cows were lame ≥50% of the scoring occasions in year *1*, and 39% in year *2*. Comparing the scoring of lameness between study years under similar housing conditions, there were 273 observations (54%) scored as *0*, 200 (39%) as *1* and 35 (6.9%) as *2* in the treatment without scrapers or feed stalls in year *1*, while there were 400 observations (71%) scored as *0*, 139 (25%) as *1* and 22 (3.9%) as *2* in the fifth treatment in year *2*.

Feed stalls increased the odds of haemorrhage by 1.8 in hind feet (P=0.032); otherwise, there were no significant associations between treatments and risk of claw diseases. The correlation between lesion records in two different feet of the same cow was estimated to be from 0.054 (separation) to 0.19 (haemorrhage). The proportions of the total variation in lesions residing at the group and cow levels were 0.6% and 26%, respectively, for the model of heel erosion, 2.2% and 14% for haemorrhage, 4.4% and 14% for dermatitis, and 0.5% and 18% for separation (estimated from empty variance-component models, without fixed effects).

In cows with access to feed stalls, comparing with no feed stalls, the odds of lameness at weekly scorings were 60% lower in second parity (P=0.002), but 40% higher in older cows (P=0.02); in first parity, the odds were marginally significantly higher (OR=1.6, P=0.05). In cows of third or higher parity kept on slatted concrete with scrapers, comparing with no scrapers, the odds of lameness at weekly scorings were 55% lower (P<0.0001), but no effect of scrapers was found in younger cows. Likewise, in cows of third or higher parity kept on solid rubber flooring, the odds of lameness were 61% lower (P=0.01) than on solid mastic asphalt, while no effect of type of solid flooring was seen in younger cows. There was no significant association between treatments and risk of lameness at ≥50% of the scorings. No significant association between time exposed to treatments and lameness was found. The correlation between to consecutive weekly lameness recordings in a cow was estimated to be 0.48. In the model of weekly recordings, the proportions of the total variation of lameness residing at the group and cow levels were estimated to 0.26% and 62%, respectively; in the model of lameness at least half the time, 0% resided at the group level.

DISCUSSION

In the present study, the prevalence and severity of claw lesions were very low. Only a few sole ulcers and abscesses were found and there was no need for emergent lesion treatment during the study, although over 100 cows were observed during two years. Possible explanations are extremely good management of the animals, excellent cow comfort through mattresses, very good alley hygiene, and balanced diets for an average production level. Thus, given the circumstances, it was no surprise that significant differences in the risks of lesions between treatments could not be detected in the present study. In the same animal material, Telezhenko et al. (2006) showed that feed stalls on an abrasive floor (mastic asphalt) reduced the weight-bearing area of the sole and thus resulted in a high contact pressure, which might explain the found effect of feed stalls on haemorrhages in the present study. Furthermore, comparisons of claw health between floorings with different abrasiveness might be biased due to different rates of claw horn growth and wear (Telezhenko et al., 2005). Vokey et al. (2001) and Vanegas et al. (2006) revealed positive effects on claw disease and-or lameness of solid rubber alley flooring, comparing with solid concrete. Danish (Thysen, 1987) and Swedish (Hultgren and Bergsten, 2001) studies have shown that slatted flooring can result in a significantly lower risk of interdigital dermatitis and heel horn erosion than solid flooring.

The scoring system used was based on both direct symptoms of lameness with altered weight bearing and the cows' signs of discomfort when walking, expressed by the arched back. The latter mechanism is very sensitive, i.e. non-lame cows can arch their backs when walking on uncomfortable flooring, like the slatted flooring used here. A majority of animals arched their back when walking, while a minority of animals arched their back while standing. No animals showed any lameness expressed as altered weight bearing. These results are in accordance with the low prevalence of claw lesions. Claw lesions cause most but not all lameness (Murray et al., 1996), and lesions are not necessarily expressed as lameness (Manske et al., 2002).

Although lameness scores were low, animals kept on slatted flooring with scrapers had significantly lower scores than those without scrapers. However, infectious lesions – such as dermatitis and heel horn erosion – were not influenced significantly by type of flooring, which may indicate that locomotion scoring was more sensitive. We also found that solid rubber flooring (in contrast to solid mastic asphalt) decreased the risk of lameness in dairy cattle of parity 3 or higher. This is in accordance with Telezhenko and Bergsten (2005), who found the gait of animals with a high locomotion score to be impaired on hard floors. It was expected that feed stalls with rubber mats would decrease the risk of lameness; however, the increased risk in cows of third or higher parities seems less logical.

We included a fifth treatment in year *2* (slatted floor without scrapers or feed stalls) to be able to make comparisons between years. However, this slatted floor was older and considerably more worn than that used in year *1*, which made such direct comparisons difficult. The proportion of cows scored as lame differed considerably between the two treatments (29 and 46%, respectively).

CONCLUSIONS

No association could be shown between scrapers on top of a concrete slatted floor (comparing with slats without scrapers), a solid rubber floor (comparing with solid mastic asphalt) or feed stalls (comparing with no feed stalls), and the risk of heel-horn erosion, sole or white-line haemorrhage, claw dermatitis, or separation in the white line or sole horn of dairy cattle. Scrapers on top of a concrete slatted floor (comparing with slats without scrapers) and a solid rubber floor (comparing with solid mastic asphalt) decrease the risk of lameness in dairy cattle of parity three or higher – as judged by posture scoring while standing and walking. Feed stalls seem to decrease the risk of lameness in cows of second parity, but not in older cows.

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