Claw health and prevalence of lameness in cows from compost bedded and cubicle freestall dairy barns in Austria

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ABSTRACT

Claw health and lameness data from five dairies with compost bedded barns (n = 201 data sets) were evaluated and compared with data from five dairy herds housed in freestall cubicle barns (n = 297 data sets). They were matched for having the same cow numbers, flooring type and similar milk yield. The prevalence of lameness, claw lesions and their severity grades were analysed. Two claw health indicators, the cow claw score (CCS) and the farm claw score (FCS), were calculated using a computerised claw trimming database programme; there was no significant difference in overall lameness prevalence in cows from five compost bedded barns (18.7%) compared to cows from five freestall cubicle herds (14.9%). A cumulative link mixed model (CLMM) did not show significant differences in locomotion between different types of bedding material, flooring system, breed, visit number, observer and time since last trimming, but locomotion was significantly influenced by CCS. Another CLMM tested the impact of parameters mentioned on CCS and showed significant influence of flooring type, visit number and cattle breed. Statistically significant differences in the prevalence of claw disorders between compost bedded and freestall cubicle barns were found for white line disease (WLD; 20.4% and 46.6%, respectively), heel horn erosion (HHE; 26.9% and 59.9%, respectively), concave dorsal wall as a result of chronic laminitis (6.5% and 15.9%, respectively) and for interdigital hyperplasia (0.2% and 3.1%, respectively). The results of this study indicate that compost dairy barns are a good alternative to common cubicle housing systems in terms of lameness, claw health and animal welfare.

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Introduction

Creating an optimal environment is critical for keeping dairy cows, both from an economic and animal welfare perspectives (Cook and Nordlund, 2009; Bruijnis et al., 2013; Barkema et al., 2015). A growing concern in the dairy industry is the consumer’s opinion and satisfaction regarding production systems and animal welfare (Ellis et al., 2009; De Vries et al., 2015). Lameness is one of the most important issues in dairy cattle welfare (Von Keyserlingk et al., 2012; Tremetsberger and Winckler, 2015). The popularity of freestall barns is increasing because they allow the cows to move and socialise, whilst minimising daily labour (Chaplin et al., 2000). Freestall cubicle systems are commonly used in Europe, but they strongly limit behavioural scope (Endres and Barberg, 2007). Loose-housing systems allow cattle freedom of movement and the ability to lie down and rest (Van Gastelen et al., 2011). In addition to stall dimensions, the quality of freestall housing is strongly dependent on the flooring system (Fjeldaa et al., 2011) and bedding material (Norring et al., 2008; Van Gastelen et al., 2011; Ito et al., 2014).

Compost bedded pack dairy barns (CBB) are loose housing systems for dairy cattle consisting of a large bedded pack area separated from a feed alley by an area of concrete or slatted floor (Janni et al., 2007; Bewley et al., 2012). CBB allow more natural behaviour and social interaction compared to common freestall housing (Endres and Barberg, 2007). Two different CBB systems have been described. In the first system, the bedding material consists of composted biodegradable waste, which is heated and treated with Lactobacillus spp. to ensure low pathogen contamination before usage in the barn (Van Gastelen et al., 2011). In the second system, the bedding material consists of dry, fine wood shavings and sawdust, which is aerated once or twice daily with a cultivator to incorporate manure and to start the compost process while is being used (Barberg et al., 2007; Endres and Barberg, 2007; Bewley et al., 2012). Lower bacterial counts in the bedding material, low mastitis prevalence and low somatic cell count in bulk tank milk compared to other housing systems have been observed for CBB (Barberg et al., 2007; Endres and Barberg, 2007). Positive effects on animal welfare have been identified with CBB, including low lameness prevalence and fewer hock injuries compared to other housing systems (Barberg et al., 2007; Lobeck et al., 2011). CBB are widely used in some countries (Israel, The Netherlands, and the USA) (Endres and Barberg, 2007; Janni et al., 2007; Klaas and Bjerg, 2011), but are used...
relatively little in central Europe; in Austria, 30 dairy herds were kept in CBB in 2015.1

The aim of this study was to evaluate the prevalence of lame-
ness and the prevalence and type of claw lesions in cows kept in compost dairy barns (CBB) and to compare these results with the data from cows kept in conventional loose housing systems with freestall cubicles (FCB), hypothesising that CBB are associated with lower prevalences of lameness and claw lesions.

Materials and methods

Selection of herds

The farmers of 16 dairies in Austria with ≥20 cows per herd, who had been using CBB for a minimum of 2 years for housing lactating and dry cows, were asked to cooperate in this study. To be eligible for inclusion into the study, herds had to have milk production records on farm level available and had to have regular hoof trimming of the complete lactating herd at two trimming visits per year. Ultimately only five farms met all the inclusion criteria and were willing to participate in this study. In total, 201 data sets from cows from CBB and 297 data sets from cows from FCB herds were evaluated. This project was discussed and approved by the institutional ethics and animal welfare committee in accordance with GSP guidelines and national legislation (project number ETK-15/02/2015 of the Veterinary University Vienna, Austria).

Study design

Four of the five dairies using CBB were visited twice from March 2014 to July 2015, 5–12 months apart, at the planned hoof trimming visits. In one farm (herd 5) the second visit was cancelled by the farmer because he could not see the need for hoof trimming of his herd 1 year after the first visit. All herd visits were coor-
dinated with the local hoof trimmers, ensuring that all of the requested claw health data could be documented by the researchers during the trimming procedure. All cows in these herds, with the exception of dry cows and cows of herd 5, had been trimmed twice a year; cows of herd 2 had been trimmed at yearly intervals. Records of five dairies housing their cows in FCB were used for comparison. CBB and FCB

herds were matched pairwise for herd size, breed of cow, annual milk yield and type of feed alley (concrete or slatted floors). Alley ways were cleaned using flat scrapers in barns with concrete floors and manually in barns with slatted floors. In both the CBB and FCB herds, cows were free of digital dermatitis. All herds in the study were housed indoors year round. The predominant cattle breed in this study was Fleckvieh in CBB (95.7%) and FCB herds (93.2%). Holstein Friesian cattle repre-
cented 5.8% in CBB and 7.3% in FCB herds. The herd size was 20–41 (mean 28.2) dairy cows in CBB herd and 20–39 (mean 29.6) dairy cows in FCB herd. Four farms in each group had solid concrete floors at the feed alley and one farm in each group had slatted floors.

Scoring of locomotion and hoof lesions

Locomotion of all cows in the herds was first scored on the hard floor of the feed alley (Sprecher et al., 1997). Locomotion scores and claw lesion documentation had been performed by two different observers on these cows from CBB and FCB herds. Functional hoof trimming was carried out in cattle restrained on a tilt table by the local hoof trimmer. The predominant cattle breed in this study was Fleckvieh in CBB (95.7%) and FCB herds (93.2%). Holstein Friesian cattle repre-
cented 5.8% in CBB and 7.3% in FCB herds. The herd size was 20–41 (mean 28.2) dairy cows in CBB herd and 20–39 (mean 29.6) dairy cows in FCB herd. Four farms in each group had solid concrete floors at the feed alley and one farm in each group had slatted floors.

Results

Locomotion scoring

When data from both farm visits were combined, the mean (±standard deviation, SD) prevalence of lame cows (locomotion score ≥2) in CBB herds was 18.7 ± 1.8% (range 0–37.5%) compared to 14.9 ± 13.4% (range 0–39.8%) in FCB herds; therefore, 81.3% of cows in CBB herds and 84.6% of the cattle in FCB herds did not exhibit lameness. In CBB and FCB housed cows, locomotion scores of 2 were detected in 13.7% and 9.9% of cows, scores of 3 in 3.9% and 4.7%, and scores of 4 (toe touching) in 1.1% and 0.3% of cows, respectively.

According to the model selection, there were no significant dif-
fferences in locomotion amongst bedding material, flooring system, breed, visit number, observer and time since last trimming. CCS was identified as a factor with a significant influence. Positive parameter estimates in Table 1 show that the odds for lameness were significantly higher for cows with moderate and severe claw health compared to cows with very good claw health (CCS < 15). The prob-
ability for impaired locomotion was <1% if claw health was low or


2 See: R Core Team, 2015. R: A Language and Environment for Statistical Com-
R-project.org (accessed 16 June 2016).

package version 2015.6-28. https://cran.r-project.org/web/packages/ordinal/
mild (CCS < 30; Fig. 1). For a cow with moderate claw health (CCS 31–100), the probability for mild, moderate and severe lameness was 45.3%, 9.4% and 1.2%, respectively. The probability for severe lameness increased to 7.1% for cows with CCS > 100. The estimated variance components for the random effects farm ($\hat{\sigma}_f^2$) and cow ($\hat{\sigma}_c^2$) were 0.281 and 1.293, respectively.

Type and prevalence of claw lesions

The results of claw lesion prevalences and claw lesion types in cows bedded in CBB compared to cows in FCB are summarised in Fig. 2. In cows from CBB, the most common lesions were heel horn erosion (HHE), sole haemorrhage (SH) and white lined disease (WLD), with prevalences of 26.9%, 26.6% and 20.4%, respectively. Statistically significant differences for prevalence of claw lesions were found for HHE (26.9% in cows from CBB compared to 59.5% in FCB) and WLD (20.4% in CBB herds and 46.6% in FCB herds). Additional differences were noted for interdigital hyperplasia (0.2% in CBB herds versus 3.1% in FCB herds) and having a concave dorsal wall (chronic laminitis) which was present in 6.5% and 15.9% of cows in CBB and FCB herds, respectively. There were no significant differences amongst cubicle types for the occurrence of double soles, SH, sole ulcers or horn fissures.

Correlations between claw lesions in case and control herds

In cows from CBB, there were significant correlations between HHE and concave dorsal wall ($r = 0.733$) and for horn fissures and sole ulcers ($r = 0.691$). In FCB herds, significant correlations were calculated for concave dorsal wall and WLD ($r = 0.802$), for WLD and double sole ($r = 0.634$), and for sole ulcer and HHE ($r = 0.700$).

Severity grades of claw lesions

In CBB herds, 92.6% of claw lesions were grade 1 (SD 4.2), 6.6% (SD 4.1) were grade 2 and 0.7% (SD 0.8) were grade 3. In FCB herds, severity grade 1 increased significantly from visit 1 to visit 2 ($P = 0.016$), whereas there was no increase in grade 2 ($P = 0.055$) or grade 3 ($P = 0.854$) lesions. Cows in FCB herds had 77.2% (SD 5.9) grade 1 lesions, 20.0% (SD 6.7) grade 2 lesions and 1.6% (SD 1.7) grade 3 lesions. Correlations between locomotion score and severity grade were statistically significant ($r = 0.215$).

Cow claw score and farm claw score

CBB cows had CCS of 0–160 and FCB cows had CCS of 2–276, FCS (median of all CCS of a herd) were 8–36 in CBB herds and 8–72 in FCB herds. Flooring system, breed and time (visit number) were identified as significant factors for CCS. Table 2 lists the parameter estimates for significant factors, reference categories and variance components for the random effects farm and cow. The probability for health problems increased for cows held on slatted floors.

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**Table 1**

<table>
<thead>
<tr>
<th>Fixed effects</th>
<th>Estimated coefficients</th>
<th>95% confidence interval</th>
<th>$P$ values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold (Locomotion score)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>6.18</td>
<td>[3.46; 8.90]</td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>8.55</td>
<td>[6.26; 12.48]</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>10.87</td>
<td>[6.00; 15.73]</td>
<td></td>
</tr>
<tr>
<td>CCS low (0–15, reference)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCS mild (16–30)</td>
<td>0.73</td>
<td>[-2.08; 3.54]</td>
<td>0.609</td>
</tr>
<tr>
<td>CCS moderate (31–100)</td>
<td>6.42</td>
<td>[3.57; 9.26]</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>CCS severe (&gt;100)</td>
<td>8.30</td>
<td>[4.45; 12.14]</td>
<td>$&lt;0.001$</td>
</tr>
<tr>
<td>Random effects</td>
<td>Variance component</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm</td>
<td>0.281</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>1.293</td>
<td></td>
<td></td>
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</table>
There was no significant difference between claw health of Fleckvieh and Holstein cows. CCS was significantly lower at the second visit (−0.42). Estimated probabilities for the different grades of claw health for Fleckvieh cows held on concrete and slatted floor at the first and second visits are shown in Fig. 3. The probability for severe CCS decreased over time (first to second visit) from 1.0% to 0.7% for cows in housing systems with concrete floors and from 8.5% to 5.7% with slatted floors. The probability for low CCS at the first visit was 48.9% for cows on farms with concrete floors and 9.6% for cows on farms with slatted floors. Estimated variance components were $\hat{\sigma}_f^2 = 0.408$ for the random effect farm and $\hat{\sigma}_c^2 = 0.860$ for the random effect cow. Estimated random intercepts and 95% prediction intervals for the farms in the study are shown in Fig. 4. Farm 2 thus had lower CCS than the average farm, whereas farms 7 and 5 had higher CCS than the average (prediction interval above 0).

**Discussion**

Animal welfare in cattle farming is a growing concern amongst consumers (Rossi and Garner, 2014) and a demanding process for the farmers who are producing highly valuable milk and meat under economic pressure (Ellis et al., 2009; Von Keyserlingk et al., 2012). Lameness has become an important issue in modern dairy herds, causing severe pain in cows and leading to economic losses for producers (Logue and Bergsten, 2007; Bruijnis et al., 2013; Barkema et al., 2015). In recent years, new housing systems, such as rubber floors, sand bedded cubicles and compost bedded freestalls have been developed to increase cow comfort, health, longevity and claw health (De Vries et al., 2015), and therefore productive performance (Norring et al., 2008; Fjeldaas et al., 2011; Lobeck et al., 2011).

Compost dairy barns tend to be used in regions with little arable land, where most of the farmers own forest and are therefore able to produce their own wood shavings for use as bedding material (Bewley et al., 2012). Even though many studies have demonstrated that regular hoof trimming contributes to the prevention of lameness and claw lesions in cattle (Manske et al., 2002; Sogstad et al., 2007; Groenevelt et al., 2014; Thomas et al., 2015), routine hoof trimming was not performed in half of the 16 CBB herds initially contacted.

The present study analysed the prevalence of lameness and claw lesions in five dairy farms that keep their lactating and dry cows in CBB (16.6% of all Austrian CBB) compared to five conventional FCB herds. The mean prevalence of lame cows in this study was 18.7% for cows housed in CBB and 14.9% for cows housed in FCB; the difference was not statistically significant. Three herds had higher lameness prevalences (>30%) than the others; two of these belonged to the CBB and one to the FCB group. An explanation for these findings might be farm specific management related factors, such as lack of regular locomotion scoring and immediate therapeutic trimming (Manske et al., 2002; Groenevelt et al., 2014). However, this study showed much lower lameness prevalences than previous studies from Austria, where mean lameness prevalences of

<table>
<thead>
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<th>Table 2</th>
<th>Estimated model parameters and 95% confidence intervals of the cumulative link mixed model for cow claw scores (CCS).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed effects</strong></td>
<td><strong>Estimated coefficients</strong></td>
</tr>
<tr>
<td>Threshold (CCS)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td><strong>-0.05</strong></td>
</tr>
<tr>
<td>Mild</td>
<td><strong>1.54</strong></td>
</tr>
<tr>
<td>Moderate</td>
<td><strong>4.57</strong></td>
</tr>
<tr>
<td>Concrete floor (reference)</td>
<td></td>
</tr>
<tr>
<td>Slatted floor</td>
<td><strong>2.20</strong></td>
</tr>
<tr>
<td>1st visit (reference)</td>
<td></td>
</tr>
<tr>
<td>2nd visit</td>
<td><strong>-0.42</strong></td>
</tr>
<tr>
<td>Breed Fleckvieh (reference)</td>
<td></td>
</tr>
<tr>
<td>Breed Holstein</td>
<td><strong>0.92</strong></td>
</tr>
<tr>
<td>Random effects</td>
<td><strong>Variance component</strong></td>
</tr>
<tr>
<td>Farm</td>
<td><strong>0.408</strong></td>
</tr>
<tr>
<td>Cow</td>
<td><strong>0.860</strong></td>
</tr>
</tbody>
</table>
27–36% (range 0–87.4%) have been reported (Dippel et al., 2009; Rouha-Müller et al., 2009; Kofler et al., 2013). Results are comparable to the prevalence of lameness reported in CBB herds by Lobeck et al. (2011), who defined lame cows showing scores ≥3 on a 1–5 scale. The cumulative link mixed model calculation revealed no significant differences in locomotion related to bedding material, flooring system, breed, visit number, observer and time since last trimming.

HHE and WLD appeared only about half as frequently in cows from CBB compared to cows in FCB. These results might be related to the softer and drier ground, and higher cleanliness of the large bedded pack area in CBB (Barberg et al., 2007; Lobeck et al., 2011), where only the separated feed alley is covered with hard concrete or slatted floors.

The total prevalence of claw lesions, including all severity grades, was high; however, minor lesions that caused little or no pain (for example grade 1 HHE and WLD) could be detected in high numbers. The severity grades for claw lesions recorded in CBB cows were significantly lower than in cows housed in FCB. There was a low positive correlation between locomotion score and sum of severity grades, but a moderately positive correlation between locomotion scores and CCS. The major lesions likely to cause pain and lameness were score ≥2 WLD and all sole ulcers, which resulted in increased locomotion scores and CCS in both study groups independently. The numerical indicators CCS and FCS, calculated from all claw lesions and their severity grades, in combination with the lameness prevalence, are recognised as useful to describe the claw health status in one single cow and in a herd (Kofler et al., 2011, 2013; Keplinger et al., 2013; Kofler, 2013). Good CCS and FCS values for cows and the herd are <35 (Kofler et al., 2013).

Mean FCS values for CBB cows from both visits were lower (mean 16.9) than mean FCS values for cows in FCB (mean 25.1). These scores provide evidence that both groups had good claw health in this study (Kofler et al., 2013). However, individual cows in both study groups showed high CCS values (>100), with a CCS maximum of 276 in a FCB herd.

In the cumulative link mixed model selection the CCS was identified as a significant influence factor for lameness, in contrast to the claw lesion type. CCS combines the sum of all documented claw lesions and their geometric severity scores of one single animal, and is therefore much more suitable for analyses than the individual claw lesion prevalences (Kofler et al., 2011, 2013; Keplinger et al., 2013; Kofler, 2013). Thus, for cows with moderate and severe claw health issues (cows with CCS > 30), the odds for lameness were assessed to be significantly higher than in cows with good claw health (CCS < 15). The mixed model for CCS identified the flooring system, breed and time (visit number) as significant factors for claw health status. The probability for claw health issues increased (parameter estimate was 2.2 on the logit scale) for cows held on slatted floors compared to concrete flooring systems. Better claw health status was expected for Fleckvieh cows compared to Holsteins, and the CCSs were significantly lower at the second visit. The findings from the mixed model revealed clearly that there were more influencing factors for claw health than type of bedding alone, which is in accordance with the results of other studies (Von Keyserlingk et al., 2012; De Vries et al., 2015).

The location of claw lesions was different between herds. In the FCB cows, the white line area and the bulbs of the heel were the most frequently affected, whereas the lesions were more frequently found on the sole, white line and heel zones in cows from CBB, similar to previous reports (Tadich et al., 2010; Kofler et al., 2013).

The absence of digital dermatitis in the five CBB herds is remarkable; therefore, only FCB herds which were free of endemic digital dermatitis infection were selected for comparison. One explanation for the total absence of digital dermatitis in the study population could be the small number of investigated herds.

One limitation of this study is that other diseases of animals and on-farm factors (such as different management practices of the herds which could have affected lameness prevalences) were not considered as possible influence factors. However, specific farm and animal effects were considered in the mixed models by incorporating the random effects for farm and cow. Some selection bias could have been produced by studying CBB herds, since these herdsmen are likely pioneers in their field and are likely to be good managers.

The implementation of good cow comfort and prophylactic measures, such as regular functional hoof trimming (two to three times a year), regular locomotion scoring (at least once a week) and immediate treatment of slightly lame cows (Thomas et al., 2015) are recommended as general measures to maintain a good claw health status in a dairy herd (Groenevelt et al., 2014) independent of the flooring and bedding system.

Conclusions

Compost dairy barns are a good alternative to common cubicle housing systems in terms of lameness, claw health and animal welfare. The prevalence of lameness was low in both study groups, without a statistically significant difference between CBB and FCB. However, cows in CBB had a significantly lower prevalence of HHE, CDW and WLD, the latter being considered causative for lameness.

Conflict of interest statement

None of the authors of this paper have a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

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