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Gait of dairy cows on floors with different slipperiness

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ABSTRACT

This study assessed the slip resistance of different types of solid flooring in cattle housing using a range of technical tests and gait analysis. Dynamic and static coefficient of friction, skid resistance, and abrasiveness were tested on concrete flooring with a smooth finish, a grooved pattern, or a tamped pattern, acid-resistant mastic asphalt, soft rubber mats, and a worn slatted concrete floor. Coefficients of friction and skid resistance were tested under clean and slurry-soiled conditions. Linear kinematic variables were assessed in 40 cows with trackway measurements after the cows passed over the floors in a straight walk. All gait variables were assessed as deviations from those obtained on the slatted concrete floor, which was used as a baseline. The coefficient of friction tests divided the floors into 3 categories: concrete flooring, which had a low coefficient of friction (0.29–0.41); mastic asphalt flooring, which had medium values (0.38–0.45); and rubber mats, which had high values (0.49–0.57). The highest abrasion (g/10 m) was on the asphalt flooring (4.48), and the concrete flooring with a tamped pattern had significantly higher abrasiveness (2.77) than the other concrete floors (1.26–1.60). Lowest values on the skid-resistance tests (dry/wet) were for smooth concrete (79/35) and mastic asphalt (65/47), especially with a slurry layer on the surface. Gait analysis mainly differentiated floors with higher friction and abrasion by longer strides and better tracking. Step asymmetry was lower on floors with high skid-resistance values. The most secure cow gait, in almost every aspect, was observed on soft rubber mats. Relationships between gait variables and physical floor characteristics ranged from average to weak (partial correlations 0.54–0.16). Thus, none of the physical characteristics alone was informative enough to characterize slip resistance. With reference to gait analysis, the abrasiveness of the hard surfaces was more informative than the coefficient of friction, but the effect of pattern was better detected by skid-resistance measurements. Consequently, several physical characteristics are needed to objectively describe the slip resistance of cattle floors. Soft rubber mats gave better tracking than hard, solid floors, even with a grooved surface or a tamped pattern.

Key words: dairy cattle, concrete flooring, mastic asphalt, rubber mat, slipperiness, locomotion

INTRODUCTION

The flooring in walking and standing areas is one of the most important components of cattle housing because of its effects on animal health and welfare (Rushen and de Passille, 2009; Bergsten et al., 2015). Because it has direct contact with cows' feet, flooring affects locomotion, claw conformation, and claw health (Vokey et al., 2001; Telezhenko et al., 2009). Type of flooring is discussed mostly in relation to its slipperiness (Albutt et al., 1990): slippery floors impair locomotion and affect behavior and estrus detection (Rushen and de Passille, 2006; Palmer et al., 2012), and they also cause injuries associated with falling (Rushen and de Passille, 2009).

Central to the understanding of floor slipperiness is the coefficient of friction, a numerical ratio of the horizontal (frictional) force between the contact surfaces of 2 objects, and the vertical force (load) between those objects (Franck et al., 2007). Frictional force is the sum of several components (Grönqvist et al., 2001). Adhesion is a surface component of friction, due to the molecular bonds between the claw and the floor. Hysteresis is another component that occurs due to delayed recovery of the elastic parts of the claw's weight-bearing surface after dimple by a floor asperity. Abrasion or wear—a loss of substance at the claw-floor interface due to mechanical interlocking between a claw and a hard, rough floor surface—may also cause high frictional forces. Rough floors provide higher hysteresis and abrasion, and therefore better friction, especially if the floor is soiled and adhesion cannot play a significant role (Mckee and Dumelow, 1995). Skid resistance is another term for friction used in the automobile industry and transportation systems.

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Concrete is the most common flooring surface used in conventional cattle housing. Although much research has described the adverse effects of concrete on cow locomotion and claw health, the majority of existing and newly built cattle facilities still use it as their first-choice walkway flooring surface, because of its ease of installation and relatively low cost. New concrete surfaces usually have an appropriate level of friction (or are sometimes even too abrasive), but most lose their friction and abrasive properties over time because of mechanical and chemical degradation of the material (De Belie et al., 2000). Several solutions are available to reduce the slipperiness of concrete surfaces. The most common is to cut grooves in the surface (Mckee and Dumelow, 1995), and several practical solutions are available for grooving concrete. However, few controlled studies have compared concrete treatments aimed at increasing slip resistance and improving cow gait (Albutt et al., 1990). Other solutions to improve walking areas involve applying alternative surface materials, which can be hard and rough, such as epoxy resin with bauxite aggregates (Phillips and Morris, 2001) or mastic asphalt (Telezhenko et al., 2009), or soft, such as rubber mats (Rushen and de Passille, 2006; Flower et al., 2007).

Objective assessment of cow gait on different surfaces is a comprehensive way to evaluate the function of a floor. However, it is time-consuming to gather gait data, it requires special arrangements, and the results depend on environmental factors and individual variability (Flower et al., 2006, Telezhenko, 2009). It would be beneficial if gait tests could be replaced by more standardized technical floor tests. However, simply testing the coefficient of friction of a surface does not give a clear indication of its actual slip resistance (Grönqvist et al., 2001). Different tests that measure various characteristics of walkway surfaces are needed to provide more objective information about slip resistance. Phillips and Morris (2001) determined the coefficient of friction and abrasiveness of a floor in parallel with gait analysis. They measured coefficient of friction using a drag test of real cow claws, making the results more relevant to cattle locomotion. On the other hand, it is difficult to completely replicate test results due to variability in claw horn quality and claw shape between animals (Telezhenko et al., 2009). Despite demand from the dairy industry, there is a lack of research comparing common ways to decrease floor slipperiness in cattle facilities, along with their actual effects. Our prediction was that by a wider range of technical tests it would be possible to describe the slipperiness of floors as comprehensively as with gait analysis. The aim of the present study was to assess the function of common solid solutions for improving the traction of cattle flooring. To obtain a comprehensive evaluation of slip resistance, we characterized the floor surfaces using several technical tests, along with cow gait analysis.

MATERIALS AND METHODS

The study took place on the research farm of the Swedish University of Agricultural Sciences in Alnarp during the housing season, from October 2002 to February 2003. The flooring experiments were made in a slatted concrete walkway (30 m long and 2.20 m wide) stretching from the pens to the milking area. All cows were housed 8 mo from September to April in a freestall system with 4 equal-sized pens. Each pen had 21 freestalls, with 2 rows parallel to the manger and 1 computer-controlled concentrate feeding station along the outer wall. The freestalls measured 1.2 × 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, which was provided twice per week. The walkways (2.20 m wide, 13 m long) between the stall rows were of slatted concrete (single 125-mm concrete beams divided by 40-mm slots). The cows were milked twice daily in a 2 × 9 herringbone parlor; the holding area had a solid concrete floor and a mechanical crowd gate, and it had room for a maximum of 50 cows. The cows were fed a mix ratio ad libitum twice daily at the manger (about 35 kg of grass-clover silage and 2 kg of grain per head per day at 50% DM) plus concentrates (grain, soy, and supplements) according to milk production in the feeding station of each pen. All cows were grazed daily for 4 mo from the beginning of May to the beginning of September before the study started. Claw trimming was performed twice (before and after the grazing period). Cows in the herd had generally a very good claw health; only 1 case of sole ulcer was recorded during the study period.

Floor Types

Each of the solid flooring types tested consisted of 5 concrete slabs measuring 2.0 m × 2.2 m, made onsite from the same batch of concrete of the same quality. The slabs were fitted together and made up a 2.2-m × 10-m portion of the original 30-m walkway from the pens to the milking area. The rest of the slatted concrete walkway to the milking parlor was used for baseline measurements.

The following 6 flooring types were assessed:

1. Smooth concrete: The concrete was cast in a plywood mold, and the smooth concrete surface formed facing the plywood was tested.