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Effect of Different Flooring Systems on Weight and Pressure Distribution on Claws of Dairy Cows

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ABSTRACT

Weight and pressure distribution on the claw were studied in Swedish Holsteins housed in different flooring systems. A total of 127 cows housed in different sections of the experimental barn were used. Each section had different flooring in the walking and standing areas. There were rubber mats or abrasive mastic asphalt flooring on the alleys or a low-abrasive slatted concrete floor. Some sections had feed-stalls equipped with rubber mats; other sections did not. The vertical ground reaction force, contact area, and average contact pressure were determined on the left hind foot using the I-Scan system and analyzed with the F-scan system. These determinations were made in each of the following 3 zones of the claw: bulb, wall, and sole. Most of the weight on claws exposed to concrete floors was carried by the bulb (37.4 ± 3.5 and 18.3 ± 2.9% of weight exerted on the foot in the lateral and medial claw, respectively) and the wall zone (20.0 ± 2.6 and 13.4 ± 2.4% on lateral and medial claw, respectively). The weight and pressure distribution in cows kept on sections with rubber covered alleys but passing daily over the asphalt floor on their way to the milking parlor did not differ in any zones, except for lateral bulbs, compared with those exposed to slatted concrete alone. Still, the weight bearing of the sole zone in cows kept on rubber mats without access to asphalt was less than that of cows kept on concrete slatted floors (5.1 ± 0.7 vs. 12.7 ± 1.1% and 1.1 ± 0.5 vs. 8.7 ± 0.7% in lateral and medial claws, respectively). In cows kept on asphalt flooring without feed-stalls, most weight was exerted to the sole zone (36.2 ± 2.9 and 22.2 ± 1.8% in lateral and medial claws, respectively). Feed-stalls in combination with asphalt flooring yielded a decreased total contact area (30.1 ± 1.2 cm^2) compared with asphalt floors without feed-stalls (35.7 ± 1.2 cm^2). The largest total contact area was obtained on the asphalt floor without feed-stalls, resulting in a lower contact pressure (39.8 ± 2.3 N/cm^2) than in claws exposed to concrete (66.0 ± 2.7 N/cm^2) or rubber mats (56.7 ± 1.7 N/cm^2). In conclusion, housing with abrasive floors resulted in claws with increased contact area at the sole surface and therefore, decreased contact pressure, but reduced the weight-bearing role of the strongest part of the claw capsule, the claw wall.

Key words: dairy cattle, floor, biomechanics, claw

INTRODUCTION

Loose housing, and in particular free-stall systems, for dairy cows is a cost-efficient system which facilitates several animal needs (e.g., free movement and performance of social behavior). Nevertheless, lameness problems impair the functionality of the system because animals with reduced ability to move have difficulty obtaining food and water and accessing the milking facilities, especially in voluntary milking systems. Moreover, lameness is most often a sign of pain and of considerable concern for animal welfare (Bergsten, 2001). The most important part of dairy housing relating to lameness control is the floor surface because of its contact with feet (Webb and Nilsson, 1983; Sommers, 2004).

Designing a proper flooring system is a challenge in free-stall barns. The construction should be durable, hygienic, and reasonably priced. Because the floor is intensively used by heavy animals, there is a great demand on flooring design. Good slip resistance, ease of cleaning, encouraging locomotion, and promotion of claw health are characteristics of an appropriate flooring system, which could be described by a general term, floor ergonomics.

Concrete, which is the most common material used in free-stall barn alleys, was usually characterized as being too slippery for normal locomotion (Webb and Nilsson, 1983; Faull et al., 1996). Both roughness and softness of the walking surface had a positive effect on cow locomotion (Telezhenko and Bergsten, 2005; Rushen and de Passillé, 2006). Yet, if the surface was too

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abrasive it caused extreme wear of the claw horn, resulting in thin soles and a greater risk of bruising the sole of the claw (Bergsten, 2001) and penetration by infection resulting in irreparable injuries. The inadequate surface of a concrete floor was improved by resilient coverings such as rubber mats (Benz, 2002), but smooth flooring may cause a reduction in claw wear resulting in increased claw overgrowth (Platz et al., 2007).

The bovine claw protects the distal phalanx from environmental challenges and transfers body-generated forces to the ground. Different parts of the claw serve this function of force transfer: claw wall, suspensory apparatus of the digit, and the digital and coronary cushions (Mülling and Greenough, 2006). The suspensory apparatus, which consists of a system of dense collagenous fibers extending between the pedal bone and the epidermal lamellae of the claw wall, is somewhat less extensive at the axial part of the claw capsule, and is absent posterior to the insertion of the deep flexor tendon and in the region of the digital cushion. Consequently, stretching of the suspension apparatus fibers allows a slight displacement and rotation of the pedal bone, which is part of the shock-absorbing mechanism, but increases the risk of sole hemorrhages and sole ulcers (Lischer et al., 2002). However, the corium of the axial part of sole bulb junction is usually protected by the natural concavity of the sole (Tranter and Morris, 1992). The greatest part of the digital cushion is situated posterior to the navicular bone and seems to play the main role in shock absorption during the first contact of the claw with the ground during locomotion. It was suggested that the bulk of the digital cushion is not weight bearing under static conditions (Mülling and Greenough, 2006).

To improve weight distribution between and within the claws that have been altered by inadequate flooring and by claw overgrowth, functional claw trimming is usually recommended. Functional claw trimming is aimed at achieving equal weight distribution between and within the claws. A larger contact area is considered a desirable effect of the claw trimming. Yet, restoration of the natural slope in the axial part of the claw was recommended (Toussaint Raven, 1989).

Floorings or flooring combinations that can provide a balance between wear and growth of claw horn (Vermunt and Greenough, 1995) may decrease the need for claw trimming. The long-term effect of different flooring systems on claw characteristics, related to its biomechanics, should be scrutinized to provide information about the most favorable flooring for normal function of the claw.

The environmental effects on the conformation of the weight-bearing surface of the claw were investigated in grazing cows by Tranter and Morris (1992). van der Tol et al. (2004) and Carvalho et al. (2005) investigated the effect of claw trimming on claw pressure distribution. Additionally, Franck and De Belie (2006) described the contact pressure between a bovine claw specimen and floors with different degrees of roughness. Nonetheless, no study described the long-term effect of different flooring surfaces in walking areas on between- and within-claw weight and pressure distribution.

The aim of this study was to investigate long-term effects of different flooring systems providing different roughness and softness on the weight distribution, contact area, and contact pressure in claws of dairy cows in a free-stall system.

MATERIALS AND METHODS

Study Herd

The study took part in an experimental, university dairy herd in the southern part of Sweden (Swedish University of Agricultural Sciences, Alnarp). Average milk production was 9,000 kg of ECM and the culling rate during the 2-yr study period was about 40%, of which low fertility, mastitis, and lameness contributed 12, 6, and 1%, respectively. Lactating cows were housed in a free-stall barn with 200 stalls (1.23 × 2.42 m) in a 2 × 2 row design on both sides of a common, drive-through feeding platform. The concrete free-stall base was covered with a 30-mm-thick polymeric mat (ethyl vinyl acetate, DeLaval Cow Mat CM30L, Tumba, Sweden) bedded with 3.5 to 7 kg of sawdust provided twice weekly.

Five free-stall sections were used in the study. Each section had 21 free-stalls and 1 automatic concentrate feeding station along the outer wall. The alleys between the free-stalls were 2.20 m wide. In 2 sections, along the feeding platform, there were 20 feed-stalls (0.80 × 1.60 m) equipped with hard rubber mats (UBO, Barneveld, the Netherlands). The alley behind the feed-stalls was 2.30 m wide. In the sections without feed-stalls there were 23 head gates per section (0.70 m per head gate) and the total alley width was 3.02 m.

The cows were milked twice daily in a 2 × 9 herringbone parlor equipped with an automatic cluster detaching device. The holding pen (6 × 12 m, ~72 m^2) had solid concrete flooring that was designed to accommodate up to 50 cows. The pen was equipped with a mechanical crowding gate. The 30-m connection alley from the free-stalls to the holding pen had slatted concrete flooring. The 4-mo grazing period that is mandatory in this Swedish region started at the beginning of May and ended at the beginning of September.