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Association of floor type with health, well-being, and performance parameters of beef cattle fed in indoor confinement facilities during the finishing phase

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Abstract

The use of slatted concrete floors (SCF) in indoor confinement housing facilities for finishing beef cattle has increased among US cattle feeders, particularly in the Midwest. The objective of this study was to investigate potential health and performance differences associated with slatted concrete flooring not covered with rubber mats (SCF) and slatted concrete flooring covered with rubber mats (RM) in confined beef operations during the finishing phase of production. An observational cohort study design was conducted by enrolling 4258 calves among 35 pens to compare selected health and performance parameters between beef calves fed in indoor confinement housing using either SCF or RM management. Compared to cattle in the RM group, SCF cattle tended to have higher morbidity (20.5% vs 7.6%; *P*=0.0701). Cattle in the SCF group had an increased frequency of lameness diagnosis (3.1% vs 1.2%; *P*=0.0358), increased locomotion score at the end of the feeding period (*P*=0.0050), and higher mortality (2.1% vs 0.7%; OR=2.1346, *P*=0.0448). There was no difference between RM and SCF in average daily gain (*P*=0.2174), mean feed intake (*P*=0.1986) or mean feed:gain ratio (*P*=0.6139) when compared to cattle fed indoors on concrete slats without rubber mats. This study demonstrated potential increased health and welfare benefits, but not performance benefits, when rubber mats were utilized.

Key words: bovine, welfare, performance, health, housing, slatted floors, concrete floors, rubber mat

Résumé

L'utilisation de sols à caillebotis en béton (SCB) dans des parcs d'engraissement intérieurs pour les bovins de boucherie en phase de finition est de plus en plus fréquente chez les engraisseurs américains particulièrement au Midwest. L'objectif de cette étude était de déterminer l'impact sur la santé et la performance de l'utilisation de SCB sans tapis en caoutchouc (SCB) ou avec tapis en caoutchouc (TC) dans des parcs d'engraissement intérieurs pour les bovins de boucherie en phase de finition. Une étude observationnelle de cohorte a été menée avec 4258 veaux dans 35 enclos pour comparer certains paramètres de santé et de performance chez des veaux engraissés dans des parcs intérieurs utilisant une régie avec SCB ou TP. La morbidité était légèrement plus élevée chez les bovins du groupe SCB que chez ceux du groupe TC (20.5% vs 7.6%; *P*=0.0701). Chez les bovins du groupe SCB, la boiterie était plus fréquemment diagnostiquée (3.1% vs 1.2%; *P*=0.0358), le score de locomotion était plus élevé à la fin de la période d'engraissement (*P*=0.0050) et la mortalité était plus élevée (2.1% vs 0.7%; RC=2.1346, *P*=0.0448). Il n'y avait pas de différence entre les deux groups au niveau du gain moyen quotidien (*P*=0.2174), de la prise alimentaire moyenne (*P*=0.1986) ou de l'indice de consommation alimentaire (*P*=0.6139). Cette étude démontre que l'utilisation de TC peut potentiellement accroitre la santé et le bien-être mais a peu d'impact sur la performance.

Introduction

The use of slatted concrete floors (SCF) in indoor confinement housing (ICH) management schemes when finishing beef cattle in North America is an increasingly common practice, particularly in the Northern United States (US).[9,15] Feeding cattle indoors may capture potential improved efficiencies in cattle performance and nutrient value, while at the same time it may present decreased environmental compliance challenges compared to conventional outdoor finishing yards.[18,34,39] Compared to outdoor finishing facilities, stocking densities are routinely higher in ICH facilities, which adds a potential business efficiency advantage because of decreased space requirements to finish cattle.[10,15] Although the use of ICH may potentially provide advantages, consistent exposure to SCF through the finishing phase may negatively impact cattle health and increase musculoskeletal abnormalities, including decreased leg and joint health expressed by alterations in gait and claw conformation.[1,4,6,7,11,13,20,33,35,41,42,43,45] Lameness has been established as an important cause of feedlot morbidity, and rubber mat (RM) manufacturers have recommended installation of their products over SCF to increase cattle comfort and well-being.[14,37,40,44,45,48] When RM are installed over concrete, cattle have demonstrated a preference to them compared to SCF without RM.[7,24,29,30] The term "comfort" is used to describe the association between calf well-being/welfare and the facility or housing system.[26] Improvements in cattle comfort and activity levels have been reported when RM are installed over concrete in ICH facilities.[16,29,36,42] Improvements in cattle welfare during the finishing phase have been associated with increased performance; however, the association between performance and RM among cattle during the finishing phase is inconclusive.[8,19] Studies have reported conflicting effects on performance, with some studies demonstrating no performance benefit[6,7,13,25,30,33] while others have shown an improvement in performance[2,3,21,50] for cattle housed on RM.

There is limited peer-reviewed literature that assesses potential welfare and performance differences between cattle fed during the finishing phase on concrete slats and cattle fed on RM in a US beef cattle production setting. The objective of this study was to address this absence of information by investigating potential health and performance differences associated with slatted concrete flooring with and without rubber mats installed over them in confined beef operations during the finishing phase of production.

Materials and Methods

The study reported herein is a hypothesis generating study conducted using animals enrolled in a randomized cohort study. The Iowa State University Institutional Animal Care and Use Committee (IACUC) approved the study protocol (IACUC 5-12-7365-B) prior to enrollment.

Study facility

The study was conducted between June 2012 and August 2014 at a commercial feedlot in the upper midwest region of the United States. An observational cohort study design was conducted by enrolling 4258 calves among 35 pens to compare selected health and performance parameters between beef calves fed in ICH using either SCF or RM management. Calves were primarily sourced from Kansas and Nebraska through normal purchasing processes by the feedlot's cattle buyer. Calves had predominantly Angus genetics with some Continental influence, and were between 6 and 10 months of age.

Calves were housed in 1 of 15 pens located in 2 confinement deep-pit beef barns, each containing 8 pens. One of the 8 pens in a barn was used as a sick pen and was not part of the study. Thus, though there were 16 pens in the 2 barns, only 15 of the pens were used. The barns were constructed using a wood-truss gable-roof system with insulation under the tin roof to protect the tin from moisture buildup (Figures 1 and 2). Pens within the barns were approximately 70 ft by 46 ft (21 m by 14 m) and were designed to hold 140 head at 23 sq ft (7 sq m) per head. All study pens had a concrete floor base[a] constructed of 12 ft by 4 ft (3.7 m by 1.2 m) precast concrete cattle gang slats that were 6.5 in thick (16.5 cm) and were custom-constructed for the feedlot dimensions. Flooring within the pens was either concrete slats with no RM covering or concrete slats with a RM covering. Pens with rubber flooring included the following types of RM: Kraiburg™ LOSPA Swiss slatted flooring mats,[b] Ani-mat™ Original rubber flooring,[c] or Easy Fix™ for Beef[d] flooring mats; only 1 type of mat was used per pen and all concrete slats within the pen were covered. Floor types are depicted in Figures 3 through 6.

Separate automatic waterers were present in each pen. A solid concrete drovers alley was located directly next to feed bunks, and was used to move cattle to the handling facilities located within the barn. Approximately 6.75 inches (17 cm) of bunk space were allocated per head when pens were populated with 140 head. All pens were limit fed 2 to 3 times daily, depending on standard operating procedure for the ration and pen-level feed consumption.

Ventilation included the use of Roll-o-matic™ curtains.[e] There were 2 curtains on the north side of each barn (Figure 2a). The bottom curtain was designed to drop down to the concrete to cover the bottom two-thirds of the opening. The top curtain was designed to cover the top one-third of the

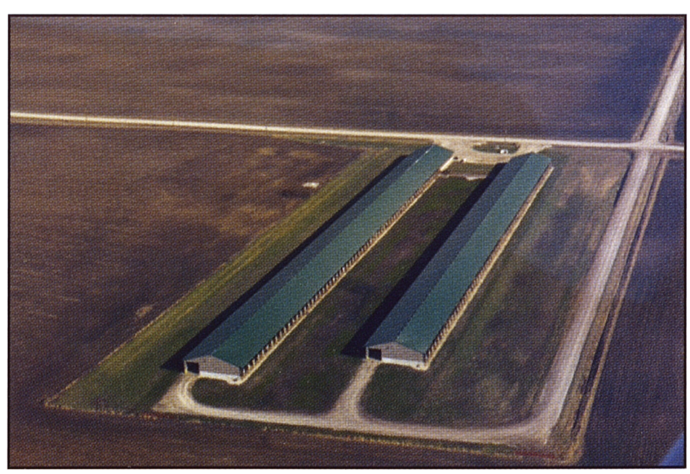

Figure 1a. Aerial image of deep pit beef confinement housing used in the current study.

Figure 1b. Layout of slatted-floor barns in the study reported herein.

	Barn 2									
511	512	513	514	515	516	517	518	519	520	521
Rubber mat	Rubber mat	Rubber mat	Rubber mat	Slatted concrete floor	Rubber mat	Rubber mat	Rubber mat	Rubber mat	Rubber mat	Rubber mat
	Barn 1									
Hospital	501	502	503	504	505	506	507	508	509	510
Cornstalks	Rubber mat	Slatted concrete floor	Rubber mat	Rubber mat	Rubber mat	Slatted concrete floor	Rubber mat	Rubber mat	Slatted concrete floor	Rubber mat

Figure 2a. Image of ventilation on north side of barn.

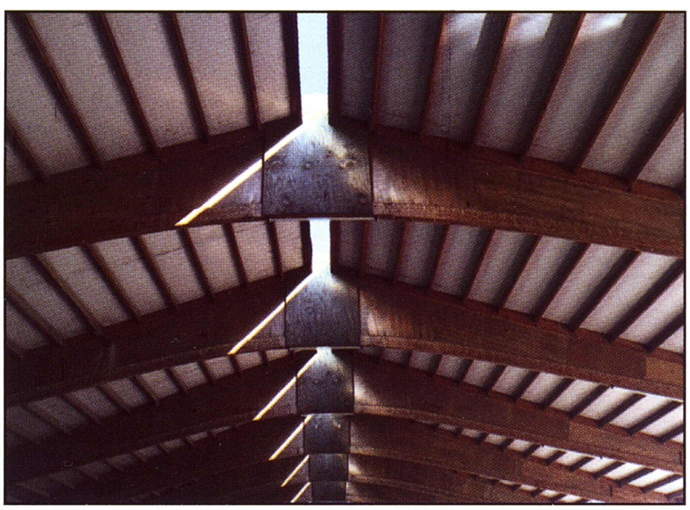

Figure 2b. Image of roof ventilation for confinement facility used in study.

Figure 3. Study pen with Kraiburg™ rubber mats installed over slatted concrete floors and close-up image of mat.

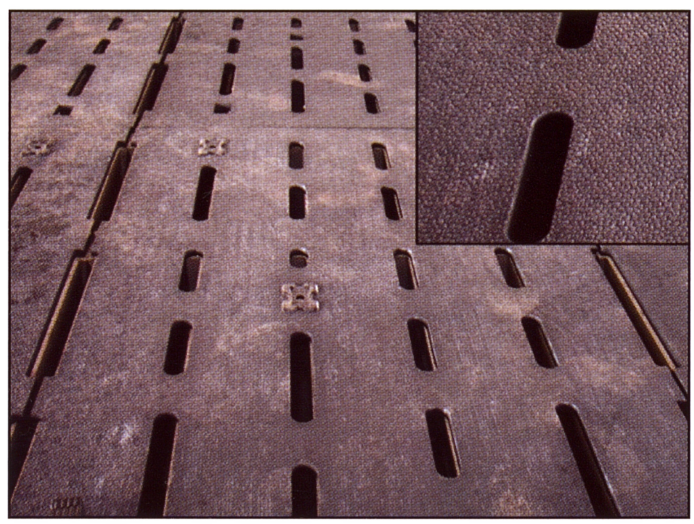

Figure 4. Study pen with Ani-mat™ rubber mats installed over slatted concrete floors and close-up image of mat.

opening. Ventilation is also provided using a chimney effect with an opening in the middle of the roof (Figure 2b).

A consulting nutritionist formulated a total of 5 rations. Following a short transition period from a forage to a grain-based diet, calves were fed a ration primarily composed of corn silage, dry-rolled corn, and modified distillers grains. Melengatrol acetate (MGA) was fed in heifer rations.

Enrollment of animals

Prior to enrollment, eligible calves were individually assessed for general health and lameness by trained and experienced personnel. Specifically, cattle were observed for signs of depression, decreased rumen fill (proxy for anorexia), bloat, droopy ears, ocular discharge, head tilt, nasal discharge, increased respiratory effort, or dyspnea. Cattle

Figure 5. Study pen with slatted concrete floors and close-up image of concrete flooring.

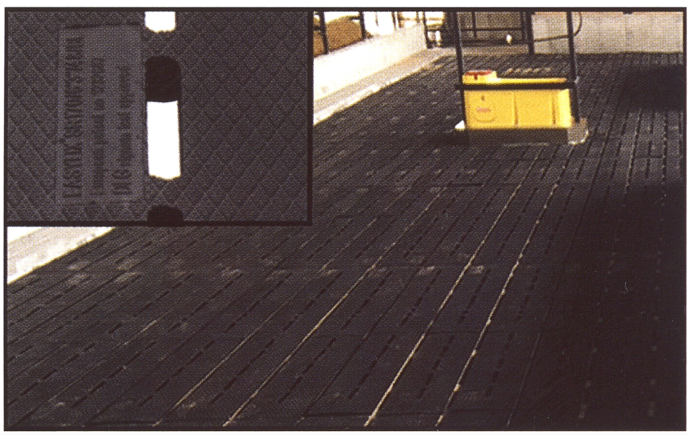

Figure 6. Pen with Easy Fix™ rubber mats installed over slatted concrete floors and close-up image of mat.

exhibiting abnormalities were not enrolled into the study. To reduce the likelihood of allocation bias, the researcher responsible for treatment group allocation did not participate in pre-enrollment exams.

Eligible calves were processed within 48 hours of arrival, and pens were filled within 72 hours. During processing, calves were vaccinated against infectious bovine rhinotracheitis virus (IBRV), bovine viral diarrhea virus (BVDV types 1 and 2), bovine respiratory syncytial virus (BRSV), and parainfluenza3 virus (PI3V). Additionally, calves were vaccinated with a combination *Clostridium chauvoei, C. septicum, C. novyi, C. sordellii, C. perfringens* Types C & D bacterin-toxoid, and *Histophilus somni* bacterin. Approximately 65 days prior to the end of the feeding period, calves were administered an IBRV-BVDV type 1 vaccine. During arrival processing, calves were administered a pour-on internal and external parasiticide. Cattle received a growth-promoting implant during arrival processing, and were re-implanted approximately 65 days prior to harvest.

Treatment group

Pens were filled over a period of several weeks and calves were allocated by truckload to either the SCF treatment group or a RM treatment group using a random number function.[f] For statistical purposes, specific mat brands were not considered different and were combined into 1 category. Once allocated to a SCF pen or RM pen, calves were not relocated to another flooring type. Either pay weights or off-truck in weights at the cattle facility were utilized to determine initial weights. A standard shrink of 1% per 100 miles of distance traveled was the factor used to verify that cattle were not over-shrunk on delivery.

Health assessment

Calves were subjectively evaluated at least once daily by experienced feedyard employees for evidence of morbidity, as described above. Feedyard employees evaluating cattle were trained to assess clinical signs of morbidity by an on-site veterinarian with assistance from the feedyard manager. Employee training for detection of sick cattle consisted of a combination of didactic education and partnering/mentoring. The feedyard manager regularly participated with employees in morbidity surveillance activities, and provided supervision on detection and treatment with oversight, supplemental training, and input as needed from the on-site veterinarian. Additional training was provided by a consulting veterinarian who conducted on-site visits and training at the feedyard every 4 to 6 weeks. Trial cattle were evaluated during the same time period and in the same manner as non-study cattle. Cattle exhibiting 1 or more clinical signs were evaluated further and, if necessary, treated. If a calf met predetermined criteria for treatment, it was identified as "morbid" and a presumptive diagnosis was assigned. Trained personnel administered treatments according to the feedyard's standard written treatment protocol developed by the consulting veterinarian. Diagnosis and treatments were recorded electronically, and included calf identification, morbidity diagnosis, date of diagnosis, treatment, dose, and route of administration.

Assessment of lameness was part of daily health checks performed by farm personnel, according to the farm's standard protocol. Calves identified with musculoskeletal or limb abnormalities, regardless of etiology, were termed "mechanical" and recorded as such by feedlot personnel. Treatments related to a mechanical diagnosis were administered and recorded using the same protocol for morbidity data.

Identification and date of death were recorded for calves that died. Assignment of animal mortality was to the pen and lot from which the deceased calf originated.

Mobility assessment

To evaluate mobility and gait, locomotion scores (LS) were individually assigned at 2 time points during the study: at enrollment and at the end of the feeding period. Following initial processing, calves were released from the chute and their gait was assessed by a licensed veterinarian or trained feedlot personnel. The second locomotion scoring occurred within 7 days of harvest. For the second LS, cattle were scored by first removing them from their pen and guiding them down a drover's alley. Cattle were then directed to walk back to their pen and each calf was individually evaluated. To reduce bias, the flooring type was not revealed to the evaluator when calves were assessed.

Locomotion was evaluated using a categorical lameness scoring system.[38] Scores from 1-5 were assigned to each potential enrollee as follows:

- 1-normal posture or gait
- 2-arches back when walking
- 3-arches back when walking and standing
- 4-arches back continuously; favors 1 or more limbs
- 5-reluctant to move; tries to avoid bearing weight on affected limb(s).

Data collection and management

Health data were entered chute-side on paper. The hard copy was delivered to the main office daily, and information was entered electronically in a conventional feedlot management and accounting system.[g] Mortalities were included in all close-out data, which includes health and performance analysis and output. Hard copies of data were stored for backup. Data were spot checked and validated as per the feedlot's standard operating procedure. Locomotion scores were hand-entered, and then transferred to a digital file and stored electronically. Data were combined into a single spreadsheet prior to analysis.

Health outcomes

Health events were measured from enrollment at day 0 until cattle were shipped for harvest. Analyzed outcome variables associated with health and welfare in this study included pen-level mean morbidity (mMorb), mortality (mMort), lameness (mLame), and mean LS (mLS). Morbidity was defined as any adverse health event, except lameness, that required treatment during the study period and were combined into a single category for analysis. If a calf was treated again following the end of the post-treatment interval for the previous treatment, it was classified as a new morbidity event. Pen and lot number were included for each outcome as the unit of analysis was the pen.

Performance outcomes

Analyzed performance variables included mean feed intake (mFI) on a dry-matter basis, mean feed-to-gain ratio (mF:G) on a dry-matter basis, and pen-level average daily gain (mADG). Feed intake was measured daily by pen in pounds. The mF:G ratio calculation is based on feed delivered to the pen divided by the pen's weight gain. The mADG calculation at harvest was the live truck weight at time of shipment to the slaughter plant adjusted for shrink (3% shrink of the truck weight if trucked the same day as harvested, or 4% shrink if calves arrived the evening prior to harvest), minus the pay-weight of the cattle.

Statistical Analysis

The objective of this study was to evaluate potential health differences associated with various types of flooring in confined beef operations during the finishing phase of production. The a priori assumption was that feeding cattle on concrete only would be associated with decreased health, well-being, and performance as determined by the 7 measures reported herein.

Quantitative variables (mADG, mFI, mF:G, mLS) were analyzed using linear models. Count variables (mMorb, mLame) were analyzed using negative binomial regression models. Pen mortality data (mMort) were assessed using logistic regression analyses. Analyses were performed using a commercially available statistical software program.[h] All models, excluding analysis of mLS, included the fixed effects of floor type, mat types and sex. For mLS, only fixed effect "floor type" was included in the model. Least squares means are reported for significant fixed effects. Statistical significance was set at 0.05.

Results

A total of 4258 calves fed in 35 pens were eligible for initial analysis (27 heifer pens; 8 steer pens), with 113 to 143 head per pen. Days-on-feed ranged from 131 days to 205 days. When comparing SCF and RM groups, there were 12 SCF pens (7 heifers, 5 steers) and 23 RM pens (20 heifers, 3 steers) included in analysis. Of the 23 RM pens, specific mat brands included 6 Ani-mat™ (6 heifer), 8 Easy Fix™ (7 heifer pens, 1 steer pen), and 6 Kraiburg™ (6 heifer pens). More than 1 brand of RM was used for 3 pens of calves because they were moved from 1 RM pen to another RM pen (1 heifer pen, 2 steer pens). All 35 pens were included in the analysis for mMorb, mLame, mADG, mFI, and mF:G. One RM pen (Easy Fix™, heifer) did not have mortality data available, and was excluded from that analysis. Thus, 34 pens were included in the mortality analysis. Fourteen of the 35 pens (n=1532 calves; SCF=326; RM=1206) had complete LS data and were included in the analysis for mLS (3 SCF, 11 RM).

Health

The mean rate of morbidity treatments was 12.0% (range 0 to 59.1%). Pen-level rate of morbidity treatments for SCF pens was 20.5% (range 1.5 to 59.1%), while the pen level of morbidity treatment rate for RM pens was 7.6% (range 0 to 39.4%). When comparing mean pen morbidity rate between RM and SCF, the SCF treatment group tended to have higher morbidity; 2.15 times more morbidity cases were identified among SCF pens compared to RM pens (P=0.0701). There was no significant difference between genders (P=0.1790) or between specific mat types (P=0.1936).

Overall mLame pull rate for all enrolled pens was 1.9%, and ranged from 0 to 9.3%. Overall mLame pull rate for SCF pens was 3.1%, and ranged from 0 to 9.3%, whereas overall mLame rate for RM pens was 1.2% and ranged from 0 to 7.8%. When comparing mLame between RM and SCF groups, cattle in SCF pens were identified as lame and pulled approximately 3 (3.021) times more than cattle in the RM group (P=0.0358). There was no significant difference between genders (P=0.3322) or between specific mat types (P=0.2343).

Pen-level mortality (mMort) for all enrolled pens was 1.2%, and ranged from 0 to 5.7%. Pen mortality rate averaged 2.1% (range 0 to 5.7%) for SCF pens, and 0.7% (range 0 to 0.35%) for RM pens. Cattle in SCF pens had higher mortality rates (odds ratio=2.1346; P=0.0448). Gender did affect mMort, and pens of steers had higher mortality rates than heifer pens (odds ratio=2.7497; P=0.0140). Similar to other analysis of outcomes within this study, specific mat types within the RM group were not significantly different (P=0.1718).

Mean locomotion scores (mLS) at the beginning of the feeding period were not abnormal (=1). Mean locomotion score 10 days prior to slaughter was 1.7 (range 1.2 to 2.2). The mLS for cattle in SCF pens was 2.1 (range 2.0 to 2.2), and 1.6 (range 1.2 to 2.1) for RM pens. At the end of the feeding period, SCF pens of cattle had an average estimated lameness score increase of 1/2 (0.47) compared to cattle in RM groups (P=0.0050). When considering distribution of LS between the treatment groups, SCF pens had more severely lame cattle compared to RM pens. Of the 326 SCF calves evaluated just prior to harvest, only 6% (n=18) demonstrated normal locomotion (LS=1), 80% were assessed as a LS=2 (n=260), 13% (n=42) were scored as LS=3, and 2% (n=6) were assigned LS=4. Among the 1206 head in mat pens, 43% (n=517) were identified as normal (LS=1), 50% (n=604) were assessed as a LS=2, 5% (n=62) were a LS=3, 0.7% (n=9) were LS=4, and 0.2% (n=2) were scored as a LS=5.

Performance

Thirty-five pens were included in the analysis of mADG, mFI, and mF:G. Overall, ADG in enrolled pens was 3.27 lb (1.48 kg; range 2.29 to 4.04 lb [1.04 to 1.83 kg]). When considering least square means, mADG for SCF pens was 3.2 lb ±0.146 (1.45 kg ±0.07), while mean ADG for RM pens was 3.44 lb ±0.13 (1.56 kg ±0.06). Mean ADG between RM and SCF pens was not significantly different (P=0.2174). Neither gender (P=0.1860) nor specific type of RM (P=0.8851) significantly affected mADG.

Overall average FI in enrolled pens was 21.54 lb (9.77 kg; range 17.68 to 27.27 lb [8.10 to 12.37 kg]). When considering least square means, mFI was 20.98 lb ±0.77 (9.52 kg ±0.35) among SCF pens and 22.30 lb ±0.70 (10.12 kg ±0.32) for RM pens. There was no significant difference in mFI between RM and SCF groups (P=0.1986) and specific mat type did not affect mFI (P=0.8231). There was also no significant difference between genders (E=-1.4746; SE=1.2545; P=0.2494).

Overall mF:G in enrolled pens was 6.64 lb (3.01 kg; range 5.84 to 7.76 lb [2.65 to 3.52 kg]). Pen-level mF:G was 6.61 lb ±0.14 (3.00 kg ±0.06) for SCF pens and 6.51 lb ±0.13 (3.02 kg ±0.06) for RM pens. Mean F:G was not different between RM and SCF groups (P=0.6139) or specific floor type (P=0.7344) or gender (P=0.2810).

Discussion

The use of rubber flooring over slatted concrete flooring in ICH, while resulting in no statistically significant difference in performance parameters, improved health and welfare through decreased mortality, a tendency for less morbidity, decreased lameness, and more favorable locomotion scores.

Reports on the effect of floor type on performance parameters in beef cattle have shown inconsistent results. In contrast to reports by Cozzi et al, Brscic et al, and Keane et al, the present study did not show improvements in ADG in cattle fed on RM compared to cattle housed on SCF.[2,3,23] Keane et al also reported improved feed conversion, contrary to the present study. The lack of improvement in cattle performance when using mats in the present study was in general agreement with Elmore et al, Lowe et al, and Graunke et al.[5,13,25] Although Graunke and co-workers did not find a difference in FI or feed efficiency, cattle fed on rubber covered slats required fewer days-on-feed to reach slaughter weight compared to calves fed on concrete.[13] Interestingly, Cozzi et al and Keane et al reported increased ADG, but not FI, for cattle fed on slats covered with RM, and suggested that the increase in ADG may be associated with increased comfort and willingness to stand compared to cattle on bare concrete floors.[3,23] In turn, increased standing may contribute to improvements in ADG without increasing FI because of increased energy expenditure when standing compared to laying.[23,31] This study did not account for potential behavior differences, such as laying and standing preference, or time budgeting, which may have further explained the lack of performance difference between treatment groups.

Performance and health benchmarks are difficult to apply broadly within the industry because of variation in environment, management, and animals. Nevertheless, some points of reference have been established that are generally applicable. Death loss among outdoor US feedlots has been estimated 1.4 to 1.6% of cattle on feed[48] and treatment rates are estimated in at least 1 study to be approximately 14% among feedlot cattle.[22]

In this study, calves fed on SCF had higher death loss (2.1%) than the average for US feedlots, while calves fed on RM experienced less (0.7%) than average. Though not statistically significant (P=0.0701), calves in RM pens had less morbidity (7.6%) than SCF pens (20.5%). Higher mortality occurs among cattle on SCF compared to rubber-matted facility systems.[32,36] One hypothesis for increased mortality and a tendency for less morbidity is that there is increased stress in calves fed on concrete flooring, contributing to a weakened immune system and greater susceptibility to disease. However, though stress has been shown to increase susceptibility to disease, this hypothesis isn't supported by 2 recent studies comparing physiologic and stress-related immune blood markers between beef calves fed on SCF or RM; no differences or potential indications of stress and immune compromise were detected between treatment groups.[6,23]

Increased mortality in SCF pens could be partially attributed to greater difficulty in identifying morbid cattle early in the disease process. Cattle on SCF may modify standing and laying behaviors as well as their gait to cope with traction difficulties associated with hard, slick concrete flooring.[2,17,51] Calves on RM have been shown to demonstrate more normal activity and behavior than calves on SCF, perhaps making recognition of clinical signs of disease, particularly in the earlier stages of the disease process, easier to identify in RM pens.[2] Identification, pulling, and treatment of sick cattle in SCF pens may be more difficult if cattle are less inclined to move or rise, and if caretakers are reluctant to observe each animal walk. This difficulty may be compounded by the progressive growth of calves in the pen and the resulting space restrictions for provision of normal movement and behavior.[16] Thus, it is possible that, although a higher proportion of calves in SCF pens were identified as sick, recognition of sick cattle early in the disease process may have been hindered by difficulty in observing cattle, ultimately resulting in higher mortality.

The present study did not include cause of death or morbidity diagnosis variables in the analysis; inclusion of more detail for these variables would have allowed a more thorough examination of health concerns, such as the occurrence of tail-tip necrosis or other injuries, respiratory disease, or digestive abnormalities. Collection, analysis, and interpretation of behavior data would provide additional clarity. Further assessment of economic impact related to the differences in performance would also be beneficial.

The effect of rubber coverings over SCF in beef cattle on hoof health and subsequent locomotion and lameness parameters is not yet clearly defined. The use of RM over concrete has been associated with decreased lameness in beef cattle in some studies, while other reports have identified potential concerns with the use of RM on hoof health and/or lameness compared to SCF.[13,32] Calves housed in both SCF and RM pens in our study demonstrated compromised mobility at the end of the feeding period. At the completion of the finishing phase, nearly all (95%, 308/326) SCF cattle had a LS equal to or greater than 2, and more than half (57%, 689/1206) of RM cattle had a LS of 2 or greater, which is in agreement with other reports.[7,35] The present study demonstrated decreased lameness among cattle housed on RM, as evidenced by fewer pulls for lameness and less alterations in locomotion. This finding is in agreement with other reports. The improvement in locomotion in the RM group may be largely due to less mechanical stress on the feet and legs. Concrete floors have high impact resistance, and will absorb minimal impact energy when calves are standing or moving. As a result, the animal's own body must absorb the great majority of the concussion, likely contributing to discomfort over time. When RM are installed over concrete, they absorb some of the impact, and decrease the concussive burden borne by the calf.

Days-on-feed were similar between groups (RM=148; SCF=155) and days-on-feed is unlikely to be a significant contributor to differences in LS and lameness between groups. While the physiological cause of the lameness or altered LS are not identified in this study, treatment groups were sufficiently controlled to identify RM as the primary cause for differences between treatments. It is highly unlikely all of the identified lameness and alterations in LS can be solely attributed to the floors; however, it is reasonable to assume, given the study design, these additional causes would be equalized to both treatments. It is also highly likely and reasonable to assume the number of days on the slats is a contributing factor to musculoskeletal abnormalities that are documented to occur on a continuous spectrum. Further research designed to define the effect of time calves are housed on SCF or RM on mobility by assessing LS at multiple time points throughout the feeding period would provide valuable information.

Another hypothesis for increased locomotion scores is that, though helpful in mitigating some of the musculoskeletal stress presumed to occur with long periods on concrete, RM cannot completely compensate for the combined long-term exposure to a hard surface and the increased weight gained as the calves grow throughout the finishing phase. This was also suggested in a recent report by Elmore et al where cattle had increased lameness scores over time when housed on concrete flooring.[7] Although laying down brings some relief from standing on hard flooring, the rigid flooring is still likely to exert some stress on the musculoskeletal system when animals are laying down. With less space for the calves as they increase in size during the finishing period, they may have more difficulty finding resting areas. This idea should be considered in the context of other studies, which have shown improvements in behavior by decreasing cattle density.[12,16,20] The present study facility routinely allotted at least 75 ft^2 (7 m^2) animal, which is considerably more than recommended in some reports.[12,16] The liberal stocking density used in the present study may have offset the potential negative impact of limited lying space and associated increased standing times on lameness and locomotion. Thus, deteriorating locomotion and mobility in both treatment groups is not likely to be related to suboptimal resting behavior related to space allotment.

In the present study, it is reasonable to conclude that concrete flooring contributed to the pen-level increase in abnormal mobility over time, which was identified in both treatment groups. Although the use of RM does appear to moderate the negative impact of concrete-based flooring, calves in RM pens still showed abnormal locomotion as they neared harvest. It is noteworthy that although trained personnel checked cattle in all study pens for signs of lameness and other maladies at least once a day, calves with LS of 4 or higher were identified in both treatment groups at the end of the feeding period. It is possible that lameness in calves in ICH is more difficult to identify compared to outdoor dirt-lot pens because of the increased cattle density. ICH likely requires more intensive and critical monitoring and management to successfully identify lame and sick cattle.

The cost to purchase rubber flooring is substantial. Quotes for the 3 mat types used in the current study varied from $4.50 to $7.75/sq ft. Each pen in this study was approximately 2,885 sq ft. Thus, depending on the brand, the cost of the mats in this study would range from approximately $12,982.50 to $23,358.75.

Conclusions

As environmental regulations become increasingly restrictive and available land for animal agriculture becomes more scarce, the use of ICH is likely to increase in the US. There is limited data regarding the effect of flooring types used in ICH facilities on health, welfare, and calf comfort, and performance parameters in US beef cattle. The objective of this research was to address this absence of information by investigating potential health and performance differences associated with uncovered concrete slatted flooring and concrete flooring covered with RM in commercial indoor confined beef operations during the finishing phase of production. Management strategies to decrease lameness and support calf comfort and normal locomotion during the finishing phase are important to safeguard cattle health and welfare as well as protect the producer's financial investment. Based on results of this study and other published reports, the use of rubber mats to cover concrete floors in ICH positively impacts beef cattle health, welfare, and comfort during the finishing phase. It seems prudent to consider installing RM over concrete floors in ICH facilities when feeding cattle during the finishing phase. Installation of RM requires a substantial investment of financial resources and labor, which may not result in improvement in performance. Additional studies that include a dirt-lot treatment group for comparison to RM and SCF would further define the usefulness of investing in rubber mats to improve comfort and welfare. Further efforts should be directed to improve flooring systems, explore other flooring surfaces that are environmentally friendly, are financially feasible, and support production efficiency while still providing for adequate welfare, comfort, and health of the cattle housed on it.

Endnotes

[a]Custom Precast Company, 995 Monroe Street NE, Box 640, Cascase, IA

[b]Agromatic Inc., N6989 Rolling Meadows Drive, P.O. Box 29, Fond du Lac, WI

[c]Ani-mat Inc, 395 Rue Rodolphe-Racine, Sherbrooke, QC J1R 0S7, Canada

[d]AGSourcing International Ltd., 6736 Perth Line 17 Kirkton, Ontario N0K 1K0, Canada

[f]Microsoft Excel, 2007. Microsoft Corporation, One Microsoft Way, Redmond, WA

[e]Roll-o-matic. Development Resources of Iowa, 109 Industrial Pkwy S # 12; Strawberry Point, IA

[g]Turnkey Computer Systems, LLC, 6117 Amarillo Blvd. West, Amarillo, TX

[h]SAS Inst. Inc., Cary, NC

Acknowledgements

This research was supported by a grant from the Iowa Livestock Health Advisory Council and a grant from the Iowa Beef Center. The authors thank Dr. Dan Loy for providing expertise and input. Gratitude and appreciation for valuable technical assistance is extended to Mike Schwark, Becky Parsons, Adrian Meyer, Ryan Dutton, Katie Reifschneider, Taylor Disch, Abbey Smith, Michelle Christianson, Jessie Juarez, and Chelsi Birchmier. The authors declare no known conflicts of interest.

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