

**FEEDLOT LAMENESS: INDUSTRY PERCEPTIONS, LOCOMOTION SCORING,
LAMENESS MORBIDITY, AND ASSOCIATION OF LOCOMOTION SCORE AND
DIAGNOSIS WITH CASE OUTCOME IN BEEF CATTLE IN GREAT PLAINS
FEEDLOTS**

by

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B.S., Chadron State College, 2006
DVM, Kansas State University, 2011
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AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Diagnostic Medicine/Pathobiology
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Abstract

In current literature, there is a limited amount of large scale data available demonstrating lameness morbidity in beef cattle feedlots, the subsequent outcomes of individuals exhibiting lameness, the morbidity and mortality of various lameness diagnoses, or the effect of locomotion score at the time of first morbidity and its effect on outcome. In addition, current perceptions of lameness by feedlot industry participants are not known and a reliable locomotion scoring system fit for use in a feedlot setting has not been developed. Consequently, the objectives of this research were three-fold. First, to obtain a baseline of the perception of lameness within the feedlot industry. Second, to develop a functional locomotion scoring system for use in feedlots and to test a training program implementing this locomotion scoring system for inter-rater reliability. Third, determine the association of lameness diagnosis and locomotion score at time of initial lameness diagnosis with case outcome in feedlot cattle and provide beef cattle feedlot lameness morbidity, mortality, and realizer incidence rates due to different lameness etiologies in a large scale, multisite study. One hundred forty-seven consulting nutritionists, veterinarians, and feedlot managers participated in the feedlot cattle lameness survey. The median response of estimated lameness incidence in the feedyard was 2%, with a mode of 1% and a mean of 3.8%. Participants indicated that footrot, injury, and toe abscesses were the most common causes of lameness.

A locomotion scoring system was developed to clinically assess locomotion of beef cattle. The scoring system consisted of 4 categories: normal movement (0), slightly affected gait (1), obviously shortened stride or bobbing of head (2), and reluctance to move or apply weight to the limb while walking or standing (3). A total of 50 commercial feedlot employees and agricultural students were trained to use the scoring system in either English or Spanish. The scoring system

was tested for inter-rater agreement and rater agreement against a cooperative standard based on consensus score by a team of individuals involved in the development of the scoring system, which included beef cattle veterinarians and welfare experts. Intra-class correlation coefficient (ICC) and Fleiss's kappa were used to evaluate inter-rater agreement and rater agreement against the cooperative standard. Inter-rater agreement using ICC was 0.85 (95% CI; 0.75 to 0.93) while the mean kappa value was 0.52 (moderate agreement). Rater agreement with the cooperative standard resulted in mean kappa value of 0.64 (substantial agreement). A dynamic population longitudinal study with an initial study population of 245,494 head of feedlot cattle, with 524,780 animal arrivals and 527,220 animal departures recorded over the 12-month study was conducted over a year by trained personnel in six participating feedlots located in Kansas and Nebraska. Lameness morbidity incidence was 1.04 cases per 100 animal-years; lameness mortality was 0.397 cases per 100 animal-years. Cattle locomotion score (LMS; scale of 0 to 3 at time of initial diagnosis) were LMS1(22% of lameness cases), LMS2 (31%), and LMS3(22%). 24% of the lameness cases were not assigned a locomotion score (NS). Mortality risks were greatest for LMS3 (33.0%) and NS (31.3%), and were least for LMS1 (10.0%) with LMS2 (19.1%) being intermediate ($P < 0.05$).

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Table of Contents

List of Figures	xi
List of Tables	xiii
Acknowledgements.....	xv
Dedication.....	xvii
Chapter 1 - Review of Literature and Justification for Research.....	1
Lameness prevalence and incidence in the feedlot.....	1
Animal welfare	3
Locomotion scoring.....	4
Conclusion	6
LITERATURE CITED.....	7
Chapter 2 - Perception of lameness management, education, and effects on animal welfare of beef cattle in the feedlot by consulting nutritionists, veterinarians, and feedlot managers ...	10
Abstract.....	10
INTRODUCTION	11
Materials and Methods.....	12
Survey Participants	12
Data Collection	12
Survey Questions	13
Data Analysis	13
Results and Discussion	13
General Information.....	13
Feedlot Health and Lameness	14
Diagnosis and Causes of Feedlot Lameness	15
Contributing factors	16
Education and recommendations	17
Economics.....	18
Discussion.....	19
Implications	21
Literature Cited.....	21

Chapter 3 - Evaluation of inter-rater reliability of a locomotion scoring system for use in beef	
cattle.....	36
ABSTRACT.....	36
INTRODUCTION	37
MATERIALS AND METHODS.....	38
Locomotion scoring system	38
Video recording	39
Rater training	40
Rater testing	40
Statistical analysis	41
RESULTS	41
Inter-rater agreement.....	41
Agreement between raters and the cooperative standard.....	42
Prevalence of score, mean, range.....	42
DISCUSSION.....	42
LITERATURE CITED.....	45
Chapter 4 - Lameness morbidity and association of locomotion score and diagnosis with case	
outcome in beef cattle in Great Plains feedlots.	53
Abstract.....	53
Abbreviations.....	54
INTRODUCTION	54
MATERIALS AND METHODS.....	55
Animals	56
Study Design.....	56
Data Collection	58
Statistical Analysis.....	58
RESULTS	59
Lameness morbidity.....	59
Mortality associated with lameness	59
Incidence of animals shipped for early salvage harvest.....	60
Retreatment rate	61

Locomotion score.....	61
Season	62
DISCUSSION.....	62
LITERATURE CITED	68
Appendix A - Questions for Consulting Nutritionists, Veterinarians, and Managers	84

List of Figures

Figure 2-1 . Percentage of 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012 by cattle head count of the yards they manage or predominantly consult.....	23
Figure 2-2. Percentage of beef cattle housed in feedlots that experience lameness as estimated by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012 reported as mean, median, and mode of responses.....	24
Figure 2-3. Percentage of beef cattle housed in feedlots experiencing lameness that require treatment as estimated by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.	25
Figure 2-4. Percentage of mortality of beef cattle housed in feedlots as estimated by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012 reported as mean, median, and mode of responses.	26
Figure 2-5. Percentage of mortality in feedlot cattle attributed to bovine respiratory disease, digestive disorders, lameness, and other causes by participants as estimated by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.....	27
Figure 2-6. Percentage of feedlot chronic/railer loss attributed to bovine respiratory disease, digestive disorders, lameness, and other causes as estimated by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.	28
Figure 2-7. The three most common causes of lameness in feedlot cattle as identified by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.....	30
Figure 2-8. Sources of information utilized by feedlot managers to make decisions on lameness management of beef cattle identified by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012. (Allowed to select more than one response)	32
Figure 2-9. Perceptions of feedlot cattle lameness as an animal welfare concern by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.....	33

Figure 2-10. Tools that would be most helpful in better managing lameness in the feedyard identified by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012..... 34

Figure 2-11. Economic loss per head of cattle that exhibit lameness in the feedyard and go untreated and of cattle treated as estimated by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012..... 35

Figure 4-1. Diagnostic algorithm utilized for lameness diagnoses for cattle identified with lameness morbidity across 6 U. S. feedlots over a single 12-month period 71

List of Tables

Table 2-1. Pen level diagnosis criteria utilized in the feedlot production to identify lameness morbidity and subsequent treatment by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.	29
Table 2-2. Most common contributing factors for the development of lameness in beef cattle housed in feedlots identified by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012. (% of respondents, respondents allowed to select up to 4)	31
Table 3-1. Clinical description of corresponding locomotion scores	48
Table 3-2. Percentage of raters (n=50) within levels of agreement between raters and “cooperative standard” as measured by Fleiss’s Kappa statistic with levels of agreement as described by Landis and Koch (1977)	49
Table 3-3. Agreement between raters using Intra-class correlation coefficient and Fleiss’ kappa evaluated as all raters (ALL), agricultural students (AS), and commercial feedlot employees (FE).	50
Table 3-4. Mean, median, and range of rater responses by locomotion score.....	51
Table 3-5. Prevalence of rater responses by locomotion score.....	52
Table 4-1. Clinical description of corresponding locomotion scores for cattle identified with lameness morbidity across six U.S. feedlots over a single 12-month period.....	70
Table 4-2. Lameness diagnoses available for selection for individual animals with lameness morbidity across six U. S. feedlots over a single 12-month period based on diagnostic algorithm	72
Table 4-3. Outcome of individuals diagnosed with specific lameness diagnoses at the time of initial lameness morbidity in cattle across six U.S. feedlots over a single 12-month period	73
Table 4-4. Days on feed at initial lameness morbidity diagnoses for individual animals across six U.S. feedlots over a single 12-month period.....	74
Table 4-5. Incidence of lameness-associated mortality by diagnoses in feedlot cattle (cases per 100 animal-years) across six U.S. feedlots over a single 12-month period.....	75

Table 4-6. Days on feed of initial morbidity event (FDO), treatment to death interval (TDI), and days on feed of mortality occurred for individual animals diagnosed as having lameness morbidity and subsequently dying across six U.S. feedlots over a single 12-month period	76
Table 4-7. Mortality rate for diagnoses at time of initial morbidity for cattle across six U.S. feedlots over a single 12-month period (%).....	77
Table 4-8. Realizer rate (cattle which are transported to harvest prior to their pen mates) for diagnoses at time of initial morbidity for cattle across six U.S. feedlots over a single 12-month period (%)	78
Table 4-9. Gross outcome and percentage of outcomes (in parenthesis) by locomotion score (1, 2, 3, or no score (NS)) at the time of initial lameness diagnosis for individual animals with lameness morbidity across six U.S. feedlots over a single 12-month period.....	79
Table 4-10. Mortality rate for locomotion score (LMS) at initial diagnosis for individual animals with lameness morbidity across six U.S. feedlots over a single 12-month period (%)	80
Table 4-11. Realizer rate (animals transported to harvest prior to pen mates) for locomotion score at time of initial diagnosis for individual animals with lameness morbidity across six U.S. feedlots over a single 12-month period (%).....	81
Table 4-12. Mortality rate by season of initial lameness diagnosis for individual animals having been previously diagnosed with lameness morbidity across six U.S. feedlots over a single 12-month period (%).....	82
Table 4-13. Realizer (animals transported to harvest prior to pen mates) rate by season of initial lameness diagnosis for individual animals with lameness morbidity across 6 U. S. feedlots over a single 12-month period (%)	83

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Dedication

This dissertation is dedicated to my wife Kelly and son Clay. I am proud to be your husband and father and look forward to the journeys we will share together.

Chapter 1 - Review of Literature and Justification for Research

Lameness in feedlot production systems is noted to affect the performance of animals, the health outcomes of individuals diagnosed with various diseases resulting in lameness, and is an important factor in the welfare of moribund animals in the feedlot setting.

Lameness prevalence and incidence in the feedlot

Relatively few studies have reported lameness incidence on a large scale. Griffin *et al.*¹ reported lameness incidence across multiple causes of lameness in a data review of feedlot health records that represented 1,843,652 animals. In total, they reported that 13.1% of cattle encompassed in the review were treated for health problems while in the feedlot. Of all those treated, 16% were associated with lameness, corresponding to a lameness morbidity of 2.09%. Additionally, lameness accounted for 5% of feedlot mortalities and 70% of cattle sold for salvage slaughter, although total mortality and salvage slaughter rates were not reported. When separated into individual causes of lameness, Griffin *et al.* reported approximately 70% of lameness morbidity were diseases of the feet, including toe abscesses, mechanical injury in the foot, and infectious footrot. Upper skeletal or major muscle injuries accounted for 15% of morbidity, septic joints accounted for 12%, and injection site lesions represented 3% of lameness morbidity. At the time of the report, the authors suggested the total loss due to lameness was \$3.36 per head in the feedyard. Unfortunately, the omission of mortality and salvage slaughter reporting in this dataset limits the ability to accurately estimate the current value if similar results were found today.

Tibbetts *et al.*² conducted a review of data from the U.S. Meat Animal Research Center feedlot over seven years to determine the impact of footrot on performance in feedlot steers. The authors reported a 6.5% infectious footrot morbidity cumulative incidence. The annual footrot

morbidity incidence over the seven years reviewed ranged from 0.75% to 13.3%. When separated into feeding periods, there was 1.06% footrot morbidity in the starting phase (0-60 days on feed), 3.03% footrot morbidity in the growing phase (61-120 days on feed), and 2.38% footrot morbidity in the finishing phase (121 or greater days on feed). There were no statistical differences between the location of the footrot by individual limb or by front or rear anatomical location. The authors reported that steers diagnosed with footrot at any point in the feeding period had a significantly decreased average daily gain (ADG) (0.017 kg) and a statistically longer feeding period (4.8 days) than steers not diagnosed with footrot. The effect on decreased ADG was greatest when steers were first treated for footrot in the finishing phase (greater than 121 days on feed), with a 0.49 kg decrease in ADG and 14.3 days increase in days on feed.

Other researchers have measured the effect of processing on lameness prevalence. Green *et al.*³ monitored the prevalence of lameness pre-processing and post-processing and also reported lameness morbidity incidence for four lameness categories at a single feedlot during the early phase of the feeding period. A total of 3,243 steers were evaluated for lameness prior to processing, at which time lameness prevalence was 1.6%. Comparatively, lameness prevalence was significantly greater ($P=0.02$) immediately post processing at 2.5%. Forty-four percent of cases resolved within 1 week, 66% had resolved within 2 weeks, and 75% had resolved within 3 weeks post-processing. Medical history and performance of individual animals were monitored through the first 100 DOF. The total incidence of lameness morbidity was 3.70%. Footrot was diagnosed in 0.15% of animals, 1.94% were diagnosed as bullers, 1.39% were diagnosed as musculoskeletal, and 0.22% were diagnosed with arthritis. Cattle diagnosed with lameness had a numerically decreased ADG (3.41 lb./day versus 3.60 lb./day), although though this was not

considered significant (P=0.11). This research is an important snapshot of the effect processing cattle can have on lameness occurrence in feedlot cattle, although it is limited as by demonstrating the effects through a single facility with a single processing crew. Repeating this in multiple facilities would be valuable and is warranted.

Other large scale assessments of lameness prevalence, morbidity, or mortality in the feedlot are scarce. However, Aloha *et al.*⁴ surveyed the incidence of quality deficits, including lameness, in western U.S. auction markets in beef cows, beef bulls, dairy cows, and dairy bulls with 23,479 animals represented. Of the beef cows and beef bulls sold at livestock auction markets in the western United States, 15.1 and 15.4%, respectively, had some degree of lameness using a 1 to 5 locomotion score, with a locomotion score of 2 or greater considered abnormal. In beef cows, 0.26% were considered to have a foot abnormality, 0.39% were sore at the hip, 0.01% were sore at the hock, and none were considered sore at the knee. Similarly, 0.68% of beef bulls were considered to have a foot abnormality and 0.19% were sore at the hip, while none were sore at the hock or sore at the knee. These data indicate adult cattle sold at slaughter have much more lameness associated with locations above the foot than in the feedlot setting, but more intensive investigation of the lesions may affect the number of cattle classified as diseases of the upper limb.

Animal welfare

Lameness morbidity and its effect on hospital populations, downed or moribund animals, and feedlot mortality make it an area of discussion when considering welfare of feedlot cattle.

Helenski *et al.*⁵ surveyed veterinary school faculty members in the U.S. and asked them a series of questions pertaining to animal welfare. The faculty members ranked animal industries in

order of need to make substantial changes in animal welfare. Those surveyed ranked beef below dairy, swine, meat birds, and layers (in most need) but above sheep (in least need). Greater than 70% of the faculty members believed at least minor changes were required in the beef production system in relation to animal welfare. However, the same number of participants believed the predominant methods used to produce beef animals provide an appropriate level of animal welfare.

The perceived impact of lameness by feedlot industry participants has not previously been described. The dairy industry, however, has demonstrated that lameness prevalence within their facilities has been underestimated by its farmers. Whay *et al.*⁶ surveyed dairy farmers in the United Kingdom and requested they estimate a mean lameness prevalence within their farms. The farmers estimated a prevalence of 5.73%. Following the farmer's estimation, an independent observer assessed the cattle for clinical lameness (animals classified as lame or severely lame) and found a prevalence of lameness to be 22.11% in 53 dairy farms. Similarly, Wells *et al.*⁷ found that farmers in Minnesota and Wisconsin underestimated lameness prevalence in their dairies, with investigators finding a 2.5 times greater lameness prevalence versus the farmer's estimation.

Locomotion scoring

Locomotion scoring has been demonstrated as a useful tool for determination of current status of groups of cattle lameness prevalence and for evaluation of individual animals. It has not been utilized on a large scale in the beef industry, but has been used to a greater degree in the dairy industry. Locomotion scoring has the potential to be a great tool for determination of the timing

of intervention feedlot settings, for evaluation of outcomes by locomotion score, and as an aid training animal caregivers to identify lame individuals.

One of the first locomotion scoring systems was described by Manson and Leaver⁸ for use in dairy cattle systems. Mason and Leaver employed a 1 through 5 scoring system, with scores in 0.5 point increments. A simplified 5-point system was developed that focused on gait and arch of the back by Spreacher *et al.*⁹. In this system, cattle are monitored for posture while standing and while walking to make an assessment of lameness. This system can be useful in a dairy system, in which cattle movement is consistent and cattle can be scored easily pre-milking or post-milking, but can be a challenge with less consistent movement in a feedlot setting.

Breuer *et al.*¹⁰ evaluated the interaction between commercial dairy cows and human handlers. The researchers developed a locomotion scoring system to use as one of the parameters to assess human handler and cow interaction. This system utilized a 0 through 3 scoring system. This scoring system focused on head movement (“head bob”) and the presence of a limp as important elements of classification. This simplified system provided a tool more friendly to use in a less controlled environment, such as a feedlot.

Other industries are also assessing the usefulness of locomotion scoring. D’Eath¹¹ evaluated the inter-observer reliability and consistency of raters over time for a 0 through 5 locomotion score. In this system, researchers focused on stride length, posture, weight bearing, and willingness to move. Main *et al.*¹² developed a locomotion score for scoring finishing pigs. This system had multiple levels of characteristics to identify locomotion score for pigs, including initial response

to human presence, response after opening the gate, behavior of the individual within the group, standing posture, and gait.

An effective locomotion scoring system for widespread use for beef cattle in a feedlot setting would have to be able to assess cattle in fluid movement, likely alongside other animals, in a short amount of time, and in a limited number of steps.

Conclusion

In comparison to other major classifications of feedlot health morbidity and mortality, such as respiratory disease and metabolic diseases, lameness is an area in which less research time and resources have been committed. This is largely due to the greater overall impact of respiratory and metabolic diseases on feedlot health and profitability. Additional challenges for focusing time and effort on lameness disease research includes the many causes of lameness in the feedlots, the sporadic nature of many primary causes of lameness, and less motivation for industry partners to invest in large scale research. However, many changes in the industry may drive increased attention to lameness in feedlots. With ever growing consumer attention to the welfare of animals, appropriate management of long-term hospital cattle and correct management to prevent lameness is of growing importance. Additionally, with increased input costs coupled with beef market instability, increased efficiencies and improved health outcomes drive improved profitability as much as ever.

Currently, there is limited large scale data demonstrating feedlot lameness morbidity and mortality in the feedlot due to various lameness diagnoses or the effect of locomotion score at the time of

first morbidity and its effect on outcome. In addition, a survey to understand current perceptions of lameness by feedlot industry participants has not previously been conducted. Nor has a reliable locomotion scoring system fit for use in a feedlot setting been developed as has been developed in dairy or in other protein producing industries. Consequently, the objective of this research is three-fold. First, to obtain a baseline of the perception of lameness within the feedlot industry and provide insight into potential management factors that participants perceived as important to the management of lameness. Second, to develop a functional locomotion scoring system for use in the feedlot and to test a training program implementing this locomotion scoring system for inter-rater reliability. Third, determine lameness morbidity and the association of locomotion score and diagnosis with case outcome in a large-scale, multiple location study.

LITERATURE CITED

- ¹Griffin, D., L. Perino, and D. Hudson. 1993. Feedlot lameness. University of Nebraska Neb-Guide. Lincoln, NE.
- ²Tibbetts, G.K., T. M. Devin, D. Griffin, *et al.* 2006. Effects of a single foot rot incident on weight performance of feedlot steers. *Prof. Anim. Sci.* 22:450–453.
- ³Green, T.M., P.T. Guichon, D. U. Thomson, *et al.* 2012. Time of onset, location, and duration of lameness in beef cattle in a commercial feedyard. Kansas State University. Agricultural Experiment Station and Cooperative Extension Service Report of Progress # 1065. pp 21-24.

- ⁴Ahola, J. K., A. Foster, D. L. VanOverbeke, *et al.* 2011. Survey of quality defects in market beef and dairy cows and bulls sold through livestock auction markets in the Western United States: I. Incidence rates. *J. Anim. Sci.* 89:1474-1483
- ⁵Heleski, C. R., A. G. Mertig, A. J. Zanella. 2005. Results of a national survey of US veterinary college faculty regarding attitudes toward farm animal welfare. *JAVMA.* 226(9): 1538-1546.
- ⁶Whay, H.R., D.C.J. Main, L.E. Green, *et al.* 2002. Farmer perception of lameness prevalence. In *Proc. 12th International Symposium on Lameness in Ruminants*, pp. 355-358. Orlando, Florida.
- ⁷Wells, S.J., A.M. Trent, W.E. Marsh, *et al.* 1993. Prevalence and severity of lameness in lactating dairy cows in a sample of Minnesota and Wisconsin herds. *JAVMA* 202(1):78-82.
- ⁸Sprecher, D. J., D. E. Hostetler and J. B. Kaneene. 1997. A lameness scoring system that uses posture and gait to predict dairy cattle reproductive performance. *Theriogenology.* 47: 1179-1187.
- ⁹Breuer, K., P. H. Hemsworth, J. L. Barnett, *et al.* 2000. Behavioural response to humans and the productivity of commercial dairy cows. *Appl. Anim. Behav. Sci.* 66:273-288.
- ¹⁰Manson, F. J. and J. D. Leaver. 1988. The influence of concentrate on locomotion and clinical lameness in dairy cattle. *Anim. Prod.* 47:185-190.
- ¹¹D'Eath, R.B. 2012. Repeated locomotion scoring of a sow herd to measure lameness: consistency over time, the effect of sow characteristics and inter-observer reliability. *Anim. Behav.* 21:219-231.

¹²Main, D.C. J., J. Clegg, A. Spatz, *et al.* 2000. Repeatability of a lameness scoring system for finishing pigs. *Vet. Rec.* 47:185-190.

Chapter 2 - Perception of lameness management, education, and effects on animal welfare of beef cattle in the feedlot by consulting nutritionists, veterinarians, and feedlot managers

Abstract

Consulting nutritionists (CN; n=37), consulting veterinarians (CV; n=47) and feedlot managers (YM; n=63) from the United States and Canada participated in the feedlot cattle lameness survey. The majority of the participants either manage or consult open air, dirt floor feedyard facilities (98.4%). Participants were directed to an online survey to answer questions pertaining to the incidence, management, perception, and economics of feedlot lameness. The median response of estimated lameness incidence in the feedyard was 2%, with a mode of 1% and a mean of 3.8%. Eighty-one percent of the survey participants estimated the contribution of lameness to total feedyard mortality as less than 10%. In comparison, 64% of participants estimate the contribution of lameness to the overall chronic and realizer loss in the feedyard to be less than 10%. Forty-one percent of participants believed that 50% or greater of the cattle suffering from lameness require treatment. Participants indicated that footrot (42% of participants), injury (35% of participants), and toe abscesses (10% of participants) were the most common causes of lameness. The major contributing factors associated with non-infectious causes of lameness, such as upper limb injuries, toe abscesses or ulcers, and lacerations include cattle handling before and after arrival, pen surface condition, and cattle temperament. Important contributing factors identified for infectious causes of lameness, such as footrot, included pen surface and condition, cattle handling prior to arrival, and weather. Lameness was considered an

animal welfare concern by 58% of participants. This survey has provided insight into the perception of lameness and potential management factors which contribute to lameness through the perspective of multiple participants in feedlot cattle production systems.

Key words: animal health, animal welfare, beef cattle, feedlot, lameness

INTRODUCTION

Increased production costs associated with an increase in the cost of feedstuffs has made animal health and production efficiency increasingly important to the feedlot beef industry. Currently, Bovine Respiratory Disease (BRD) is identified as the most costly disease in the feedlot industry and thus it is widely researched (Smith, 1998). Conversely, lameness in the feedlot is not as well-researched, although lameness has been reported to account for 16% of all feedlot health problems (Griffin et. al., 1993). Feedlot health costs associated with lameness include the cost of treatment, death loss, and loss due to chronic animals or realizer sale (Griffin et. al., 1993). The costs associated with lost performance may be the most impactful. Research has reported that footrot decreases performance in feedlot cattle, Tibbetts et al., 2006). Tibbetts et al. demonstrated a decrease of 0.049 kg in average daily gain (ADG) in steers diagnosed with footrot in the finishing phase (121 days on feed until harvest), along with an average of 14.3 additional days on feed for those animals.

Lameness has animal welfare implications. Other meat and protein production industries, such as the dairy industry, have identified lameness as a major factor influencing animal welfare (Heleski et. al., 2005). The potential impact of lameness on cattle comfort and overall welfare, along with health and performance, drives the need to better understand the diseases causing lameness and their pathogenesis.

There has not been a study conducted to understand the beef feedlot industry members' perceptions of lameness and its effects on health and welfare within the feedlot industry. A survey of feedlot industry professionals, including consulting veterinarians, consulting nutritionists, and feedyard managers was completed to identify management causes of lameness, common treatment practices for lameness, diagnostic philosophies for lameness, and to pinpoint areas of focus for future research and education.

Materials and Methods

Survey Participants

Feedyard managers (YM), consulting veterinarians (CV), and consulting nutritionists (CN) were contacted for participation in this study based on their participation in professional organizations. Sixty-three YM, 47 CV, and 37 CN participated in the survey. Consulting veterinarians were contacted through the Academy of Veterinary Consultants' and American Association of Bovine Practitioners' respective email list-serves. Through email, the veterinarians were asked to participate and were provided an html link to access the survey online. Feedlot managers and CN were identified through industry mailing lists and contacted individually by mail that encouraged participation and provided a URL to access the survey online. Approval was granted by the Kansas State University Institutional Review Board (#5971) to conduct this survey.

Data Collection

Data were collected using a web based survey system through Kansas State University (Axio Online, K- State Survey Services, Manhattan, KS). All participants completed the survey through the URL provided.

Survey Questions

The survey consisted of 24 questions covering general information (n=3), feedlot health and lameness (n=5); diagnosis, treatment, and causes of feedlot lameness (n=6); contributing factors of lameness (n=2); education and recommendations (n=6); and the economics of feedlot lameness (n=2). (Appendix A)

Data Analysis

Data collected via the web-based survey system were downloaded into Excel® (Microsoft, Redmond, WA) for data summarization and statistical analysis. Answers given as ranges, i.e. 10 to 15%, were reported as a calculated average for summary statistics and analysis. The mean, mode, median, and number of responses from the survey were calculated using Microsoft Excel.

Results and Discussion

General Information

A total of 147 feedlot industry members participated in the survey. Of these participants, 63 were feedyard managers (YM), 47 were consulting veterinarians (CV), and 37 were consulting nutritionists (CN). Eleven percent of participating YM managed yards with a one-time capacity of 0 to 4,999 cattle, 36.5% of YM managed yards with a one-time capacity of 5,000 to 20,000 cattle, and 52.4% of YM managed yards with a one-time capacity greater than 20,000 cattle (Figure 1). Sixty-two (98.4%) of the participating YM manage primarily open air, dirt floor type facilities while 1 (1.6%) YM manage primarily confinement barns with slatted floors. Forty (85.1%) CV consult primarily open air, dirt floor facilities, and 7 (14.9%) CV consult primarily confinement barns with slatted floors. Thirty-three (89.2%) CN consult primarily open air, dirt

floor facilities, 1 (2.7%) CN consult primarily confinement barns with slatted floors, and 3 (8.1%) CN consult primarily confinement barns with deep bedding.

Feedlot Health and Lameness

Participants were asked a series of questions about their perceptions of feedlot health and specifically about the impact of lameness on overall health. Participants were asked what percent of feedlot cattle they thought suffered from lameness. The median estimated lameness incidence from all participants was 2.0%. When separated by professional group, the median estimated lameness incidence was 2.0% by YM, 3.0% by CV, and 3.0% by CN (Figure 2). The participants were then asked what percentage of cattle suffering from lameness require treatment, with response ranges of 0 to 10%, 11 to 25%, 26 to 50%, or above 50% (Figure 3). Twenty-four (16.3%) participants responded 0 to 10%, 27 (18.4%) participants responded 11 to 25%, 35 (23.8%) participants responded that 26 to 50%, and 59 (40.1%) participants responded that greater than 50% of cattle suffering lameness require treatment. Two (1.4%) of the participants responded they did not know what percentage of cattle required treatment.

Participants were asked to report the average death loss for all causes in their feedlot or in the feedlots they consult. The median response when estimating average death loss for all participants was 1.25%. When separated into professional fields, YM had a median response of 1.0% while both CV and CN had a median response of 1.5% (Figure 4).

Participants responded as to what percentage range of chronic or realizer and mortality losses in the yards they manage or consult is due to each of four categories; BRD, digestive disorders, lameness, or other causes (Figures 5 and 6). The majority of respondents (81.0%) estimated the 0-9% of feedlot mortality was associated with lameness while 36.7% of respondents estimated

0-9% of feedlot chronic and realizer loss were associated with lameness. Another 38% of respondents estimated chronic realizer loss associated with lameness to be 10 to 29%.

Diagnosis and Causes of Feedlot Lameness

There are not well-defined standards of practice within the feedlot industry for the diagnosis of lameness, both within the pen or when confined in a chute. A series of questions were asked to better understand the tools that are utilized at the feedlots to diagnose lameness, along with perceptions of what lesions are most commonly diagnosed within the feedlot.

Participants were asked what criteria were used to identify a lame animal that subsequently requires treatment for its injury or disease at the pen level (Table 1). Sixty (40.8%) of the participants responded that all cattle found lame in the home pen required further diagnosis and potential treatment. Forty (27.2%) participants responded that cattle with lameness along with depression and apparent significant pain needed to have further diagnostic and treatment follow-up. Twenty-seven (18.4%) participants responded that cattle with lameness along with decreased performance are removed from their home pen for further evaluation and potential treatment. Twenty (13.6%) participants responded that no set protocol was utilized.

Participants identified the diagnosis that is the most common cause of lameness in feedlot cattle, which diagnosis was the second most common cause, and which was the third most common cause (Figure 7). Among all respondents, 62 (42.2%) selected footrot as the most common diagnosis, 52 (35.4%) selected injury, 14 (9.5%) selected toes abscesses or ulcers, 11 (7.5%) selected laminitis, 6 (4.1%) selected sole bruises/ulcers, 1 (0.7%) selected hairy heel wart (Digital Dermatitis), and 1 (0.7%) listed other causes.

To better understand how cattle were diagnosed with different causes of lameness, participants were asked what tools were utilized at the chute to help diagnose the appropriate cause of lameness. Participants were allowed to select all answers that applied to the yard or yards they manage or consult. Sixty-five (44.2%) participants responded that palpation of the foot, joints, and upper leg for swelling and heat was utilized for lameness diagnosis. Eighty-five (57.8%) participants responded that picking up the foot to view the bottom of the foot was used for diagnosing lameness in the chute. Twenty-eight (17.2%) participants responded that picking up the foot and using hoof testers was utilized for diagnosis. Finally, 130 (88.4) participants indicated visualization of the foot, joints, and upper leg for swelling was utilized to diagnose the cause of lameness at the chute including 56 (88.9%) YM, 41 (87.2%) CV, and 33 (89.2%) CN. Similarly, participants were asked what treatments were implemented in the feedlot or feedlots they manage or consult. One hundred and forty-two (96.6%) participants responded injectable antibiotics were implemented as a treatment. Conversely, only 70 (42.9%) participants responded that corrective trimming, opening of abscesses, or removing of sole ulcers or bruises were implemented as a treatment. Topical treatments (listed as antimicrobials, copper sulfate, etc.) were implemented in the feedlots of 57 (35.0%) participants.

Contributing factors

To gain a better understanding of factors that can potentially be managed to better control cattle lameness in the feedlot industry, participants were asked to identify the four most important contributing factors for each category (infectious and non-infectious causes of lameness). The most common contributing factors for infectious causes of feedlot cattle lameness identified by all survey participants (Table 2) were, in order of importance, pen conditions (125 responses,

85.0%), pen surface (83 responses, 56.5%), weather patterns (67 responses, 45.6%), and cattle handling before arrival (51 responses, 34.7%). The remaining contributing factors were cattle handling after arrival (42 responses, 28.6%), nutrition (41 responses, 27.9%), cattle temperament (35 responses, 23.8%), cattle type (23 responses, 15.6%), insufficient preconditioning nutrition program (19 responses, 12.9%), breed (14 responses, 9.5%), and cattle age (7 responses, 4.8%). The four most common contributing factors for non-infectious causes of feedlot cattle lameness identified by all survey respondents (Table 2) were cattle handling after arrival (99 responses, 67.3%), cattle temperament (96 responses, 65.3%), cattle handling before arrival (94 responses, 63.9%), and pen conditions (85 responses, 57.8%). The remaining contributing factors were pen surface (61 responses, 41.5%), nutrition (37 responses, 25.2%), weather patterns (29 responses, 19.7%), cattle type (17 responses, 11.6%), insufficient preconditioning nutrition program (13 responses, 8.8%), breed (12 responses, 8.2%), and cattle age (10 responses, 6.8%).

Education and recommendations

Participants were asked to identify from what sources they receive lameness prevention information (Figure 8). Sixty-one (96.8%) YM received information about lameness prevention from a veterinarian, 45 (71.4%) from a nutritionist, 13 (20.6%) from training seminars, 11 (17.5%) feed or mineral companies, 9 (14.3%) from magazines, 7 (11.1%) from the internet, and 5 (7.9%) from other producers. Seventeen (36.2%) CV received information about lameness prevention from nutritionists, 16 (34.0%) from training seminars, 10 (21.3%) from feed or mineral companies, 8 (17.0%) from the internet, 8 (17.0%) from magazines, and 1 (2.1%) from the local feed store. Twenty-two (59.5%) CN received lameness prevention information from

feed or mineral companies, 17 (45.9%) from training seminars, 17 (45.9%) from a veterinarian, 10 (27.0%) from the internet, and 2 (5.4%) from magazines.

Impressions about lameness, its impacts and animal welfare implications were varied. A larger percentage of CV (93.6%) felt more work needs to be done to improve understanding about lameness as compared to 70.3% of CN and 81.0% of YM. Similarly, 95.7% of CV considered lameness to be a welfare concern or a growing welfare concern, as compared to 73.0% of CN and 66.7% of YM. (Figure 9)

Participants were asked what tools would most help them to better manage feedlot lameness in cattle (Figure 10). Twenty-eight (44.4%) YM, 10 (21.3%) CV, and 12 (32.4%) CN identified new therapies as a tool that would most help them manage lameness in the feedlot. Assistance with employee training was selected by 20 (31.8%) YM, 14 (29.8%) CV, and 9 (24.3%) CN. Eight (12.7%) YM, 14 (27.7%) CV, and 9 (24.3%) CN believed assistance with facility design would most likely help them manage lameness. Only 2 (3.2%) YM, 5 (10.6%) CV, and 3 (8.1%) CN believed improved nutrition would be of the most help to manage lameness. Finally, 5 (7.9%) YM, 5 (10.6%) CV, and 4 (10.8%) CN listed other tools as most helpful in improving lameness management. Some of the other suggestions included improving facilities and development of vaccination programs for prevention.

Economics

Economic costs associated with feedlot lameness are not well defined. Survey participants were asked to estimate the economic losses associated with lameness in the feedlot for affected cattle that go untreated and for cattle that are lame and are treated for lameness (Figure 11). Two (13.6%) participants estimated no economic losses, 27 (18.4%) participants estimated \$1 to \$50,

27 (18.4%) participants estimated \$51 to \$100, 32 (21.8%) participants estimated \$101 to \$200, and 31 (21.1%) participants estimated greater than \$200. Twenty-eight (19.0%) participants responded that they did not know the economic cost of untreated lameness.

Participants similarly estimated the economic loss per affected animal that is treated for lameness. One (0.7%) participant responded that there was no economic loss, 59 (40.1%) responded \$1 to \$50, 41 (27.9%) responded \$51 to \$100, 13 (8.8%) responded \$101 to \$200, and 8 (5.4%) responded greater than \$200. Twenty-five participants responded they did not know what is the economic loss associated with animals treated for lameness. (Figure 11)

Discussion

Understanding the perceived impact of lameness within the feedlot industry can lay groundwork for further investigation of the influence lameness has on health and welfare outcomes in meat and production industries. Previously, lameness prevalence has been underestimated in the dairy industry; dairy farmers in the United Kingdom estimated a mean lameness prevalence of 5.73% with an actual clinical lameness (animals classified as lame or severely lame) of 22.11% in 53 dairy farms (Whay et. al., 2002). Of the beef cows and beef bulls sold at livestock auction markets in the western United States 15.1 and 15.4%, respectively, had some degree of lameness (Ahola et. al., 2011).

The data available for estimating lameness in the feedyard typically reports incidence over the feeding period as opposed to prevalence rates as illustrated in most dairy data. In this survey, the mean estimate for the lameness incidence was 3.8% and the median estimate was 2%. A seven-year analysis of a single feedlot in Nebraska indicated a footrot incidence of 6.46% for calves fed an average of 262 days (Tibbets et. al., 2006). Consequently, cattle diagnosed with footrot were

on feed for an average of 5 days longer and had a decreased ADG of 0.02 kg. In a similar data review of over 1.8 million cattle, 13.1% of cattle experienced health problems in the feeding period, with 16% of the health problems associated with lameness (Griffin, 1993). This would indicate an approximate 2.1% lameness incidence over the feeding period.

Animal welfare is a relevant issue within the animal protein production industries and among consumers. Veterinary school faculty members in the U.S. ranked beef below dairy, swine, meat birds, and layers (in most need) but above sheep (in least need) when animal industries were ranked by need of substantial welfare related changes (Heleski et. al. 2005). However, over 70% of the faculty members believed at least minor changes were required in the beef production system in relation to animal welfare. With 78% of industry members that participated in our survey considering lameness as a concern or growing concern for animal welfare in feedlot industry, improving lameness in the feedyard could be an opportunity to make positive changes to improve the beef production system.

For improvement to be made with regard to lameness in the feedyard, targeting specific causes of lameness and contributing factors is necessary. Footrot, injury, and toe abscesses appear to be considered the most common causes of lameness (Miskimins 2002; Van Metre et. al. 2005). The major contributing factors associated with lameness as identified in this survey, include cattle handling before and after arrival, pen surface and condition, cattle temperament, and weather. Some strategies to prevent lameness have been identified, but improvement is necessary (Stokka et. al., 2001; Van Metre et. al., 2005). Targeting important contributing factors along with further research to identify means of prevention, diagnosis, and treatment of lameness are important steps for more efficient beef production practices and improved animal welfare.

Implications

This survey provides a background of what views are currently held by the feedlot industry members with regard to the influence of lameness to industry economics, animal health, and animal welfare. The impact of lameness on cattle comfort and overall welfare are other driving factors in need of further research. It is essential that the beef industry continue working toward a better understanding of the effects of lameness within the feedlot.

Literature Cited

- Ahola, J. K., A. Foster, D. L. VanOverbeke, K. S. Jensen, R. L. Wilson, J. B. Glaze Jr., T. E. Fife, C. W. Gray, S. A. Nash, R. R. Panting, and N. R. Rimbey. 2011. Survey of quality defects in market beef and dairy cows and bulls sold through livestock auction markets in the Western United States: I. Incidence rates. *J. Anim. Sci.* 89:1474-1483
- Ahola, J. K., A. Foster, D. L. VanOverbeke, K. S. Jensen, R. L. Wilson, J. B. Glaze Jr., T. E. Fife, C. W. Gray, S. A. Nash, R. R. Panting, and N. R. Rimbey. 2011. Quality defects in market beef and dairy cows and bulls sold through livestock auctions in the Western United States: II. Relative effects on selling price. *J. Anim. Sci.* 89: 1484-1495
- Bartle, S. J., R. L. Preston. Effects of successfully treated footrot on subsequent gains in feedlot steers. 1991. *Agric. Sci. Technical Rep.* pp 56
- Griffin, D., L. Perino, and D. Hudson. 1993. Feedlot lameness. *University of Nebraska- Lincoln Neb Guide.*
- Heleski, C. R., A. G. Mertig, and A. J. Zanella. 2005. Results of a national survey of US veterinary college faculty regarding attitudes toward farm animal welfare. *JAVMA.* 226(9): 1538-1546

- Misikimins, D. 2002. Predominant causes of lameness in feedlot and stocker cattle. *Proceedings of the 12th International Symposium on Lameness in Ruminants*. 147-151
- Smith, R. A. 1998. Impact of disease on feedlot performance. *J. Anim. Sci.* 76: 272-274.
- Stokka, G. L., K. Lectenber, T. Edwards, S. MacGregor, K. Voss, D. Griffin, and D.M. Grotelueschen. 2001. Lameness in feedlot cattle. *Vet Clin North Am Food Anim Pract.* 17(1): 189-207
- Tibbets, G. K., T.M. Devin, D. Griffin, J. E. Keen, and G. P. Rupp. Effects of a single foot rot incident on weight performance of feedlot steers. *The Professional Animal Scientist.* 22: 450-453
- Van Metre, D. C., J. R. Wenz, and F. B. Garry. 2005. Lameness in Cattle: Rule of Thumb. *Proceedings of the AABP.* 38: 40-43
- Whay, H. R., D. C. J. Main, L. E. Green, and A. J. F. Webster. 2002. Farmer perception of lameness prevalence. *Proceedings of the 12th International Symposium of Lameness in Ruminants.* 355-358

Figure 2-1 . Percentage of 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012 by cattle head count of the yards they manage or predominantly consult.

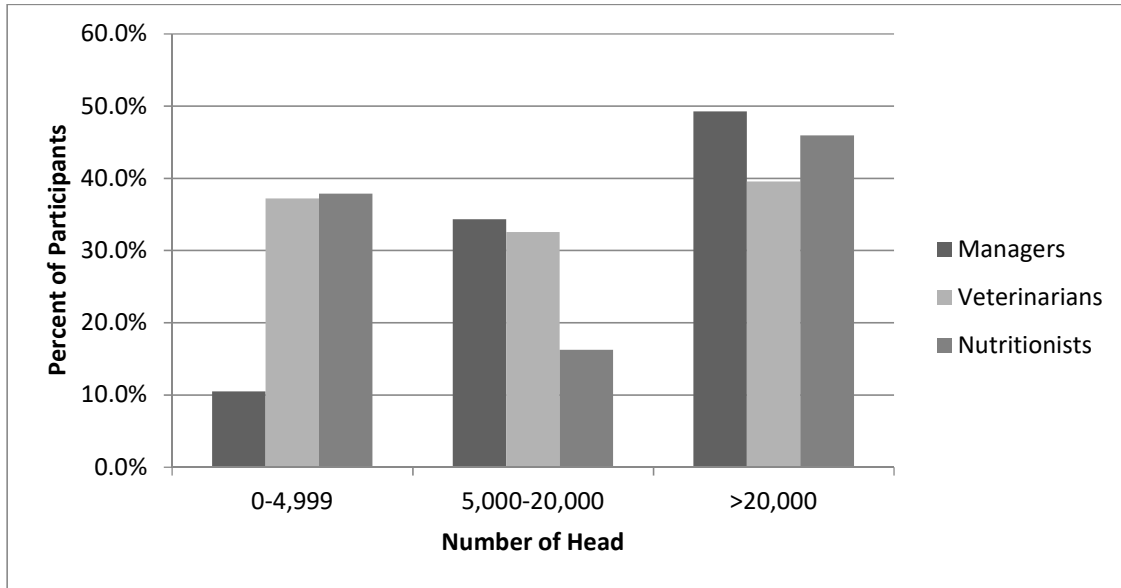


Figure 2-2. Percentage of beef cattle housed in feedlots that experience lameness as estimated by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012 reported as mean, median, and mode of responses.

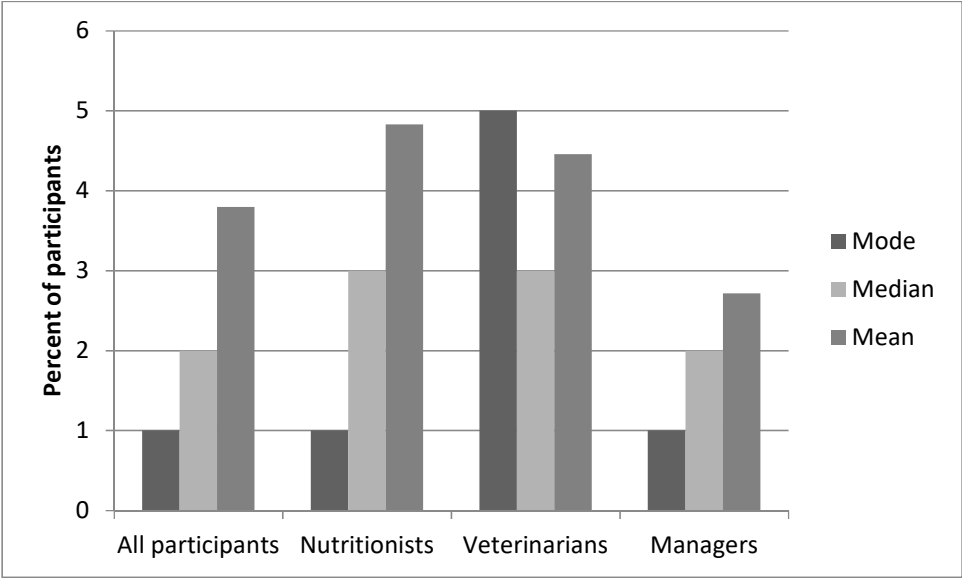


Figure 2-3. Percentage of beef cattle housed in feedlots experiencing lameness that require treatment as estimated by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.

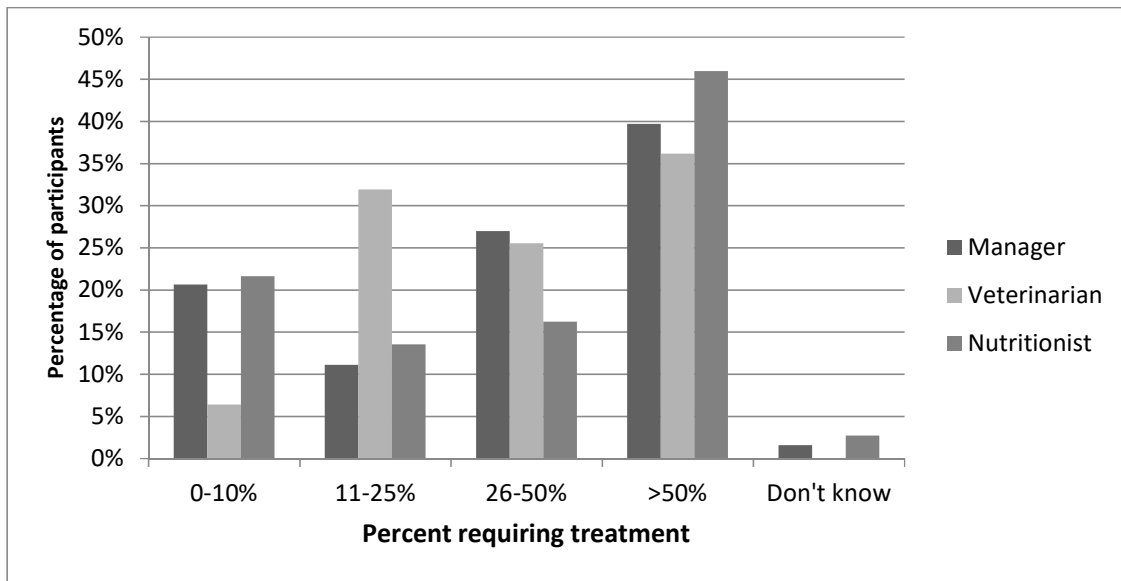


Figure 2-4. Percentage of mortality of beef cattle housed in feedlots as estimated by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012 reported as mean, median, and mode of responses.

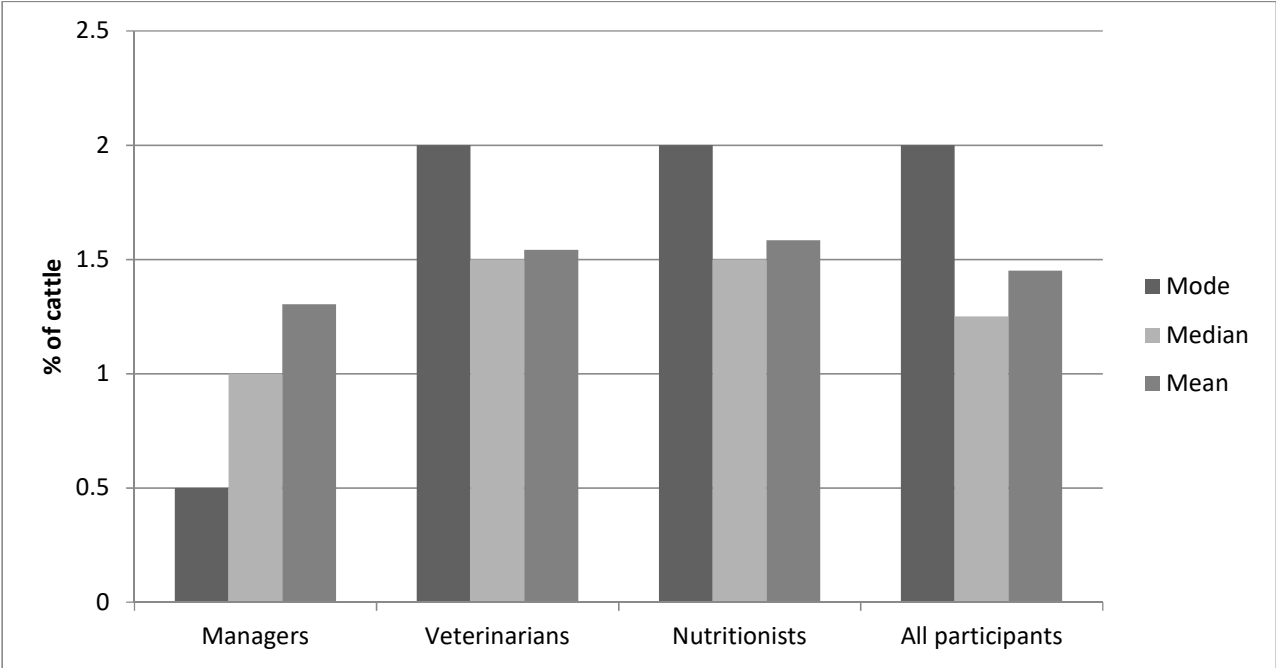


Figure 2-5. Percentage of mortality in feedlot cattle attributed to bovine respiratory disease, digestive disorders, lameness, and other causes by participants as estimated by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.

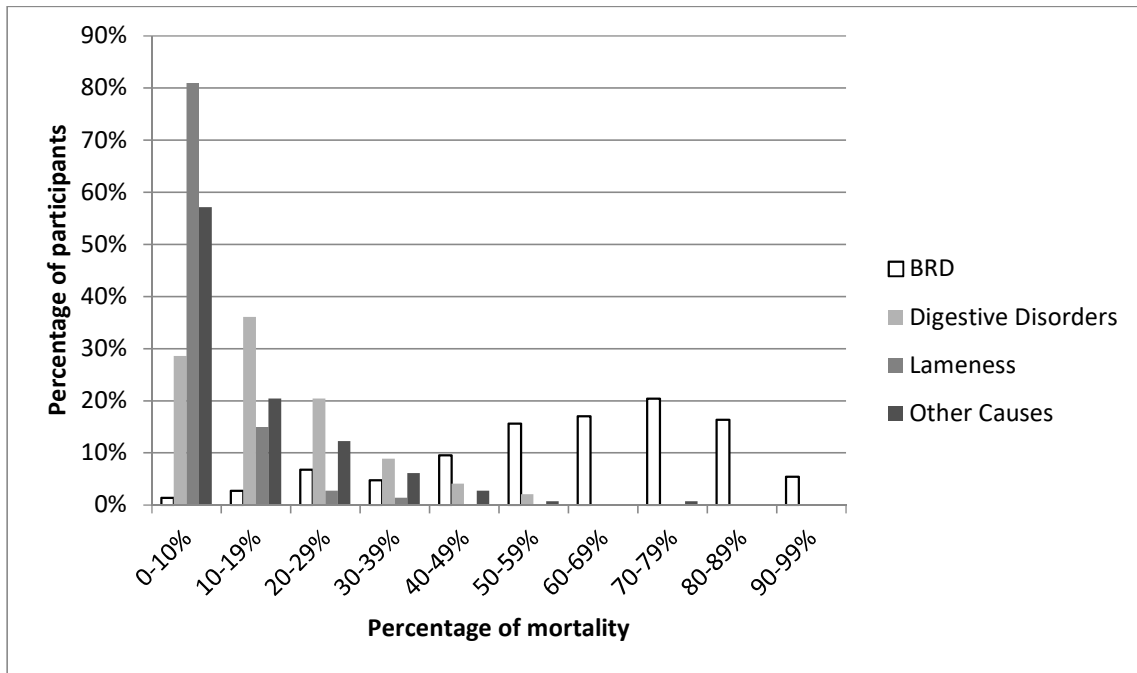


Figure 2-6. Percentage of feedlot chronic/railer loss attributed to bovine respiratory disease, digestive disorders, lameness, and other causes as estimated by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.

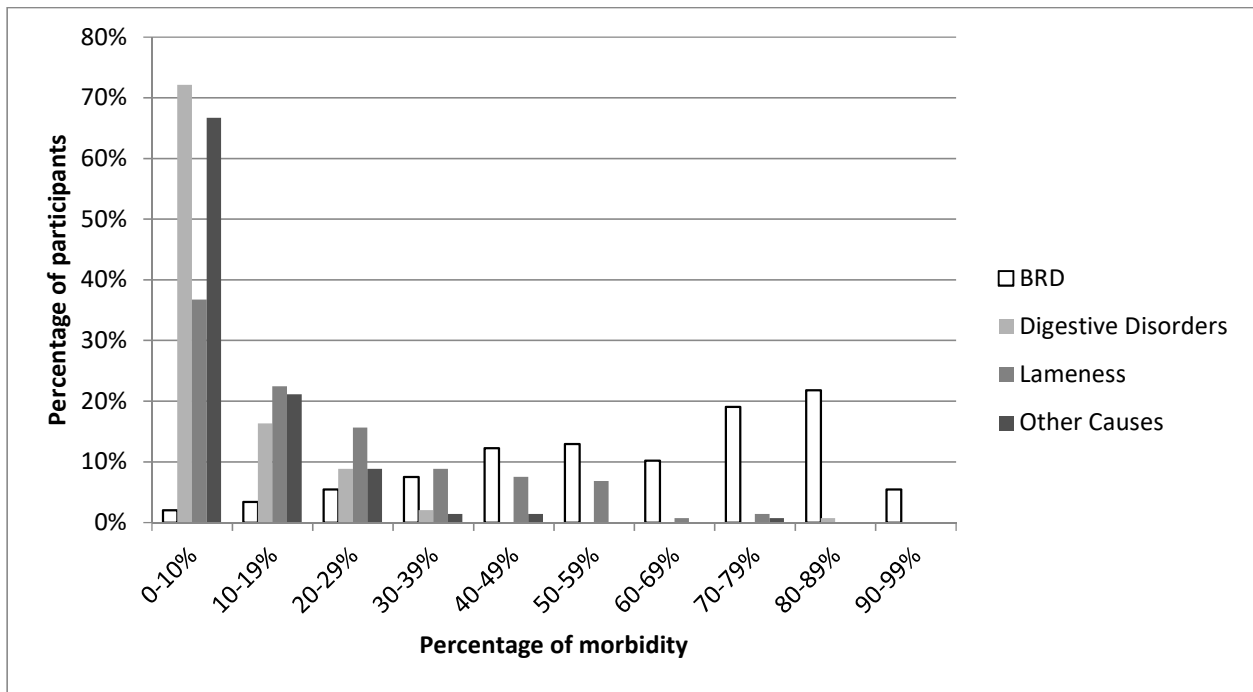


Table 2-1. Pen level diagnosis criteria utilized in the feedlot production to identify lameness morbidity and subsequent treatment by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.

Pen level lameness diagnosis criteria	% of respondents
Any sign of lameness	41%
Lameness along with depression, apparent significant pain	27%
Lameness along with a decrease in performance	18%
No set protocol	14%

Figure 2-7. The three most common causes of lameness in feedlot cattle as identified by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.

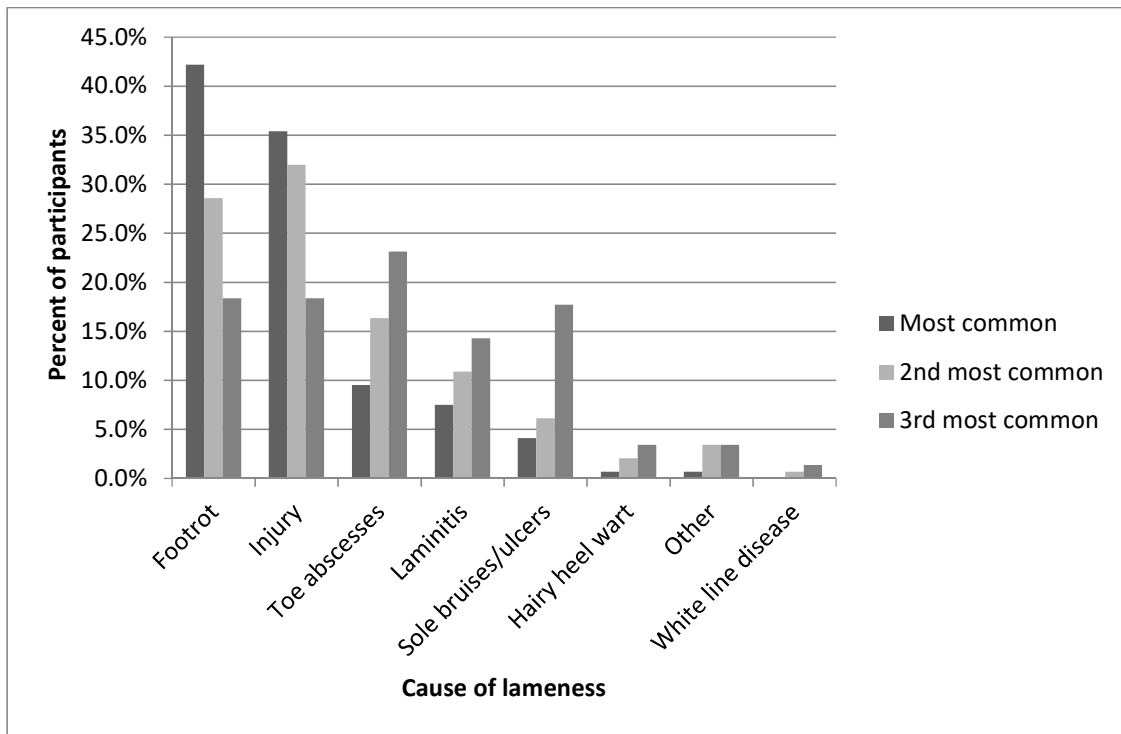


Table 2-2. Most common contributing factors for the development of lameness in beef cattle housed in feedlots identified by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012. (% of respondents, respondents allowed to select up to 4)

Factors	Infectious causes	Non- Infectious causes
Pen Conditions	85%	58%
Pen Surface	56%	41%
Weather Patterns	46%	20%
Cattle handling before arrival	35%	64%
Cattle handling after arrival	29%	67%
Nutrition	28%	25%
Cattle temperament	24%	65%
Cattle type (i.e. high risk, low risk)	16%	12%
Insufficient preconditioning nutrition program	13%	9%
Breed	10%	8%
Cattle age	5%	7%

Figure 2-8. Sources of information utilized by feedlot managers to make decisions on lameness management of beef cattle identified by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012. (Allowed to select more than one response)

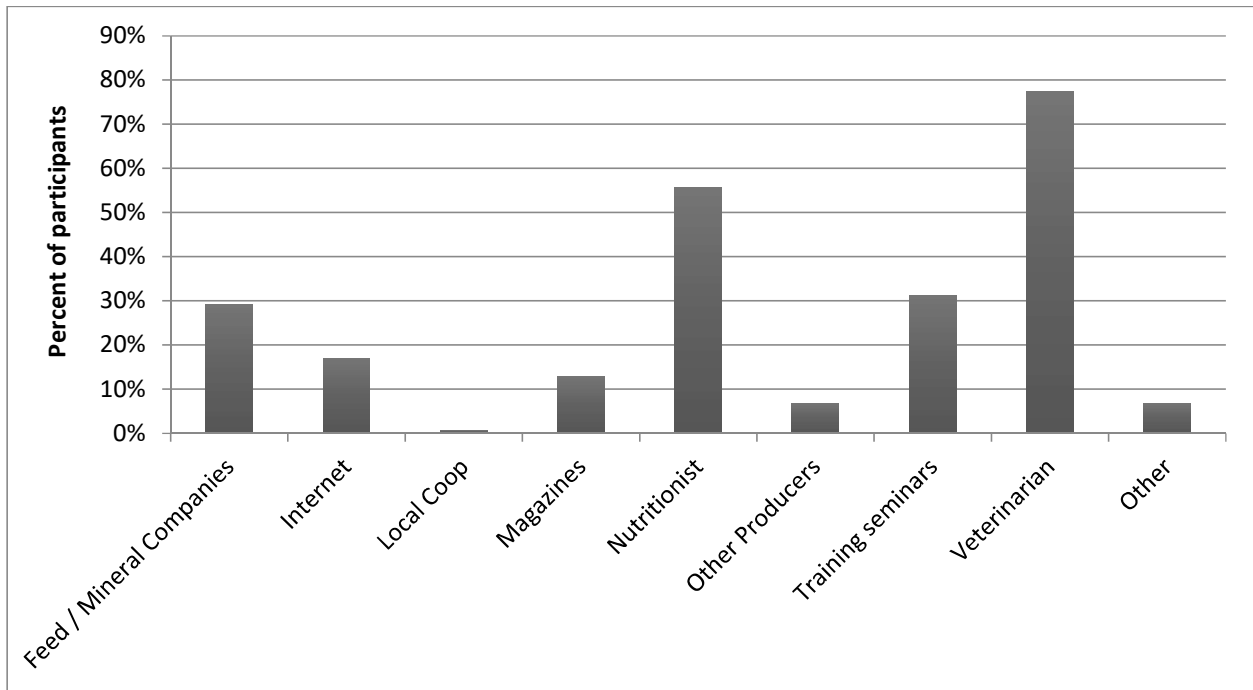


Figure 2-9. Perceptions of feedlot cattle lameness as an animal welfare concern by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.

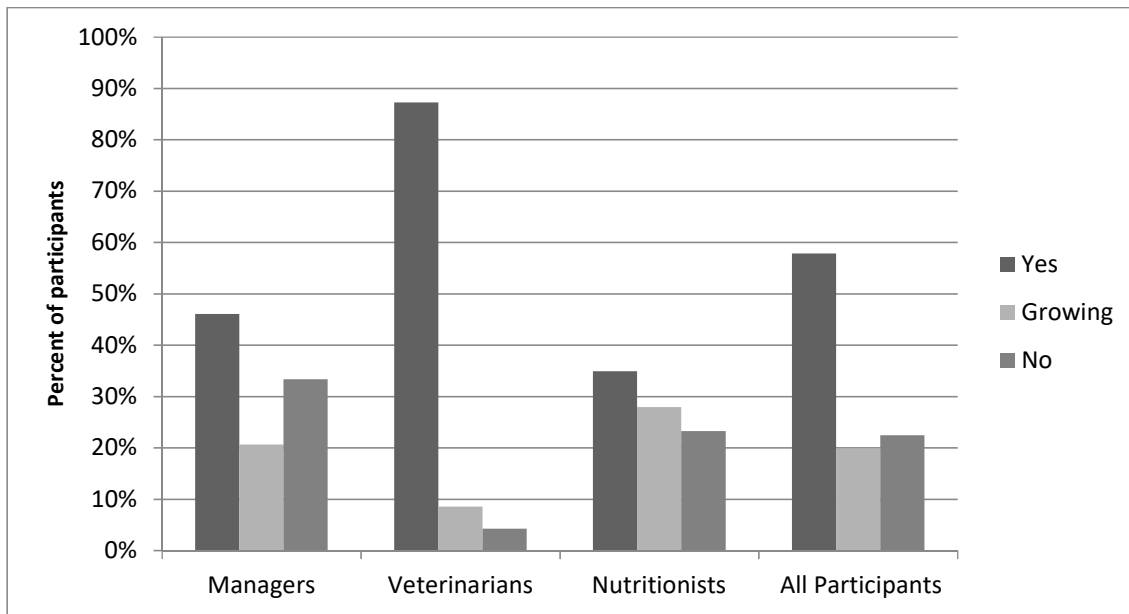


Figure 2-10. Tools that would be most helpful in better managing lameness in the feedyard identified by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.

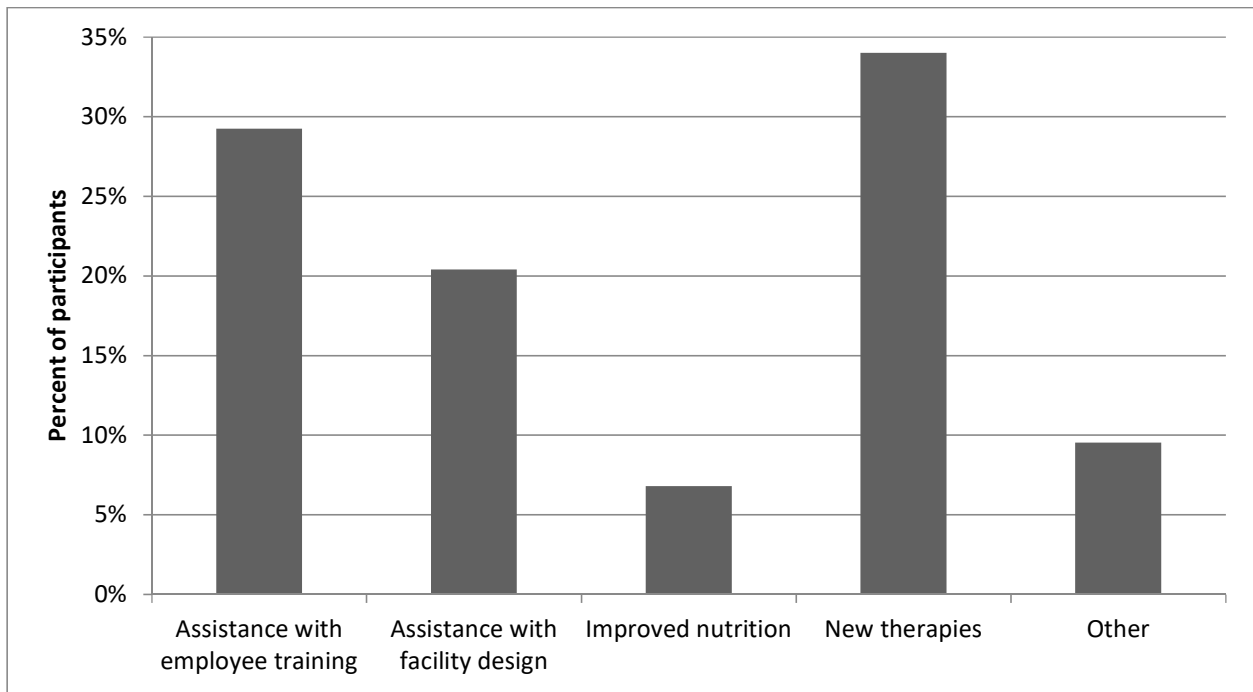
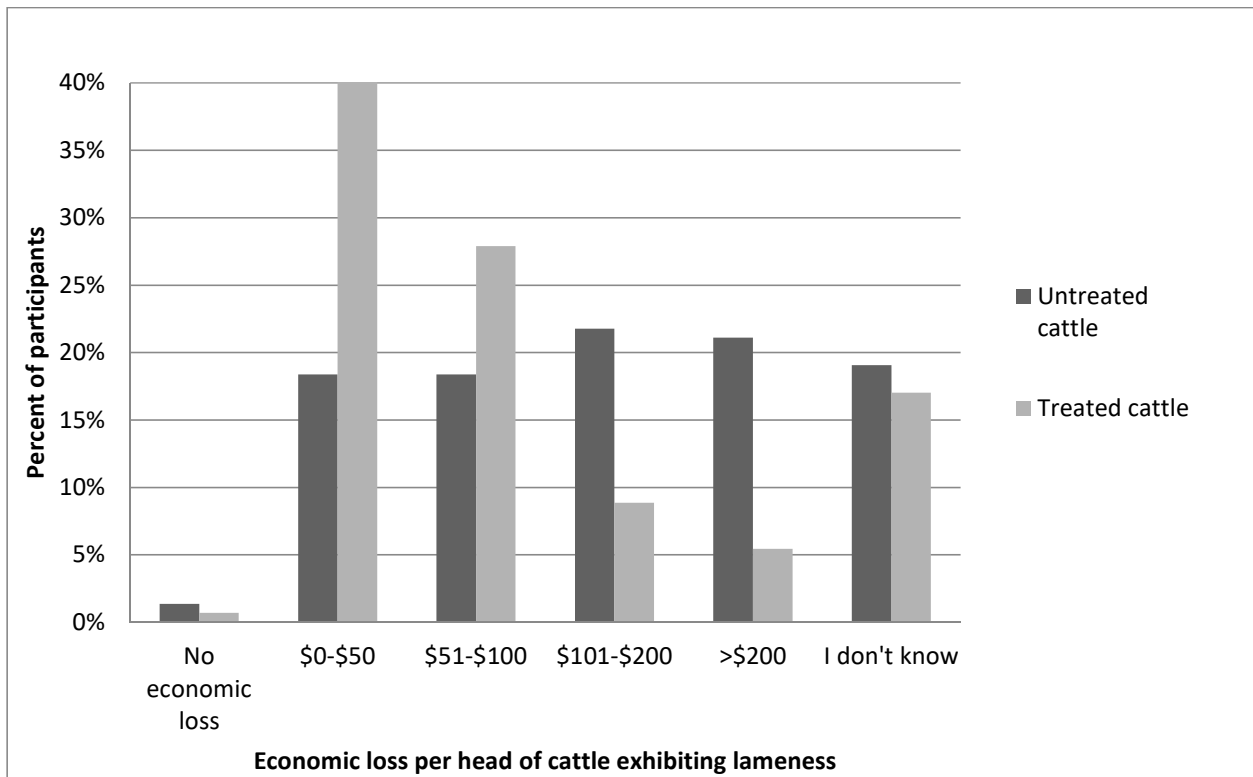


Figure 2-11. Economic loss per head of cattle that exhibit lameness in the feedyard and go untreated and of cattle treated as estimated by 147 feedlot managers, consulting nutritionists, and consulting veterinarians surveyed during 2012.



Chapter 3 - Evaluation of inter-rater reliability of a locomotion scoring system for use in beef cattle

ABSTRACT

A locomotion scoring system was developed to clinically assess locomotion of beef cattle. The scoring system consisted of 4 categories: normal movement (0), slightly affected gait (1), obviously shortened stride or bobbing of head (2), and reluctance to move or apply weight to the limb while walking or standing (3). A total of 50 commercial feedlot employees and agricultural students were trained to use the scoring system in either English or Spanish, depending upon preference of the participant. The scoring system was tested for inter-rater agreement and rater agreement against a cooperative standard based on consensus score by a team of individuals involved in the development of the scoring system which included beef cattle veterinarians and welfare experts. To validate the scoring system, trained participants viewed 16 individual video clips of beef cattle displaying varying degrees of lameness. Following the viewing of each video, participants were then asked to score the locomotion of the animal in the video. Intra-class correlation coefficient (ICC) and Fleiss's kappa were used to evaluate inter-rater agreement and rater agreement against the cooperative standard. Inter-rater agreement using ICC was 0.85 (95% CI; 0.75 to 0.93) while the mean kappa value was 0.52 (moderate agreement). Rater agreement with the cooperative standard resulted in mean kappa value of 0.64 (substantial agreement). The beef cattle locomotion scoring system: 1) Is a valid tool in assessing locomotion of beef cattle, 2) Can be taught in a relatively short period of time (25 to 35 minutes) to people with varying level of experience evaluating locomotion, and 3) Can be used to communicate severity of lameness across beef cattle disciplines.

Key words: animal health, animal welfare, beef cattle, feedlot, lameness, locomotion

INTRODUCTION

Lameness affects 2.1% of feedlot cattle (Griffin et al., 1993) and is present in 15.1% of beef cows sold at auction markets (Ahola et al., 2011), signifying that lameness is a key concern for animal health and the productivity of beef operations in both the feedlot and cow-calf sector. Animal science faculty have identified the effects of flooring on lameness as the highest ranking concern regarding husbandry practices in farm animal welfare. (Heleski et. al., 2005) The dairy and swine industries have identified lameness as a major factor influencing animal welfare and have utilized locomotion scoring systems to better define and manage lameness within their respective industries (Sprecher et. al., 1997; Mouttotou et al., 1999). The potential effects of lameness on cattle comfort and overall welfare, along with health and performance, drives the need to better understand lameness and the severity of individuals within the production system. A locomotion scoring system that is easy to teach, learn, and implement would provide a consistent framework for communication within and across various segments of the beef industry, allowing for improved efforts to define and address lameness in production settings. Scoring systems are used routinely in the beef industry to describe cattle (body condition score, frame score) and to assign carcass value (quality grade, yield grade). These standardized scoring systems already utilized in the beef industry allow accurate communication and uniform pricing across the various segments of the beef industry. The objective of this research was to demonstrate the reliability of the proposed locomotion scoring system for beef cattle between multiple raters.

MATERIALS AND METHODS

The locomotion scoring system was developed using the following steps: 1) Development of a scoring criteria to describe normal and abnormal locomotion, 2) Video capture of cattle without lameness and displaying normal locomotion, and those with various lameness that represented abnormal locomotion scores, 3) Evaluation and scoring by a test audience viewing previously recorded videos of cattle, and 4) Statistical evaluation of the agreement between raters and agreement of raters with consensus score.

Animals were cared for in accordance with the Guide for the Care and Use of Agricultural Animals in Research and Teaching (FASS, 2010).

Locomotion scoring system

A locomotion scoring system was developed to categorize lameness in beef cattle (Table 1). The system was developed by a team of beef cattle veterinarians and welfare experts at the Beef Cattle Institute at Kansas State University (Manhattan, Kansas) using practical beef production terminology along with components of the dairy lameness scoring systems described by Sprecher et al. (1997) and Breuer et al. (2000). The locomotion score (LMS) classifications were based on the animal's stride length, head movement, exhibition of affected limb or limbs, willingness to move, and willingness to place weight on the limb. Stride length was evaluated by assessing the symmetry of the distance between the front foot and rear foot placement of the left front and hind limbs compared to the right front and hind limbs. Head movement evaluation was based on the exhibition of a "head bob" in which the head of the animal drops or raises noticeably from its normal plane. Animals were scored as normal (LMS 0), mild lameness present (LMS 1; animal exhibited a shortened stride length, with no head bob or no identifiable limb affected), moderate lameness present (LMS 2; animal exhibited a limp, with obviously

identifiable limb(s) affected and/or there was a head bob present when walking, with the limb still bearing weight), and severe lameness present (LMS 3; animal applied little or no weight to the affected limb while standing or walking and the animal was reluctant or unable to move) as described in Table 1.

Video recording

Video recordings of cattle exhibiting different locomotion scores 0, 1, 2, or 3 were captured utilizing cattle in a commercial beef feedlot operation. The recordings were framed so that the entire animal and its stride and head movements were clearly visible. Animals were selected for video capture by the feedyard animal health crew who identified those cattle as lame. Additionally, individual cattle deemed normal and without changes in locomotion were identified by the animal health crew from cattle with similar weights and cattle type as the lame cattle identified for video capture. A total of 41 video recordings were captured. Recordings were 15 to 35 s in duration, during which the animal walked approximately 30 m in distance on a level dry dirt surface representative of a walking surface in conventional feedlot operations. All cattle were recorded at the same location. At the time of video capture, the investigator (Shane Terrell) evaluated and determined locomotion scores for the cattle. Videos were reviewed for picture quality, consistent cattle movement, and maintenance within the frame. Seven videos did not meet these criteria and were not utilized. A consensus score was derived for each video by a team of three individuals, which included two beef cattle veterinarians and a PhD animal scientist at the Beef Cattle Institute at Kansas State University who developed the locomotion scoring system. This set of videos was deemed the cooperative standard to be used in training and testing sessions. Four videos were selected for each locomotion score for a total of 16 videos to be utilized for testing of trainees. The remaining 18 videos were utilized for training.

Rater training

A total of 50 raters participated in the locomotion score training and testing sessions. Trainees represented two general professional backgrounds: (1) commercial feedlot employees (FE) responsible for identifying morbid animals in feedlot pens and for providing treatment to morbid animals, and (2) agricultural students (AS) at Kansas State University. Raters underwent training and testing at one of seven training sessions conducted in either English or Spanish, depending upon participant preference. Training sessions were conducted by the investigator and by an English and Spanish bilingual veterinarian. The training sessions lasted between 25 to 35 min and included viewing a total of 18 video recordings showing examples of LMS 0, LMS 1, LMS 2, and LMS 3 animals. Raters also received a handout of the clinical descriptions. The training sessions began with a review of the handout that provided clinical descriptions of locomotion scores. Once trainees were comfortable with the clinical descriptions and terminology used, the training videos were viewed. Training was completed once the participants were comfortable with the assessment and scoring of the training videos, and with the scoring terminology utilized in the handout.

Rater testing

After training was completed, raters were asked to score the locomotion of 16 individual feedlot cattle captured and displayed in previously recorded videos using the Locomotion Scoring System. A sheet was provided for the raters to select the individual locomotion score for each video. The scoring sheet included a number corresponding with each video along with locomotion scores from 0 to 3 to be circled. Each video was displayed twice, back-to-back, prior

to moving to the subsequent video. Durations of the videos ranged from 15 to 35 s, depending on the speed in which the animal moved. Additional opportunities to view the video were provided upon request.

Statistical analysis

Agreement among raters and agreement between raters and the cooperative standard (the score previously established for animals in each video by the team of beef cattle veterinarians and welfare experts at the Beef Cattle Institute at Kansas State University) was determined using Fleiss's kappa, and the Intra-class correlation coefficient (ICC) (R Foundation for Statistical Computing, Vienna, Austria). Fleiss's kappa is a measure of inter-rater agreement, which evaluates the amount of agreement between raters compared to how much agreement would be expected based on chance alone (Viera and Garrett, 2005). Fleiss's kappa values range from -1 (zero agreement) to 1 (perfect agreement). Landis and Koch (1977) provided guidelines for interpretation of Fleiss's kappa, as represented in Table 2. The ICC was calculated in a two-way random effects model, with both raters and subjects as random effects. Shrout (1998) established guidelines for interpretation of ICC. These guidelines interpret agreement as: 0-0.1 virtually none, 0.11-0.40 slight, 0.41-0.60 fair, 0.61-0.80 moderate and 0.81-1.00 substantial.

RESULTS

Inter-rater agreement

The kappa value for all raters was 0.52 (Table 3). The ICC for inter-rater agreement between all raters was 0.85 (95% CI; 0.75 to 0.93). Separated by professional group, AS (9 raters) had a kappa value of 0.69 and an ICC of 0.91 (95% CI; 0.85 to 0.96) while FE (41 raters) had a kappa value of 0.84 (95% CI; 0.73 to 0.93).

Agreement between raters and the cooperative standard

Agreement between raters and the cooperative standard was measured using Fleiss' kappa (Table 2). The corresponding mean kappa value was 0.64 indicating substantial agreement between raters and the cooperative standard. Separated by professional group, AS mean kappa was 0.77 and the mean kappa for FE was 0.61. Eighteen percent of raters' kappa values for agreement were between 0.81 to 1.00, 36% were between 0.61 to 0.80, 34% were between 0.41 to 0.60, 10% were between 0.21 to 0.40, and 2% were between 0.00 to 0.20. No raters had a kappa value less than 0.

Prevalence of score, mean, range

Cattle scored as LMS 0, LMS 1, LMS 2, and LMS 3 by consensus received mean scores of 0.29, 1.04, 2.11, and 2.96, respectively (Table 4). The corresponding ranges for LMS 0, LMS 1, LMS 2 and LMS 3 were 0 to 2, 0 to 2, 1 to 2, and 2 to 3, respectively.

Scores by raters agreed with the cooperative standard 72% of the time for LMS 0, 55.5% for LMS 1, 68.0% for LMS2, and 98.0% for LMS3. (Table 5) There was a single response out of 800 in which the locomotion score was greater than one score away from the cooperative standard score.

DISCUSSION

Systematic evaluation of locomotion in beef cattle provides animal caregivers and animal health scientists the opportunity to define and describe the incidence, severity, and cost of lameness in beef cattle in a more uniform approach. In addition, early recognition of lameness can help to refine cattle management in each phase of production. Areas where management can

be evaluated include transport practices, post-arrival processing, permanent and temporary housing facilities, feeding practices, disease therapy, and pre-slaughter handling.

This locomotion scoring system was developed for use as a systematic evaluation of beef animals in a practical setting. As there has been little published research for use in beef cattle, evaluation of other livestock industry tools for evaluating locomotion and/or lameness guided the development of this tool. In the dairy industry, multiple scoring systems have been utilized although some systems may have limitations when relating to either practical use or reported evaluation of inter-rater agreement. Less practical systems, such as the 9-point scale developed by Mason and Leaver (1988) did not find significant inter-rater agreement when evaluated using Fleiss' kappa and proportional agreement by Channon et. al. (2009). Other locomotion scoring systems, such as the 5-point scale developed by Sprecher et. al. (1997) and the 4-point scale developed by Breuer et.al. (2000) are more practical for use in a production setting, but were not evaluated for inter-rater agreement.

The Locomotion Scoring System as developed by the Beef Cattle Institute at Kansas State University described here is limited in that it requires assessment of individuals while they move at a walk for proper evaluation. This requires some baseline space requirements to allow individual animals the ability to move freely at a walk in order to visually assess individual stride length. This requirement would be met in most beef production systems, although in some circumstances minimal requirement of lighting and depth of view may not be met. It is also limited as the cattle used to evaluate the agreement between raters were all cattle from the feedlot phase of the industry. The characteristics of locomotion utilized to score the animals such as shortened stride length, the presence of a "head bob", and ability to identify affected limbs are characteristics present in cattle with changes in locomotion across different facilities and walking

surfaces. The scores of individual animals may change between surfaces, but this is not likely to limit the ability to track outcomes within individual production systems and to address points of management within those production systems.

Use of video was necessary in this study as there were a limited number of raters available for training and evaluation per session at the commercial feedyard operations. Utilizing the videos provided uniformity in the different sessions as all raters had an identical view of each animal. Good reliability between observers scoring live animals vs. scoring animals via recorded video has been demonstrated in lameness scoring of horses, but has not been tested in cattle (Fuller et. al., 2006)

Although there were numerical differences in ICC between AS and FE, these differences were not statistically significant between professional groups ($P>0.05$). Identifying differences among professional group was not a primary outcome of the research. Further testing with additional observations would be required to further evaluate these differences. However, Fleiss' kappa for all raters and FE were considered to indicate moderate agreement, with AS having substantial agreement. The ICC for all participants is considered to be substantial at 0.85, although the lower limit of the 95% confidence interval falls into moderate agreement at 0.75. This is also true of FE with an ICC of 0.84 and a lower limit of the 95% confidence interval at 0.73. However, the lower limit of the 95% confidence interval of ICC for AS was still considered substantial agreement of 0.85 and an ICC of 0.91.

Intra-rater agreement was not evaluated for trainees as the testing was conducted at multiple locations and at commercial feedlot operations, which made conducting multiple testing sessions at uniform time intervals at each location difficult. Also, intra-rater reliability of the

trainers was not accessed. However, this research demonstrated moderate to high inter-rater reliability and high reliability between the raters and the cooperative standard.

The Locomotion Scoring System as developed by the Beef Cattle Institute at Kansas State University is a reliable tool when utilized to systematically evaluate locomotion of beef cattle. The fundamentals of this tool can be taught in less than an hour to people with variable locomotion assessment experience. The Locomotion Scoring System could be utilized to accumulate incidence, prevalence, and treatment success data in order to better evaluate the timing of treatment, effectiveness of treatment, causes of lameness, and prevention measures in all phases of beef production.

LITERATURE CITED

Ahola, J. K., A. Foster, D. L. VanOverbeke, K. S. Jensen, R. L. Wilson, J. B. Glaze Jr., T. E.

Fife, C. W. Gray, S. A. Nash, R. R. Panting, and N. R. Rimbey. 2011. Survey of quality defects in market beef and dairy cows and bulls sold through livestock auction markets in the Western United States: I. Incidence rates. *J. Anim. Sci.* 89:1474-1483.

Breuer, K., P. H. Hemsworth, J. L. Barnett, L. R. Matthews, and G. J. Coleman. 2000.

Behavioural response to humans and the productivity of commercial dairy cows. *Appl. Anim. Behav. Sci.* 66:273-288.

- Channon A. J., A. M. Walker, T. Pfau, I. M. Sheldon, and A. M. Wilson. 2009. Variability of Manson and Leaver locomotion scores assigned to dairy cows by different observers. *Vet. Rec.* 164:388-392.
- FASS. 2010. Guide for the care and use of agricultural animals in research and teaching. 3rd ed. Federation of Animal Science Societies. Champaign, IL.
- Fuller, C. J., B. M. Bladon, A. J. Driver, and A. R. S. Barr. 2006. The intra- and inter-assessor reliability of measurement of functional outcome by lameness scoring in horses. *Vet. J.* 171: 281-286.
- Garner J. P., C. Falcone, P. Wakenell, M. Martin, and J. A. Mench. 2002. Reliability and validity of a modified gait scoring system and its use in assessing tibial dyschondroplasia in broilers. *Vet. Rec.* 43:355-363.
- Griffin, D., L. Perino, and D. Hudson. 1993. Feedlot lameness. University of Nebraska Neb-Guide. Lincoln, NE.
- Heleski, C. R., A. G. Mertig, and A. J. Zanella. 2005. Results of a national survey of US veterinary college faculty regarding attitudes toward farm animal welfare. *J. Am. Vet. Med. Assoc.* 226(9): 1538-1546.
- Landis, J. R. and G. G. Koch. 1977. The measurement of observer agreement for categorical data. *Biometr.* 33:159-174.
- Manson, F. J. and J. D. Leaver. 1988. The influence of concentrate on locomotion and clinical lameness in dairy cattle. *Ani Prod.* 47:185-190.
- Mouttotou, N., F. M. Hatchell, and L. E. Green. 1999. Foot lesions in finishing pigs and their association with the type of floor. *Vet Rec.* 144: 629-632.

- Shrout, P.E. 1998. Measurement reliability and agreement in psychiatry. *Statistical Methods in Medical Research*. 7: 301-317.
- Sprecher, D. J., D. E. Hostetler and J. B. Kaneene. 1997. A lameness scoring system that uses posture and gait to predict dairy cattle reproductive performance. *Theriogenology*. 47: 1179-1187.
- Viera, A. J. and J. M. Garrett. 2005. Understanding interobserver agreement: the kappa statistic. *Fam Med*. 37(5): 360-363.

Table 3-1. Clinical description of corresponding locomotion scores

Locomotion Score	Clinical Description (All animals are scored at a walk)
0- Normal	Animal walks normally No apparent lameness or change in gait.
1- Mild lameness	Animal exhibits shortened stride, may move head slightly side to side, but no head bob.
2- Moderate lameness	Animal exhibits a limp, with an obviously identifiable limb or limbs affected and/or head bob present when walking Limb(s) still bears weight
3- Severe lameness	Animal applies little or no weight to affected limb while standing or walking Animal reluctant or unable to move While walking, animal's head dropped, back arched, with head bob and limp detected.

Table 3-2. Percentage of raters (n=50) within levels of agreement between raters and “cooperative standard” as measured by Fleiss’s Kappa statistic with levels of agreement as described by Landis and Koch (1977)

Agreement	Range	% of Raters	Count of Raters
Slight	0.00 to 0.20	2	1
Fair	0.21 to 0.40	10	5
Moderate	0.41 to 0.60	34	17
Substantial	0.61 to 0.80	36	18
Near Perfect	0.81 to 1.00	18	9

Table 3-3. Agreement between raters using Intra-class correlation coefficient and Fleiss' kappa evaluated as all raters (ALL), agricultural students (AS), and commercial feedlot employees (FE).

	ICC (95% CI)	Fleiss' kappa	Count of Raters
All	0.85 (0.75 to 0.93)	0.52	50
AS	0.92 (0.85 to 0.96)	0.69	9
FE	0.84 (0.73 to 0.93)	0.50	41

Table 3-4. Mean, median, and range of rater responses by locomotion score.

Locomotion score	Mean	Median	Range
0	0.29	0	0 – 2
1	1.04	1	0 – 2
2	2.11	2	1 – 3
3	2.96	3	2 – 3

Table 3-5. Prevalence of rater responses by locomotion score.

Rater responses	LMS 0	LMS1	LMS 2	LMS 3
0	144 (72.0%)	41 (20.5%)	0 (0%)	0 (0%)
1	55 (27.5%)	111(55.5%)	21 (10.5%)	0 (0%)
2	1 (0.5%)	48 (24%)	136 (68%)	4 (2.0%)
3	0 (0%)	0 (0%)	43 (21.5%)	196 (98.0%)

Chapter 4 - Lameness morbidity and association of locomotion score and diagnosis with case outcome in beef cattle in Great Plains feedlots.

Abstract

Objective: Determine the association of lameness diagnosis and locomotion score at the time of initial lameness diagnosis with case outcome in feedlot cattle, and provide beef cattle feedlot lameness morbidity, mortality, and realizer incidence due to different lameness etiologies.

Design: Dynamic population longitudinal study

Animals: The initial study population was 245,494 head of feedlot cattle, with 524,780 animal arrivals and 527,220 animal departures recorded over the 12-month study.

Procedure: Cattle health records were maintained for a year by trained personnel for analysis from six participating feedlots located in Kansas and Nebraska. Additional treatments and outcome of each individual cattle lameness case were tracked until either the animal was transported for harvest with its entire original pen, realized, or the animal died.

Results: Lameness morbidity incidence was 1.04 cases per 100 animal-years; lameness mortality was 0.397 cases per 100 animal-years. Cattle locomotion score (LMS; scale of 0 to 3 at time of initial diagnosis were LMS1(22% of lameness cases), LMS2 (31%), and LMS3(22%). 24% of the lameness cases were not assigned a locomotion score (NS). Mortality risk were greatest for LMS3 (33.0%) and NS (31.3%), and were least for LMS1 (10.0%) with LMS2 (19.1%) being intermediate ($P < 0.05$).

Conclusion and Clinical Relevance: This research has contributed to reported lameness morbidity, mortality, and realizer incidence for cattle in U.S. feedyards. These data report the differences in observed case outcomes for lame cattle diagnosed by etiology of lameness and LMS.

Key words: beef, bovine, feedlot, lameness, welfare

Abbreviations

LMS: locomotion score

DOF: days on feed

FR: Footrot (Phlegmon)

SJ: Septic Joint or Deep Digital Sepsis

HW: Digital Dermatitis (Hairy Heel Wart)

LC: Laceration of the foot or hoof wall

UL: Upper Limb Lameness

LM: Laminitis

TA: Toe Ulcer/Abscess

SA: Sole Ulcer/Abscess

UD: Undefined Lameness

^a SAS version 9.4; SAS Institute Inc. Cary, NC

INTRODUCTION

Feedlot lameness accounts for 16% of all feedlot morbidity and up to 70% of loss due to salvage slaughter for chronic injury¹. Feedlot health costs associated with lameness include the cost of treatment, death loss, and loss due to chronic animals or realizer sale¹. Tibbetts *et al.*² found that

cattle diagnosed with footrot anytime in the feeding period had a decreased ADG of 0.02 kg/d and required 5 additional d to reach a similar slaughter BW compared to steers not diagnosed with footrot. If the steers were diagnosed during the final 120 days on feed, the steers had a decreased ADG of 0.05 kg/d and required 14 additional d to reach a similar slaughter BW than steers not diagnosed with footrot.

In a survey of feedlot consulting nutritionists, veterinarians, and managers, 58% of respondents considered lameness in the feedlot to be a welfare concern³. An additional 20% of respondents considered lameness in feedlot cattle to be a growing concern. The potential impact of lameness on cattle comfort and overall welfare, along with health and performance, drives the need to better understand the diseases causing lameness.

There have been a limited number of studies focused on feedlot lameness incidence, especially in relation to lameness severity and specific lameness causes. Footrot morbidity incidence was reported at 6.5% over an average 262 day feeding period by Tibbetts *et al.*² in steers placed in a single feedyard over an 8-year period. Lubbers and Apley⁴ reported an estimated 0.01% yearly prevalence of digital dermatitis based on a survey of feedlot veterinary practitioners.

The purpose of this research was to better understand the magnitude of lameness morbidity and mortality, the relationship of locomotion score with health outcomes, the incidence of specific lameness diagnoses, and factors associated with lameness outcomes in large, High-Plains region feedlots.

MATERIALS AND METHODS

Animals were cared for in accordance with the Guide for the Care and Use of Agricultural Animals in Research and Teaching⁵.

Animals

Cattle health records were analyzed for a study population consisting of cattle from six commercial (>20,000 head capacity) beef feedlot operations in Kansas and Nebraska. The population for each feedyard was observed by trained feedyard personnel and data collected for each day of the study period. An average of daily populations was utilized to determine the average population for the year (reported as animal-years) and for each month (animal-month). The average daily population of all six feedlots for each month ranged from 223,544 to 252,825 head of cattle, with an average daily population for the year of 243,602 cattle. The mean and median of the average feedlot arrival body weight for each lot of cattle received over the duration of the study were 334 and 335 kg, respectively. Feedlots were selected based on geographic area and the ability of investigators to regularly visit the participating feedyards to train new personnel and ensure quality data collection. All cattle from participating feedlots were enrolled in the study at the time of initial data collection.

Study Design

This study was designed as a dynamic population longitudinal study. The study began on August 1, 2012, continued for 12 months, and concluded on July 31, 2013. The initial population of the study was 245,494 head of feedlot cattle with 524,780 animal arrivals and 527,220 animal departures from the participating feedyards over the 12-month study period. Feedyard personnel responsible for within-pen diagnoses of diseased animals and in-hospital diagnoses and treatment were trained to the use 4-point locomotion scoring system (0-3) developed at the Beef Cattle Institute at Kansas State University for identification and severity scoring of lame cattle in the feedyard (Table 1). The locomotion score (LMS) classifications

were based on the animal's stride length, head movement, exhibition of affected limb or limbs, willingness to move, and willingness to place weight on the limb. Stride length was evaluated by assessing the symmetry of the distance between the front foot and hind foot placement of the left front and hind limbs compared to the right front and hind limbs. Head movement evaluation was based on the exhibition of a "head bob" in which the head of the animal drops or raises noticeably from its normal plane. Animals were scored as normal (LMS0), mildly lame (LMS1), moderately lame (LMS2), and severely lame (LMS3). Additionally, personnel responsible for in-hospital diagnoses and treatment were trained to diagnose lameness using a diagnostic algorithm (Figure 1). Diagnoses available for selection included infectious footrot (phlegmon), septic joint (deep digital sepsis), digital dermatitis (hairy heel wart), laceration of the foot or hoof wall, upper limb lameness, laminitis, toe ulcers (toe abscess), sole ulcers (sole abscess), and undefined lameness (Table 2). Training and training materials were provided to feedlot personnel responsible for lameness diagnosis in both English and Spanish. Training for new feedyard personnel was conducted by the investigator at the feedyard as needed throughout the study period.

Upon diagnosis of cattle lameness in the home pen, feedyard personnel recorded the locomotion score and identification of lame cattle on a diagnosis card. The individual animal was removed from the pen and moved to the feedlot hospital. If the locomotion score was not determined in the pen, feedyard hospital personnel recorded locomotion score prior to placing the animal in the treatment chute for specific etiology diagnosis. Once in the treatment chute, feedyard hospital personnel utilized the diagnostic algorithm to identify the cause of lameness for the individual animal (Figure 1). The diagnosis, LMS, and treatment were recorded for each individual animal at this time. Treatment and recommended hospital care for each lameness case by diagnosis

were based on the recommendation of the consulting veterinarian for the respective feedlot operation. Additional treatments required after initial diagnosis and outcome of each individual cattle lameness case were tracked until either the animal was transported for harvest with its entire original pen, realized (transported for harvest prior to harvest date for pen mates), or the animal died. Therefore, additional treatments and individual outcomes were tracked after the conclusion of the study until all cattle on the study either died, were transported for harvest prior to pen mates (realized), or were transported for conventional harvest with pen mates. Cattle euthanized following a lameness diagnosis or for reasons associated with lameness were included in mortalities. Euthanasia decisions followed euthanasia protocol established by each participating feedyard's consulting veterinarian.

Data Collection

Data collected for all cattle diagnosed for lameness included: individual identification, lot identification, average lot starting BW, sex status of the lot, weight at time of lameness treatment, locomotion score, treatment regimen, treatment cost, DOF at the time of treatment, outcome (shipped with lot, dead, or realized), and DOF at time of death or when realized.

Statistical Analysis

Data collected for locomotion score at initial diagnoses, season of morbidity, initial diagnosis, number of pulls and sex were analyzed for outcome using the LOGISTIC procedure of SAS statistical systems^a. The model was a baseline-category multinomial logit model. Least square means and standard errors, along with exponentiated least square means and 95% confidence intervals are reported. The FREQ procedure was used to provide descriptive statistics for percentage incidence of lameness morbidity, mortality, and realizers and by incidence of lameness morbidity, mortality, and realizers by locomotion score and diagnoses. The MEAN

procedure was used to provide mean and median values for average days of feed at the time of pull, average days on feed at death, fatal disease onset, and treatment to death interval. Incidence rates for morbidity, mortality, and realizers were calculated as follows: number of incidences ÷ head-years at risk.

RESULTS

Lameness morbidity

There were 2,532 lameness instances at initial diagnosis, equivalent to a 1.04 cases per 100 animal-years. The average DOF at first cattle lameness case identification was 57 days. The most commonly diagnosed lameness etiology in feeder cattle was UL, with 901 animals removed for UL treatment, comprising 35.6% of all lameness cases (Table 3). Two hundred fifty-seven (10.2%) lame animals were diagnosed with SJ, and 222 (8.8%) lame animals were diagnosed with FR. There were 685 (27.1%) lame cattle diagnosed with UD. The lameness diagnosis in feedlot cattle with the earliest average initial lameness morbidity identification was TA, with an average of 25 DOF at the time of initial diagnosis (Table 4). This was followed by SA at 29 DOF and FR at 40 DOF at the time of initial diagnosis. The lameness diagnosis with the latest average initial lameness morbidity onset was HW at 137 DOF.

Mortality associated with lameness

During the 12-month study, a total of 567 animals were treated for lameness and subsequently died, resulting in 0.23 lameness mortalities per 100 animal-years. An additional 401 animals that were untreated died for lameness related causes. A total of 968 animals died, resulting in an incidence of 0.39 lameness mortalities per 100 animal-years (Table 5). Undefined lameness had the highest lameness mortality incidence rate, followed by UL, SJ, and SA cases (0.161, 0.119, 0.041 and 0.021 cases/100 animal-years, respectively).

Mean DOF at mortality for the individual lameness diagnoses ranged from 48-139 d, with an overall mean of 74 DOF for all mortalities associated with lameness (Table 6). Cattle with TA cases had the lowest DOF at time of death at 44 d, followed by cattle diagnosed with SA at 48 DOF and LA at 50 DOF. Cattle with HW that subsequently died had the highest DOF at time of death at 139 d compared with cattle suffering from other lameness etiologies.

The average days on feed at the time of the initial morbidity event, or the fatal disease onset (FDO), for the individual lameness diagnoses ranged from 14-104 d, with an overall mean of 58 DOF for all lameness diagnoses (Table 6). Cattle diagnosed with TA had lowest DOF of FDO at 14 d, followed by cattle diagnosed with LA at 21 DOF and FR at 24 DOF. Cattle with HW also had the highest DOF of FDO at 104 d.

The average days between the initial morbidity event and death, or the treatment to death interval (TDI) ranged from 10-31 d, with the overall mean of 16 d for all lameness diagnoses (Table 6). Cattle diagnosed with UL had the shortest TDI at 10 d, followed by UD at 14 d and SA at 17 d. Cattle diagnosed with TA had the longest TDI at 31 d.

Mean percent mortality of cattle diagnosed with lameness was categorized and recorded. Mean mortality rate for feedlot cattle suffering from SJ was 32.9%, which was greater ($P<0.001$; Table 7) than cattle suffering from FR and TA (12.4% and 14.9%, respectively). Mean percent mortality for cattle suffering from SA, UD, and UL cases (28.8%, 24.2%, and 21.6%, respectively) were also greater ($P<0.05$) than cattle suffering from FR cases.

Incidence of animals shipped for early salvage harvest

Over the study period, 230 animals receiving a lameness diagnosis were sold for salvage slaughter or realized, prior to transportation of the animal's cohort lot for harvest. This represents a 0.096 cattle lameness realizer incidence per 100 animal-years (Table 3). The highest

number of cattle realized due to lameness were those suffering from UL, followed by cattle suffering from UD, SJ, and TA (98, 82, 15, and 11 head, respectively). No animals were realized that were not diagnosed at first sign of morbidity.

Mean realizer rates for cattle identified with UD and UL (8.5% and 8.1%, respectively) were greater ($P<0.001$; Table 8) than cattle diagnosed with FR, LM, and SA (3.1%, 1.8%, and 2.3%, respectively).

Retreatment rate

Of the 2,532 cattle diagnosed with lameness at initial morbidity, 2,304 (91.0%) of them were not treated again following additional diagnosis. One-hundred sixteen animals (4.6%) received 2 treatments, and the remaining 112 (4.4%) animals received 3 or more treatments. No differences were noted between the numbers of treatments based on diagnosis.

Locomotion score

At initial diagnosis of lameness morbidity, 561 (22.2% of lame cattle) animals were classified as LMS1, 795 (31.4% of lame cattle) were LMS2, and 576 (22.8% of lame cattle) were LMS3 (Table 9). There were 600 (23.7% of lame cattle) animals identified and removed from their pen for treatment due to lameness that did not receive a LMS (NS).

Mean mortality rates differed ($P<0.05$; Table 10) between cattle with LMS1 (10.0%) and LMS2 (10.1), LMS1 and LMS3 (33.0%), LMS1 and NS (31.3%), and LMS2 and LMS3. Mortality rates between cattle with LMS3 and NS were similar ($P>0.05$).

A greater ($P<0.05$; Table 11) percentage of lame cattle with LMS1 and LMS3 (6.40% and 6.67%, respectively) were realized than cattle with LMS2 and NS (3.67% and 3.63 %, respectively).

Season

Mean mortality and realizer rates were categorized by season of initial lameness diagnoses. Seasons were classified in 3-month intervals where “spring” included March, April, and May; “summer” included June, July, and August; “fall” included September, October, and November; and “winter” included December, January, and February.

Mean mortality rates of feeder cattle differed ($P<0.05$; Table 12) by season of initial lameness diagnosis between spring (19.4%) and winter (29.7%) and between summer (18.3%) and winter. However, Mean realizer rates of feeder differed ($P<0.05$; Table 13) by season of initial lameness diagnosis between spring (9.76%) and winter (3.25%), and between spring and fall (3.45%).

DISCUSSION

Although reviews of lameness in feedlot cattle have been conducted over large datasets¹ and multiple years², there have been no studies that have demonstrated incidence of specific lameness diagnosis in the feedlot based on a diagnostic algorithm utilized across a large number of cattle at multiple locations. Also, no studies have previously been conducted in beef feedlot cattle that evaluated how changes in locomotion at the time of initial lameness morbidity relate to the likelihood of a positive outcome.

Lameness incidence was reported in a data review of feedlot health records representing over 1.8 million cattle by Griffin *et al.*¹ They reported 13.1% of cattle experienced health problems during the feeding period, with 16% of the health problems associated with lameness resulting in a lameness morbidity of 2.09% over the average feeding period for the cattle in the dataset.

Comparatively, our study demonstrated lameness incidence rate of 1.04 initial lameness events per 100 animal-years. While the incidence rates are nearly 50% different for lameness in feedlot cattle, the current study was more prospective in the fact that feedlot personnel were trained to

diagnosis, utilized locomotion scoring and followed treatments for all lame cattle rather than just summarizing feedlot health data over a set period of time from feedyards where workers received no formal training or follow up. Incidence rates are affected by sensitivity of feedlot personnel trained to identify, remove and treat lame cattle and should be evaluated in conjunction with death loss and realizer rates.

Tibbetts *et al.*² reported a 6.5% infectious FR incidence in an analysis of a single feedlot in Nebraska over eight years for steer calves fed an average of 262 days. Comparatively, we noted a much lower FR incidence, with 222 cases of FR reported over the 12-month period for a 0.0076 FR incidence per 100 animal-months or a 0.09 cases per 100 animal-years. There are several factors that can be associated with the disparity between reported data by Tibbetts *et al.*² and our reported data, including all data from the Tibbetts *et al.*² were from a single feedyard. There are possible specific yard differences that can affect FR incidence such as pen condition, type of cattle in the yard, and ration differences³. Also, utilizing the diagnostic algorithm for diagnosis at the chute could have caused a greater specificity for the FR diagnosis.

Targeting specific causes of lameness and contributing factors to lameness is important for improving the management of each disease process. Footrot, injury, and TA were previously considered the most common causes of lameness^{6,7}. This was confirmed to be the perception in a survey of feedlot veterinarians, and nutritionists, and managers³. Footrot was selected as the most common cause of lameness in the feedlot by 42.2% of participants while injury was selected by 35.4%, and 9.5% selected TA. Conversely, FR and TA had the 4th and 6th greatest morbidity incidence in feedlot cattle in this surveillance study. Upper limb, UD and SJ lameness cases ranked as the three most common diagnoses in this feedlot lameness study. It is possible that a large number of cattle are diagnosed with FR that have other infectious or secondary

infection lameness etiologies, such as HW, TA, SA, and SJ. Limitations to this ranking include the number of animals with UD, which were unable to be identified as one of the other lameness diagnosis. The algorithm used in this research focused on specificity of the diagnosis and therefore sacrifices some sensitivity to diagnose these UD cases. As a result, the estimated incidence of the eight remaining diagnoses are likely conservative. Also, this surveillance study, along with Tibbets *et al.*² and Griffin *et al.*¹, are snapshots in time of specific feeding operations. The observations of the veterinarians and feedlot managers in the published survey³ are reflective of constant long-term surveillance through practice and management.

Prevalence of lameness pre-processing and post-processing, along with lameness morbidity incidence for four lameness categories were analyzed for cattle from a single feedlot early in the feeding period by Green *et al.*⁸ The pre-processing lameness prevalence was 1.6% of 3,243 feedlot steers compared to 2.5% immediately post-processing. The researchers then evaluated medical history of individual animals through the first 100 DOF. There was a total incidence of lameness morbidity comprising 3.70%, with 0.15% diagnosed with FR, 1.94% diagnosed as bullers, 1.39% diagnosed as musculoskeletal, and 0.22% diagnosed with arthritis. If bullers are removed from the evaluation, there was 1.76% incidence of lameness morbidity over the time period. Although this study differentiated incidence of specific lameness etiologies, it does not follow these animals through slaughter. As with Tibbetts *et al.*² the lameness incidence was much higher than found in this lameness surveillance study, but represented a much smaller population of cattle from a single feedlot over a much shorter period of time.

There are less reported data on lameness mortality and realizer rates. Griffin *et al.*¹ reported 70% of non-performing cattle which were realized and 5% of mortalities were due to lameness, although total realizer and mortality rates were not reported. The cost associated with realizers

and lameness is significant; the authors estimate the current annual cost associated with lameness mortality to be \$6.60 per animal-year. This estimate was based on the reported lameness mortality of 0.033 per 100 animal-months, and the associated 0.40 cases per 100 animal-years. The average lot initial weight of the study population was 334 kg and the average DOF at time of mortality was 77 d. Using a conservative 1.25 kg ADG for feeder cattle, the average BW of animals within the average lot would be 430 kg at the time of death ($1.25 \text{ kg/d} \times 77 \text{ days} = 96 \text{ kg}$ weight gain). For the estimate, authors used \$3.87/kg as the value of the animals based on April 2015 average price for 432 kg steers and heifers from Oklahoma sale barns. This results in an estimated \$1,665 lost value per animal mortality. At a lameness mortality rate of 0.033 mortalities per 100 animal-months, a conservative monthly mortality cost of lameness is estimated to be \$0.55 per animal-month and a mortality cost of \$6.60 per animal-year. Comparably, the authors estimate the annual cost associated with lameness realizers at \$0.76 per animal capacity. This estimate was based on the reported lameness realizer rate of 0.008 per animal-month and an associated lameness realizer rate of 0.096 per 100 animal-years. The estimate used 334 kg for average cattle arrival weight and an estimated 1.25 kg ADG as in the previous estimate, for mortality costs. The average DOF at time of early harvest for feeder cattle suffering from chronic lameness was 91 d. The average estimated weight of cohort animals within the lot would be 447 kg at the time of early harvest for the lame animal ($1.25 \text{ kg/day} \times 91 \text{ days} = 113 \text{ kg}$ weight gain). For the estimate, authors used \$3.85/kg, which is April 2015 averages for 447 kg steers and heifers from Oklahoma sale barns. This results in an estimated \$1,722 value of the average animal in the lot at 91 DOF. Using a 54% salvage value and making an assumption of no weight loss occurred in the lame animal, a 447 kg animal would return \$930. The lost opportunity due to early sale of the realized animal in this estimation would be

\$792 per animal. Using the 0.008 per 100 animal-months lameness realizer rate, the conservative estimated cost would be just over \$0.06 per animal-month with an associated cost of \$0.76 per animal-year.

Although not widely utilized in the beef industry, locomotion scoring has been utilized to a greater degree in the dairy industry. One of the first locomotion scoring systems was described by Manson and Leaver⁹. This system employed a 9-point scale, with scores 1 through 5, increasing in 0.5 point increments. A simplified 5-point system was developed that focused on gait and arch of the back¹⁰. Breuer *et al.*¹¹ utilized a 4-point locomotion scoring system, with scores 0 through 3, in a behavior study which looked at animal and human interaction. This scoring system added head movement, or the presence of a “head bob” to the presence of a limp for further classification.

The LMS developed and used in for this research utilized a combination of practical beef production terminology and components of the dairy lameness scoring systems described by Sprecher *et al.*¹⁰ and Breuer *et al.*¹¹ with the expectation that it could be utilized by feedlot personnel across diverse experience, educational, and cultural backgrounds. As described in this study, an animal’s likelihood of death increases significantly with each increase in LMS at the time of initial lameness diagnoses. The increase in realizer rates in LMS1 vs LMS2 animals did not follow the similar trend. This warrants more investigation and could be due to an increase in realizing mild lameness in heavy cattle early if treatment is not necessary with the hope of salvaging the animal before the disease progressed. However, the total percentage means of mortality and realizer for LMS1 remained less than LMS2, indicating a greater percentage of LMS1 were transported for harvest with their respective lots. With the clear differentiation of outcomes by LMS at initial diagnosis, LMS could be utilized as a tool for training feedyard

personnel to achieve increased lameness detection in the pen. More diligent lameness detection at the pen level has the potential to improve the outcomes of lameness cases with earlier timing of intervention. It also has relevance for treatment, realizer, and endpoint management decision-making processes based on the relationship between LMS and outcome.

Further research utilizing LMS could be warranted to better understand both clinical and subclinical lameness within the feedyard. Previously, lameness prevalence has been underestimated in the dairy industry; dairy farmers in the United Kingdom estimated a mean lameness prevalence of 5.73% with an actual clinical lameness, when assessed for locomotion (animals classified as lame or severely lame), of 22.11% in 53 dairy farms¹². Currently available beef data, including this research, is limited as pen removal morbidity incidence within the feedyard but does not give an exact indication to the prevalence of lameness within the pen, the feedyard, or the feedyard industry. Large-scale, within the pen assessment of lameness would be beneficial to further estimate the losses, both clinical and subclinical, associated with beef cattle lameness.

The LMS could be utilized in other areas within the beef industry. Ahola *et al.*¹³ reported a 15.1% prevalence of lameness issues in beef cows at auction markets in the western U.S.

Further research into the association between LMS and outcomes in beef cows and bulls could provide insight into making culling decisions.

This research has provided a thorough examination of feedlot cattle lameness and contributed data to describe morbidity, mortality, and realizer incidence for lame cattle in U.S. feedyards.

The data are unique in the approach of utilizing a diagnostic algorithm to differentiate lameness diagnosis and reporting differences in observed case outcomes for cattle identified with lameness

by etiology and LMS. The etiology of cattle lameness and the severity of LMS at the time of initial diagnosis in the feedlot setting could be predictive of positive and negative case outcomes.

LITERATURE CITED

- ¹Griffin, D., L. Perino, and D. Hudson. 1993. Feedlot lameness. University of Nebraska Neb-Guide. Lincoln, NE.
- ²Tibbetts, G.K., T. M. Devin, D. Griffin, *et al.* 2006. Effects of a single foot rot incident on weight performance of feedlot steers. *Prof. Anim. Sci.* 22:450–453.
- ³Terrell, S. P., D. U. Thomson, C. D. Reinhardt, *et al.* 2104. Perception of lameness management, education, and effects on animal welfare of feedlot cattle by consulting nutritionists, veterinarians, and feedlot managers. *The Bovine Practitioner.* 48: 53-60.
- ⁴Lubbers, B.V. and M. D. Apley. 2006. Determination of papillomatous digital dermatitis (PPD) prevalence in the U.S. Feedlot Industry through practitioner survey. *Proceeding of the Am. Assoc. of Bovine Practitioners.* 243.
- ⁵FASS (Federation of Animal Science Societies). 2010. *Guide for Care and Use of Agricultural Animals in Research and Teaching (Third Edition).*
- ⁶Misikimins, D. 2002. Predominant causes of lameness in feedlot and stocker cattle. *Proceedings of the 12th International Symposium on Lameness in Ruminants.* 147-151.
- ⁷Van Metre, D. C., J. R. Wenz, and F. B. Garry. 2005. Lameness in Cattle: Rule of Thumb. *Proceedings of the AABP.* 38: 40-43.
- ⁸Green, T.M., P.T. Guichon, D. U. Thomson, *et al.* 2012. Time of onset, location, and duration of lameness in beef cattle in a commercial feedyard. Kansas State University.

Agricultural Experiment Station and Cooperative Extension Service Report of Progress # 1065. pp 21-24.

⁹Manson, F. J. and J. D. Leaver. 1988. The influence of concentrate on locomotion and clinical lameness in dairy cattle. *Anim. Prod.* 47:185-190.

¹⁰Sprecher, D. J., D. E. Hostetler and J. B. Kaneene. 1997. A lameness scoring system that uses posture and gait to predict dairy cattle reproductive performance. *Theriogenology*. 47: 1179-1187.

¹¹Breuer, K., P. H. Hemsworth, J. L. Barnett, *et al.* 2000. Behavioural response to humans and the productivity of commercial dairy cows. *Appl. Anim. Behav. Sci.* 66:273-288.

¹²Whay, H.R., D.C.J. Main, L.E. Green, *et al.* (2002) Farmer perception of lameness prevalence. In Proc. 12th International Symposium on Lameness in Ruminants, pp. 355-358. Orlando, Florida.

¹³Ahola, J. K., A. Foster, D. L. VanOverbeke, *et al.* 2011. Survey of quality defects in market beef and dairy cows and bulls sold through livestock auction markets in the Western United States: I. Incidence rates. *J. Anim. Sci.* 89:1474-1483

Table 4-1. Clinical description of corresponding locomotion scores for cattle identified with lameness morbidity across six U.S. feedlots over a single 12-month period

Locomotion Score	Clinical Description (All animals are scored at a walk)
0- Normal	Animal walks normally No apparent lameness or change in gait.
1- Mild Lameness	Animal exhibits shortened stride, may move head slightly side to side, but no head bob.
2- Moderate Lameness	Animal exhibits a limp, with an obviously identifiable limb or limbs affected and/or head bob present when walking Limb(s) still bears weight
3- Severe Lameness	Animal applies little or no weight to affected limb while standing or walking Animal reluctant or unable to move While walking, animal's head will be dropped, back arched, with head bob and limp detected.

Figure 4-1. Diagnostic algorithm utilized for lameness diagnoses for cattle identified with lameness morbidity across 6 U. S. feedlots over a single 12-month period

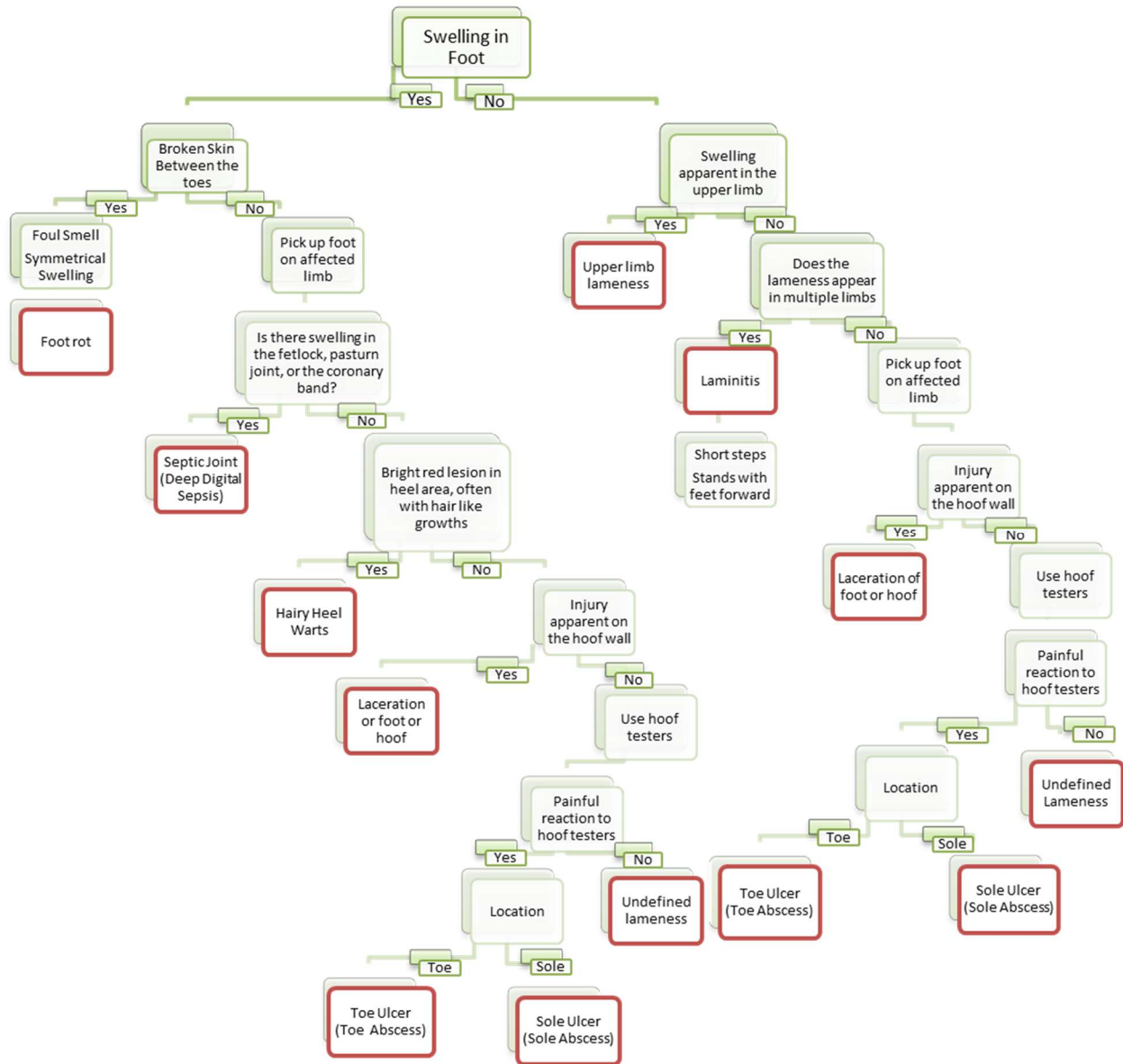


Table 4-2. Lameness diagnoses available for selection for individual animals with lameness morbidity across six U. S. feedlots over a single 12-month period based on diagnostic algorithm

Diagnosis	Code
Footrot (Phlegmon)	FR
Septic Joint or Deep Digital Sepsis	SJ
Digital Dermatitis (Hairy Heel Wart)	HW
Laceration of the foot or hoof wall	LC
Upper Limb Lameness	UL
Laminitis	LM
Toe Ulcer/Abscess	TA
Sole Ulcer/Abscess	SA
Undefined Lameness	UD

Table 4-3. Outcome of individuals diagnosed with specific lameness diagnoses at the time of initial lameness morbidity in cattle across six U.S. feedlots over a single 12-month period

Outcome	UD ¹	UL ²	FR ³	SJ ⁴	SA ⁵	TA ⁶	LC ⁷	LM ⁸	HW ⁹	Total
Shipped ¹⁰	446	619	184	156	88	100	58	73	11	1,735
Realized ¹¹	82	98	9	15	4	11	4	2	5	230
Dead ¹²	157	184	29	86	46	17	19	24	5	567
Total	685	901	222	257	138	128	81	99	21	2,532

¹undefined lameness, ²upper limb lameness, ³footrot (phlegmon), ⁴septic joint or deep digital sepsis, ⁵sole ulcer or abscess, ⁶toe ulcer or abscess, ⁷laceration of the foot or hoof wall, ⁸laminitis, ⁹hairy heel wart (digital dermatitis).

¹⁰survived to harvest date of pen mates

¹¹were transported to harvest prior to the harvest date of pen mates

¹²did not survive to be transported to harvest, including cattle euthanized following a lameness diagnosis

Table 4-4. Days on feed at initial lameness morbidity diagnoses for individual animals across six U.S. feedlots over a single 12-month period

Diagnosis	n	Mean	Standard deviation
Footrot (phlegmon)	222	40	44
Hairy heel wart (digital dermatitis)	21	137	49
Laceration of the foot or hoof wall	81	42	45
Laminitis	99	79	56
Sole abscess	138	29	37
Septic joint	257	44	41
Toe abscess	128	25	41
Undefined lameness	685	68	50
Upper limb lameness	901	70	56

Table 4-5. Incidence of lameness-associated mortality by diagnoses in feedlot cattle (cases per 100 animal-years) across six U.S. feedlots over a single 12-month period

	UD ¹	UL ²	FR ³	SJ ⁴	SA ⁵	TA ⁶	LC ⁷	LM ⁸	HW ⁹	Total
Treated mortalities	0.064	0.076	0.012	0.035	0.019	0.007	0.008	0.010	0.002	0.233
Untreated mortalities	0.096	0.044	0.000	0.006	0.002	0.005	0.003	0.006	0.003	0.165
Total Mortalities	0.161	0.119	0.012	0.041	0.021	0.011	0.011	0.016	0.005	0.397

¹undefined lameness, ²upper limb lameness, ³footrot (phlegmon), ⁴septic joint or deep digital sepsis, ⁵sole ulcer or abscess, ⁶toe ulcer or abscess, ⁷laceration of the foot or hoof wall, ⁸laminitis, ⁹hairy heel wart or digital dermatitis.

Table 4-6. Days on feed of initial morbidity event (FDO), treatment to death interval (TDI), and days on feed of mortality occurred for individual animals diagnosed as having lameness morbidity and subsequently dying across six U.S. feedlots over a single 12-month period

Diagnosis	n	FDO		TDI		DOF of Death	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Footrot	29	24	36	29	35	53	49
Hairy heel wart (digital dermatitis)	5	104	45	26	43	139	47
Laceration of the foot or hoof wall	19	21	25	29	29	50	37
Laminitis	24	63	46	18	14	80	47
Sole abscess	46	31	30	17	13	48	34
Septic joint	86	45	46	21	22	65	44
Toe abscess	17	14	33	31	31	44	42
Undefined lameness	157	66	51	14	23	79	51
Upper limb lameness	184	75	60	10	16	85	58

Table 4-7. Mortality rate for diagnoses at time of initial morbidity for cattle across six U.S. feedlots over a single 12-month period (%)

Diagnosis	Mortality, %	SEM	95% CI
Footrot	12.4 ^c	2.3	7.8-16.9
Hairy heel wart (digital dermatitis)	21.2 ^{abc}	9.0	3.5-38.8
Laceration of the foot or hoof wall	23.8 ^{abc}	5.1	13.9-33.7
Laminitis	19.1 ^{abc}	3.9	11.5-26.7
Sole abscess	28.8 ^a	4.2	20.6-36.9
Septic joint	32.9 ^a	3.4	26.2-39.6
Toe abscess	14.9 ^{bc}	3.5	8.1-21.9
Undefined lameness	24.2 ^a	2.1	20.0-28.3
Upper limb lameness	21.6 ^a	1.9	17.9-25.3

^{abc} means within a column without a common superscript differ ($P < 0.05$)

Table 4-8. Realizer rate (cattle which are transported to harvest prior to their pen mates) for diagnoses at time of initial morbidity for cattle across six U.S. feedlots over a single 12-month period (%)

Diagnosis	Realizers, %	SEM	95% CI
Footrot	3.1 ^a	1.1	0.9-5.3
Hairy heel wart (digital dermatitis)	14.6 ^{ab}	7.0	0.9-28.2
Laceration of the foot or hoof wall	4.4 ^{ab}	2.2	0.0-8.7
Laminitis	1.8 ^a	1.3	0.0-4.2
Sole abscess	2.3 ^a	1.2	0.00-4.7
Septic joint	4.5 ^{ab}	1.3	2.0-7.1
Toe abscess	6.6 ^{ab}	2.2	2.4-10.9
Undefined lameness	8.5 ^b	1.4	5.8-11.3
Upper limb lameness	8.1 ^b	1.3	5.5-11.1

^{abc} means within a column without a common superscript differ ($P < 0.05$)

Table 4-9. Gross outcome and percentage of outcomes (in parenthesis) by locomotion score (1, 2, 3, or no score (NS)) at the time of initial lameness diagnosis for individual animals with lameness morbidity across six U.S. feedlots over a single 12-month period

Outcome	1 ¹	2 ²	3 ³	NS ⁴	Total
Shipped ⁵	430 (76.7%)	601 (75.6%)	325 (56.4%)	379 (63.2%)	1,735
Realized ⁶	77 (13.7%)	50 (6.3%)	62 (10.8%)	41 (6.8%)	230
Dead ⁷	54 (9.6%)	144 (18.1%)	189 (32.8%)	180 (30.0%)	567
Total	561	795	576	600	2,532

¹Mild lameness, ²Moderate lameness, ³Severe lameness, ⁴no score given upon initial diagnosis

⁵ survived to harvest date of pen mates

⁶ were transported to harvest prior to the harvest date of pen mates

⁷ did not survive to be transported to harvest, including cattle euthanized following a lameness diagnosis

Table 4-10. Mortality rate for locomotion score (LMS) at initial diagnosis for individual animals with lameness morbidity across six U.S. feedlots over a single 12-month period (%)

	Mortality, %	SEM	95% CI
Locomotion score			
1 ¹	10.0 ^a	1.6	6.8-13.1
2 ²	19.1 ^b	2.0	15.1-23.1
3 ³	33.0 ^c	2.9	27.3-38.7
No score given at initial diagnosis	31.3 ^c	2.9	25.7-37.0

¹Mild lameness, ²Moderate lameness, ³Severe lameness

^{abc} means within a column without a common superscript differ ($P < 0.05$)

Table 4-11. Realizer rate (animals transported to harvest prior to pen mates) for locomotion score at time of initial diagnosis for individual animals with lameness morbidity across six U.S. feedlots over a single 12-month period (%)

Locomotion score ¹	Realizers, %	SEM	95% CI
1	6.40 ^a	1.42	3.62-9.17
2	3.67 ^b	0.82	2.06-5.27
3	6.67 ^a	1.37	3.98-9.36
NS	3.63 ^b	0.86	1.95-5.31

¹ 1 = Mild lameness, 2 = Moderate lameness, 3 = Severe lameness, NS = no score given at time of initial diagnosis

^{abc} means within a column without a common superscript differ ($P < 0.05$)

Table 4-12. Mortality rate by season of initial lameness diagnosis for individual animals having been previously diagnosed with lameness morbidity across six U.S. feedlots over a single 12-month period (%)

Season	Mortality, %	SEM	95% CI
fall	20.1 ^{ab}	2.4	15.3-24.8
spring	19.4 ^a	2.2	15.1-23.7
summer	18.3 ^a	2.0	14.4-22.1
winter	29.7 ^b	2.9	23.9-35.4

^{abc} means within a column without a common superscript differ ($P < 0.05$)

Table 4-13. Realizer (animals transported to harvest prior to pen mates) rate by season of initial lameness diagnosis for individual animals with lameness morbidity across 6 U. S. feedlots over a single 12-month period (%)

Season	Mean realizer rate, %	SEM	95% CI
fall	3.45 ^a	0.90	1.68-5.22
spring	9.76 ^b	1.83	6.17-13.34
summer	6.13 ^{ab}	1.21	3.76-8.5
winter	3.25 ^a	0.86	1.57-4.93

^{abc} means within a column without a common superscript differ ($P < 0.05$)

Appendix A - Questions for Consulting Nutritionists, Veterinarians, and Managers

Position title

- Consulting Nutritionist
- Consulting Veterinarian
- Feedyard Manager

If you are a manager, what is the size of your feedyard?

- 0-4,999
- 5,000-20,000
- >20,000

What is the predominant type of feeding facilities utilized?

- Confinement barn / deep bedded
- Confinement barn / slatted floor
- Open air/dirt floor

What percentage of feedyard cattle do you think suffer from lameness?

Of the cattle that suffer from lameness, what percentage require treatment?

- 0 to 10%
- 11 to 25%
- 26 to 50%
- 50%
- Don't know

What is the average percent death loss for cattle on feed?

Of the following, what percentage of your death loss is attributed to the following?

- BRD
- Digestive disorders
- Lameness
- Other

What is the average year-to-date realizer/chronic loss rate?

Of the following, what percentage of your realizer/chronic loss is attributed to the following?

- BRD
- Digestive disorders
- Lameness
- Other

At pen level, what criteria are used to identify a lameness pull?

- Any sign of lameness
- Lameness along with depression, apparent significant pain
- Lameness along with a decrease in performance

Pick the most common cause for lameness in feeder cattle?

- Foot Rot
- Hairy Heel Warts
- Hoof/ Ankle Injuries
- Laminitis
- Sole Bruises
- Toe Abscess
- White Line Disease

Pick the second most common cause for lameness in feeder cattle?

- Foot Rot
- Hairy Heel Warts
- Hoof/ Ankle Injuries
- Laminitis
- Sole Bruises
- Toe Abscess
- White Line Disease

Pick the third most common cause for lameness in feeder cattle?

- Foot Rot
- Hairy Heel Warts
- Hoof/ Ankle Injuries
- Laminitis
- Sole Bruises
- Toe Abscess
- White Line Disease

What tools are used for diagnosing the cause of the lameness in the chute? (Select all that apply)

- Palpation of foot, joints, and upper leg for swelling and heat
- Picking up the foot to visualize the bottom of the foot
- Picking up the hoof and using hoof testers
- Visualization of foot, joints, and upper leg for swelling
- None

What treatments are implemented to treat lameness in your feedyard/feedyards? (Select all that apply)

- Corrective trimming/ opening abscesses/ removing sole ulcers
- Injectable antimicrobial
- Topical treatment (antimicrobial, copper sulfate, etc.)

What are the most important contributing factors for infectious causes of lameness? (Select the top 3)

- Cattle age
- Cattle handling after arrival
- Cattle handling prior to arrival (auction market/transportation)
- Cattle temperament
- Cattle type more work
- Nutrition
- Pen Conditions
- Pen Surface
- Trace mineral program
- Weather Patterns

What are the most important contributing factors for non-infectious causes of lameness? (Select the top 3)

- Cattle age
- Cattle handling after arrival
- Cattle handling prior to arrival (auction market/transportation)
- Cattle temperament
- Cattle type more work
- Nutrition
- Pen Conditions
- Pen Surface
- Trace mineral program
- Weather Patterns

Do you make/receive recommendations for trace mineral programs at your feedyard/feedyards?

- Yes
- No

Where do you get lameness prevention and treatment information? (check all that apply)

- Feed / Mineral Companies
- Internet
- Local Coop
- Magazines
- Nutritionist
- Other Producers
- Training seminars
- Veterinarian
- Other

What are the economic losses to cattle that suffer from lameness that are never detected or treated?

- No economic losses
- 0 to \$50/head
- \$51 to 100/head
- \$101 to 200/head
- >\$200/head
- I don't know enough to guess

What are the economic losses to cattle that suffer from lameness that ARE detected and subsequently treated?

- No economic losses
- 0 to \$50/head
- \$51 to 100/head
- \$101 to 200/head
- >\$200/head
- I don't know enough to guess

Do you consider lameness to be a welfare concern?

- Yes
- No
- Growing

Do you feel more work needs to be done to better understand the impact of lameness in feeder cattle on feedlot operations?

- Yes
- No

Comments