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Bovine respiratory disease during the mid-portion of the feeding period: Observations of frequency, timing, and population from the field

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ABSTRACT

Objective: The objective of this study is to provide observations related to bovine respiratory disease (BRD) in high-performing cattle during the mid-portion of the feeding period describing the occurrence, timing, and population.

Materials and Methods: Data from a feedlot in Kansas were evaluated for temporal occurrence of BRD in high-performing and high-risk calves on a lot level. High-performing calves were categorized based on performance potential and carcass characteristics. High-risk calves were categorized based on administration of a macrolide at arrival processing. Cumulative incidence of BRD was evaluated within high-performing and high-risk categories. Models included the fixed effects of categorization (high performing and high risk), days on feed (DOF), and 2-way interaction between categorization and DOF and the random effect for repeated measures on individual lot. Additional data came from high-performing calves from Noble Research Institute cooperators' cattle from 2 separate feedlots.

Results and Discussion: The cumulative percentages of BRD for the high-performing and high-risk categories at 45 DOF were 33.7 and 67.2%, respectively. High-performing calves had BRD occurring later in the feeding period compared with high-risk calves. Cumulative BRD from the Noble Research Institute cooperators' calves had an earlier onset of BRD morbidity compared with other high-performing cattle.

Implications and Applications: Morbidity caused by BRD in high-performing cattle is greater than expected. Timing of BRD morbidity occurs at later DOF in high-performing calves compared with high-risk calves. Incidence for BRD occurred at ≥45 DOF in all 3 feedlots evaluated. Additional research is needed to identify potential causes for BRD morbidity during the mid-portion of the feeding period.

Key words: carcass weight, high-performing, quality grade, temporal

INTRODUCTION

Bovine respiratory disease (**BRD**) continues to be the most common and economically significant disease affecting the beef feedlot industry, accounting for $800 million to $900 million annually in economic losses from death, reduced feed efficiency, and treatment costs (Griffin, 1997; Brooks et al., 2011). Despite the advancements in technology and efficacy of products, feedlot death loss has continued to increase. From 1999 to 2011, feedlot death loss increased 23.1% from 1.3 to 1.6% (USDA, 2000, 2013). Feedlot closeout mortality has increased 0.04% per year from 2005 through 2014 (Vogel et al., 2015).

Over time, cattle producers have selected for steady to slightly decreased birth weight, increased growth rate, and increased carcass quality (Kuehn and Thallman, 2016; Lalman et al., 2019). Furthermore, feedlot finish BW and ADG has continued to increase (Vogel et al., 2015). In addition to genetic selection, producers have used practices such as preconditioning to improve the management of their cattle. Generally, preconditioning encompasses many management characteristics including administering respiratory vaccines, training cattle to use water and feed troughs, and weaning for a minimum of 45 d before feedlot entry (Cole, 1985; Seeger et al., 2011; Hilton, 2015). All of these management practices have individually and collectively improved the subsequent health outcomes of cattle while they are in the feedlot; however, there have been anecdotal observations of increased incidence of BRD at

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later days on feed (**DOF**) in these high-performing cattle that have gone through preconditioning programs.

Commingling, arrival sorting, and terminal sorting practices performed at commercial feedlots make it more difficult to assess the relationship of increased morbidity and mortality among preconditioned cattle; however, morbidity and mortality observations have been made on high-growth (performance potential of top 25% of cattle fed in the industry for ADG and feed conversion) and preconditioned cattle. Morbidity can lead to mortality and typically requires the use of an antibiotic treatment for animal welfare concerns and improved production outcomes. Mortality is not desired, but an animal that dies early in the feeding period has less resources (feed, hay, water, medicine, equipment, and labor) invested compared with animals that die later in the feeding period. The objective of this study was to provide observations related to BRD morbidity in high-performing cattle during the mid-portion of the feeding period (**MFP**) describing the occurrence and timing of BRD and the population in which BRD occurs during MFP.

MATERIALS AND METHODS

Data used in this experiment were acquired from cooperating feedlots, and no animals were used in this study. Therefore, no animal care and use approval was acquired.

Historic Carcass Outcomes from USDA

Monthly hot carcass weights for steers and heifers were obtained from the USDA Economic Research Service livestock and poultry live and dressed weights report from 1993 through 2018 (USDA, 2019b). Monthly hot carcass weights were averaged by year. The percent of cattle grading prime or choice was obtained from the USDA Agriculture Marketing Service Meat Grading Report for each year from the same time period (USDA, 2019a). The percentages of prime and choice carcasses were determined based on the total pounds of meat graded each year.

Retrospective Temporal BRD Patterns in High-Performing and High-Risk Populations

Health record data were evaluated from a commercial feedlot (Hy-Plains Feedyard LLC, Montezuma, KS) located in southwest Kansas from 2017 and 2018. Hy-Plains Feedyard LLC is a custom feeding operation that provides services for retained ownership as well as customers purchasing calves from sale barns. Lots were categorized into high-performing and high-risk groups. High-performing lots were categorized based on performance potential of top 25% of cattle fed in the industry for ADG and feed conversion with high-quality carcasses that were 90% prime and choice from the retained ownership population for arrival weight, sex, and time of year. Expected performance potential was categorized based on breeding decisions made at the cow-calf operation. All of the lots that met the inclusion criteria at Hy-Plains Feedyard LLC during the time period that were single sex lots were included in the analyses. Lots were from multiple different sources across the United States.

High-risk calves were categorized based on administration of a macrolide antimicrobial at arrival processing. The decision to metaphylactically treat individual lots was based on subjective risk classification by feedlot personnel with oversight from a consulting veterinarian. The subjective risk classification was independently and collectively based on origin, distance traveled, arrival BW, shrink, and visual appearance of the calves upon arrival to the feedlot, as well as environmental conditions.

Individual lots that did not meet the inclusion criteria for high-performing or high-risk categorization were removed from the data set before analysis. First treatment for BRD health records were selected, and data were imported into a commercial software program (RStudio Team 2016, Boston, MA). Case definition for BRD was made by feedlot personnel trained by veterinarians. Case definition of BRD was based on presence of depression or lethargy, dyspnea, abnormal respiration, sunken eyes, dehydration, nasal discharge, ocular discharge, lowered head carriage, or depressed ruminal fossa. Daily cumulative incidence of BRD was evaluated within high-performing and high-risk categories. Models included the fixed effects of categorization (high performing and high risk), DOF, and the 2-way interaction between categorization and DOF and the random effect for individual lot, and covariates for arrival BW, sex, and arrival quarter. Cumulative BRD incidence was modeled as a binomial proportion. Data were transformed to arithmetic means. Cumulative incidence of BRD morbidity was extended for lots that closed out before 200 DOF to allow each lot to have equal weight in the temporal pattern. For example, if a lot closed out with 15% incidence for BRD at 150 DOF, data were extended from 151 to 200 DOF at 15% incidence for BRD. Because most incidence of BRD was early in the feeding period, extending to a common 200 DOF for lots that closed out earlier should give equal weight in the temporal pattern analyses. Incidence of BRD morbidity and mortality data were also evaluated for both categories. Cumulative percentage of BRD cases was evaluated by DOF for high-performing and high-risk populations.

Repeatability of Health Outcomes: Retrospective Health Observations from Noble Research Institute Cooperators

Health outcomes from cattle sourced from Noble Research Institute (Noble Research Institute, Ardmore, OK) cooperating producers were tracked at 2 separate feedlots. One of the feedlots was in Kansas, and the other feedlot was located in Texas. All cattle in this data set from producers associated with the Noble Research Institute used a herd health protocol that incorporates vaccination, deworming, and castration of male calves before shipment to the feedlot. Case definition for BRD was determined by feedlot personnel, and definition was not standardized among the feedlots; however, each of the feedlots used a similar case definition for BRD relying on pen riders for observation. Case definition of BRD was based on presence of depression or lethargy, dyspnea, abnormal respiration, sunken eyes, dehydration, nasal discharge, ocular discharge, lowered head carriage, or depressed ruminal fossa. Data on first treatment for BRD health were extracted, and temporal BRD morbidity patterns were evaluated as described previously.

RESULTS AND DISCUSSION

Historic Carcass Outcomes from the USDA

There has been great genetic improvement of beef cattle during the past 25 yr, with DMI and ADG increasing in most breeds as producers select for increased growth traits (Retallick et al., 2017). As QG improved, steer and heifer carcass weights also increased (Figure 1). Steer carcass weights have increased 2.39 kg (5.26 lb) per year, and heifer carcass weights have increased 2.30 kg (5.07 lb) per year from 1994 to 2018. Increased carcass weights and improved QG have largely been accomplished by cow-calf producers using genetics with increased growth potential, using technologies including implants and β agonists (Wileman et al., 2009; Vogel et al., 2015), and increasing DOF at the feedlot.

We continue to produce more kilograms of boxed beef with fewer animals due to a wide variety of improvements; United States beef cow numbers have decreased 10.7% over the past 25 yr (USDA, 2019c) Furthermore, the improved QG and carcass weights have resulted in productions of a high-quality product; however, the authors hypothesize there has been little emphasis on the relationship between the cardiopulmonary system and the increased body mass of the feedlot calf. Compared with other animals, cattle have decreased lung volume relative to total body mass (Gallivan et al., 1989). Increasing the BW of cattle may result in increased susceptibility to disease if the relationship between cardiopulmonary capability and total body mass changes and continues to decrease because of increasing BW. Increased adipose deposition has been shown to be related to cardiopulmonary remodeling (including left ventricular fibrosis, pulmonary venous and arterial hypertension, and subsequent right ventricular fibrosis) and heart failure in feedlot cattle (Krafsur et al., 2019). Pulmonary arterial pressure is a measure of blood flow resistance through the lungs and is used as a predictor of brisket disease at high altitude (Holt and Callan, 2007). Pulmonary arterial pressure in cattle increases with age, BW, and altitude (Neary et al., 2015a,b); however, weaning weight and pulmonary arterial pressure is positively correlated (Shirley et al., 2008). Additional research is needed to fully understand the effect of pulmonary function capability of the bovine lung and increased growth rates on BRD incidence. Larger-scale studies are needed to evaluate all potential risk factors and phenotypes for BRD during the MFP, to identify the potential drivers of disease.

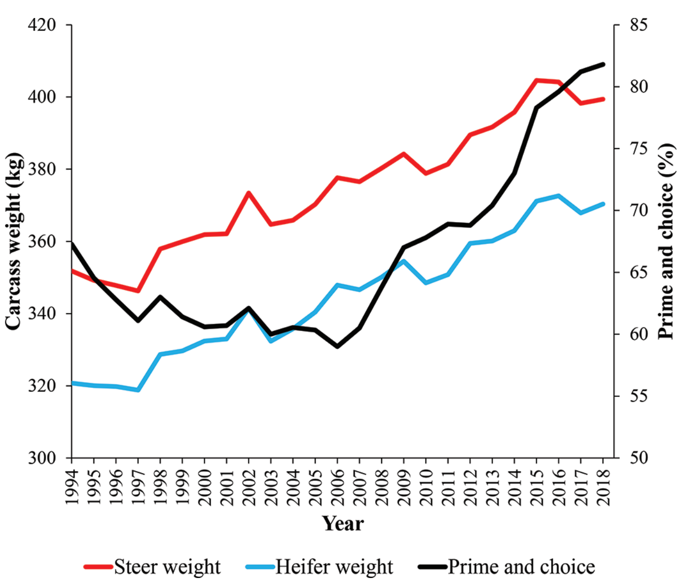

Figure 1. Historical average steer and heifer carcass weights (USDA, 2019b) and percentage of calves grading prime and choice (USDA, 2019a) in the United States from 1994 to 2018.

Retrospective Temporal BRD Patterns in High-Performing and High-Risk Populations

Descriptive health and performance outcomes for high-performing and high-risk calves are presented in Table 1. There was a significant interaction ($P < 0.01$) between DOF and classification status on cumulative BRD incidence (Figure 2). Covariates for arrival BW category ($P = 0.04$), sex ($P = 0.01$), and arrival quarter ($P < 0.01$) were all statistically significant. Actual average cumulative incidence for BRD in the high-performing group was 12.8% (range 2.8 to 36.1%), and average cumulative incidence for BRD in the high-risk group was 15.1% (range 1.0 to 54.1%). Cumulative BRD incidence in the high-performing category was greater than desired. Overall mortality in the high-performing category was 2.54% (range 0 to 7.14%), which was greater than desired as well. Overall mortality in the high-risk category was 4.83% (range 0 to 26.78%). The authors included all of the lots that met the initial inclusion criteria as the data actually occurred. The authors have observed high-risk calves with 0% mortality and low-risk calves with >10% mortality. All calves included in the high-performing group were preconditioned and received a minimum of one modified-live viral vaccine and *Mannheimia haemolytica* vaccine before shipment to the feedlot. Additional collaboration through the supply chain is needed to identify potential causes for morbidity and mortality to make improvements.

Causative reasons for BRD include not only pathogen exposure, but the entire host, environment, and pathogen

Table 1. Descriptive statistics (quartile 1, quartile 3 in parentheses) of high-performing and high-risk classifications of individual lots from a southwest Kansas commercial feedlot[1] used for temporal bovine respiratory disease comparison

Parameter	High performing	High risk
Number of lots (no.)	27	171
Number of calves received (no.)	2,405	13,597
In weight (kg)	331.7 (298.5, 364.5)	320.6 (282.2, 358.0)
ADG[2] (kg/d)	1.54 (1.41, 1.68)	1.43 (1.28, 1.60)
G:F[2]	0.1520 (0.1425, 0.1627)	0.1486 (0.1415, 0.1623)
Out weight (kg)	611.7 (594.7, 629.3)	588.2 (553.9, 628.2)
Mortality (%)	2.54 (1.15, 3.81)	4.83 (1.67, 6.71)
Hot carcass weight (kg)	384.4 (371.5, 393.4)	N/A[3]
DP (%)	64.31 (63.84, 64.79)	N/A
QG prime and choice (%)	94.78 (92.07, 99.16)	N/A

[1]Hy-Plains Feedyard LLC (Montezuma, KS).

[2]Dead animals were included in analysis.

[3]N/A = data not available due to marketing strategy.

disease triad. Focusing on only one portion of the disease triad will most likely result in minimal effect in reducing disease. There are many hypotheses, but to the authors' knowledge, no published studies have been conducted to evaluate potential causes of BRD in the MFP. Although

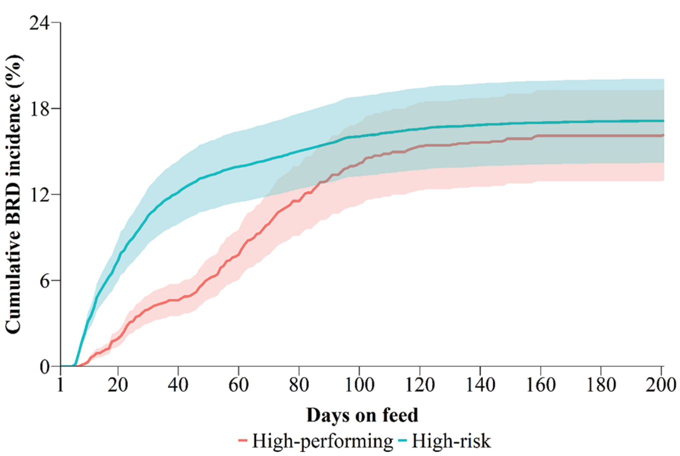

Figure 2. Retrospective cumulative bovine respiratory disease (BRD) incidence (±SE) from high-performing and high-risk lots at a southwest Kansas commercial feedlot (Hy-Plains Feedyard LLC, Montezuma, KS). Model included random effect for repeated measures on individual lot, and covariates for arrival BW, sex, and arrival quarter. There was a significant interaction (P < 0.01) between days on feed and classification status on cumulative BRD incidence. High-performing lots were selected with the genetic capabilities to have high-performing (top 25% of cattle fed in the industry for ADG and feed conversion) and high-quality carcass characteristics (estimated >90% prime and choice). High-risk lots were administered a macrolide at arrival processing based on subjective risk classification by feedlot personnel.

the overall BRD incidence is similar between high-performing and high-risk categories, it is important to note lots from the high-risk group were administered metaphylaxis during arrival processing. Metaphylaxis consistently reduces morbidity (Wileman et al., 2009), and magnitude of effect is determined based on the type of antimicrobial used (Abell et al., 2017). None of the calves in the high-performing group were administered metaphylaxis. Efforts to perform preconditioning programs and administer vaccinations before the feedlot reduce BRD morbidity (Taylor et al., 2010; Hay et al., 2016).

United States feedlot closeouts from 2000 to 2008 showed 13% of the lots in a feedyard displayed an inflection point of increased BRD morbidity at approximately 40 DOF (Babcock et al., 2010). An additional 5% of the lots showed the inflection point at approximately 65 DOF (Babcock et al., 2010). The inflection point for the high-risk and high-performing groups occurred at 7 and 45 DOF, respectively (Figure 3). The current data provide evidence for the population where BRD occurs during the MFP. The authors define MFP BRD as incidence for BRD occurring between 45 and 120 DOF based on temporal patterns of BRD. The cumulative percentages of BRD for the high-performing and high-risk categories at 45 DOF were 33.7 and 67.2%, respectively. These results indicate BRD occurs later in the feeding period for high-performing cattle compared with high-risk cattle. The traditional belief of feedlot managers and pen riders is that once cattle reach 30 to 45 DOF, the bulk of morbidity has already occurred (Buhman et al., 2000; Babcock et al., 2010); however, high-performing cattle appear to break with respiratory disease later than traditional morbidity patterns. Feedlot management needs to be aware of the timing and occurrence of BRD during the MFP in high-performing cattle to develop appropriate management strategies.

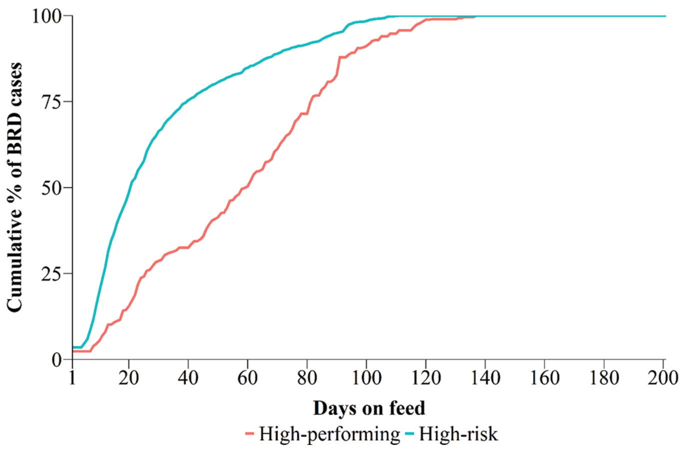

Figure 3. Cumulative percentage of bovine respiratory disease (BRD) cases within high-performing and high-risk lots of feedlot cattle at a southwest Kansas commercial feedlot (Hy-Plains Feedyard LLC, Montezuma, KS).

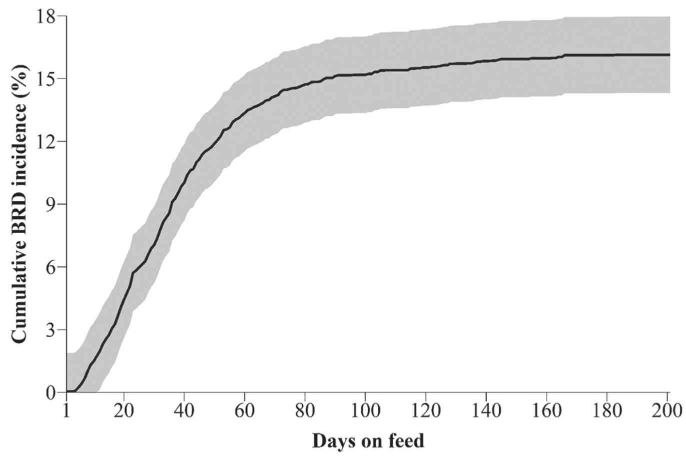

Figure 4. Cumulative bovine respiratory disease (BRD) incidence (±SE) from 4,346 high-performing steers and heifers fed at a Kansas feedlot from 2017 to 2019 in 37 different lots. Model included random effect for repeated measures on individual lot.

Calves treated later in the feeding period require a larger dose of antibiotics due to increased BW, as dosage is based on BW. Adipose tissue is deposited in feedlot cattle throughout the cattle feeding period. Adipose cells have a large amount of pro-inflammatory cytokines and are involved in the immune response with inflammatory insult (Rosen and Spiegelman, 2006; Desruisseaux et al., 2007). The increased quantity of pro-inflammatory cytokines may partially explain the rapid progression of onset in MFP BRD cases. Affected calves often appear clinically normal and 8 h later may appear severely morbid. The authors have observed the rapid progression of BRD even with veterinarians performing daily observations on the calves. Some cases progress rapidly and result in death even with keen pen-rider observation. Cases have a febrile response (≥40.0°C; 104.0°F) and respond to antibiotic treatment within expectations (Theurer et al., 2015). Cattle have a natural rectal temperature diurnal pattern related to environmental conditions, which may explain the febrile cases (Theurer et al., 2014); however, cases occur during the winter, spring, and fall seasons as well when the temperature-humidity index is lower than in summer months. The rapid progression of disease, timing, and population that occurs makes managing MFP BRD frustrating for feedlot personnel.

Repeatability of Health Outcomes: Retrospective Health Observations from Noble Research Institute Cooperators

Cumulative BRD incidence for the Noble Research Institute cooperators from the Kansas feedlot (Figure 4) and Texas feedlot (Figure 5) had an earlier onset of BRD morbidity observed descriptively to the high-performing group. Health records from the Texas feedlot were only able to be provided in 15-d intervals for temporal evaluation. At 45 DOF, 69.2 and 78.0% of the morbidity had already occurred for calves at the Kansas and Texas feedlots, respectively; however, both feedlots had BRD incidence past 45 DOF. Additional studies are needed to identify reasons why only a portion of cattle are affected with BRD, whereas cohorts are unaffected even though all of them have been through the same management and environmental systems. Research to determine whether MFP BRD is an issue at the individual-animal or lot level will help develop future projects and management strategies to evaluate. The health outcomes observed during the initial 45 DOF can be influenced by transportation stress (Coffey et al., 2001; Arthington et al., 2003), distance traveled (Cernicchiaro et al., 2012a), shrink (Cernicchiaro et al., 2012b), and adaptation to feedlot environment. Individual lots of cattle with high morbidity are not uncommon in the feedlot industry (Theurer et al., 2015) but create concerns because of decreased profitability, lower quality carcass, increased antimicrobial use, and negative effects

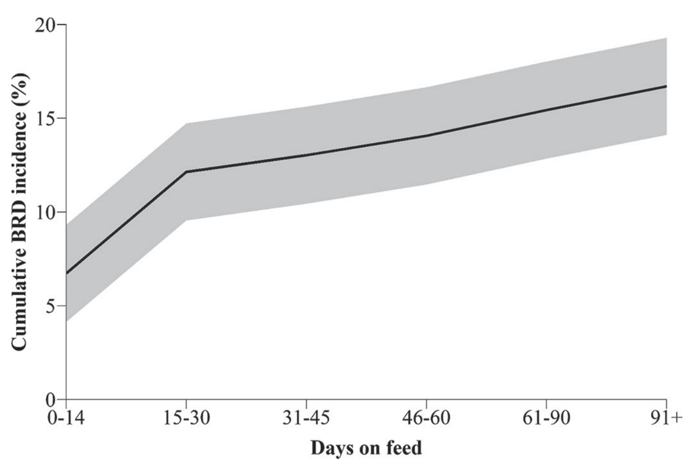

Figure 5. Cumulative first bovine respiratory disease (BRD) treatment (±SE) of 1,012 of high-performing steers and heifers fed at a Texas feedlot in 2016 in 7 different lots. Model included random effect for repeated measures on individual lot.

on animal welfare (Gardner et al., 1999; Reinhardt et al., 2009; Holland et al., 2010; Theurer et al., 2019).

Limitations of the current study include the limited amount of data as additional data are necessary for more thorough analyses; however, the beef supply chain is not structured to share information throughout the supply chain (Peel, 2020). Efforts to collect information on calves from the ranch through the feedlot are warranted to make improvements (Peel, 2020). Additional limitations include the feedlots where calves were fed were located in Kansas and Texas. The authors have observed MFP BRD in other geographic regions of the United States as well.

APPLICATIONS

Morbidity caused by BRD in high-performing cattle is greater than expected and desired. Timing of BRD morbidity occurs at later DOF in high-performing calves compared with high-risk calves. Incidence of BRD occurred at ≥45 DOF in all 3 feedlots evaluated. Additional research is needed to identify potential causes of BRD morbidity during the MFP. Research needs to focus on the entire host, environment, and pathogen triad. The beef industry must work collaboratively to better understand the health issue and potential implications up and down the supply chain.

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