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PRODUCTION AND MANAGEMENT: *Original Research*

Bovine respiratory disease during the mid-portion of the feeding period: Observations from vaccination history, viral and bacterial prevalence, and rate of gain in feedlot cattle

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ABSTRACT

Objective: The objective of this research was to provide preliminary observations related to bovine respiratory disease (BRD) morbidity in high-performing cattle related to cow-calf operations, number of vaccines received before the feedlot, viral and bacterial presence in the nasal cavity during the mid-feeding period, and rate of gain related to incidence of BRD.

Materials and Methods: Health outcomes were evaluated from 4,346 cattle. Cattle were evaluated by the number of modified-live-viral, *Mannheimia haemolytica*, *Histophilus somni*, or *Clostridia* spp. vaccines administered before feedlot entry. Individual animal rate of gain was evaluated by incidence of BRD. Nasal swabs were collected from BRD cases and controls to evaluate presence of viruses and bacteria.

Results and Discussion: First treatment for BRD was associated with the number of times cattle received modified-live-viral vaccines before the feedlot ($P = 0.02$). Cattle administered a modified-live-viral vaccine 3 times before the feedlot had a greater first treatment for BRD (21.32%) compared with cattle vaccinated 1 time (9.56%; $P = 0.06$). Cattle that developed BRD had lower ($P < 0.01$) ADG through the first 30 d on feed compared with clinically healthy cattle. Preliminary nasal swab PCR results show common respiratory viral or bacterial pathogens were not identified in BRD during the mid-feeding period.

Implications and Applications: There is great variability in BRD morbidity among cow-calf operations. A greater number of vaccinations administered before the feedlot was detrimental to health outcomes. Additional research is needed to further evaluate the entire host, environment, and pathogen triad for development of BRD.

Key words: health, pathogen, polymerase chain reaction, vaccine

INTRODUCTION

Bovine respiratory disease (**BRD**) continues to be the most common and economically significant disease affecting the feedlot industry (Griffin, 1997; Brooks et al., 2011). Practices performed on cow-calf operations have been shown to improve health outcomes in the feedlot (Seeger et al., 2008; Hay et al., 2016). The Noble Research Institute works with a large number of cow-calf producers in the southern Great Plains that keep detailed records of management practices. Many of these producers use a herd health protocol that incorporates vaccination, deworming, and castration of male calves before shipment to the feedlot. Those adhering to the herd health protocol are allowed some flexibility to determine which brand of products to use and when to administer the protocols to allow effective integration into their program. At a minimum, the cattle must receive one multivalent clostridial bacterin/toxoid, viral respiratory complex, and bacterial vaccine (i.e., *Mannheimia*, *Pasteurella*, *Histophilus*, or all 3) before shipment to the feedlot. Producers must also wean and precondition the cattle for a minimum of 60 d before shipping. Further, the producers are required to test for and maintain a negative herd status for persistently infected bovine viral diarrhea virus. These producers have selected for cattle with increased growth characteristics, including weaning weight, yearling weight, and ADG, that are consistent with the type of cattle that experience increased BRD during the mid-portion of the feeding period (**MFP**)

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at the feedlot (Theurer et al., 2021). The authors define MFP BRD as first treatment for BRD occurring between 45 and 120 d on feed (**DOF**), which occurs later than typical morbidity patterns (Babcock et al., 2010).

Commingling and sorting practices performed at commercial feedlots make it difficult to assess the relationship of BRD with management strategies performed at the cow-calf operations. There have been anecdotal observations of BRD at later DOF (≥45 DOF) in preconditioned and high-performing cattle that do not follow typical morbidity patterns (Babcock et al., 2010). These observations have been made on preconditioned cattle that have generally been selected for their high growth and carcass characteristics. The objective of this study was to provide preliminary observations related to BRD morbidity in high-performing cattle related to cow-calf operations, number of vaccines received before the feedlot, nasal swab evaluating viral and bacterial presence during the MFP, and rate of gain related to incidence of BRD.

MATERIALS AND METHODS

Data used in this experiment were acquired from cooperating feedlots or procedures and were approved by the Veterinary Research and Consulting Services LLC Institutional Animal Care and Use Committee (IACUC number 1005) before study initiation.

Health Outcomes by Cow-Calf Operation

A total of 4,346 cattle from 36 different cow-calf operations that were Noble Research Institute cooperators were fed at a commercial feedlot in Kansas in 2017 through 2019. Sixteen of the cow-calf operations participated in both years, whereas 20 of the cow-calf operations only participated 1 yr. Lot level average arrival pay weight was 328.1 kg (range 255.8 to 399.6 kg). Average DOF at first treatment for BRD was 41 (range 1 to 184 DOF; median 35 DOF). All cattle were backgrounded for a minimum of 60 d before shipping to the feedlot. Each cow-calf operation would have adhered to a herd health protocol that incorporated vaccination, deworming, and castration of male cattle before shipment to the feedlot. Cattle all had a low-frequency radio frequency identification tag placed in each calf at the cow-calf operation, which allowed health records from the feedlot to be traced back to each cow-calf operation. None of the cattle were administered metaphylaxis at the feedlot. Health records such as BRD first treatment, BRD mortality, and overall mortality at the feedlot were extracted. Separate binary variables were created to identify cattle based on first treatment for BRD, BRD mortality, and overall mortality.

Effects of Previous Vaccines at Cow-Calf Operation on BRD

Variation in individual producer vaccination protocols allowed for a retrospective analysis to evaluate the relationship between the number of times vaccines were administered at the cow-calf operation of origin and health outcomes in the feedlot. Individual animal health outcomes from the feedlot were traced back to vaccine programs used on the cow-calf operation of the same 4,346 cattle as described previously. Health outcomes were evaluated by the number of times a modified-live-viral (**MLV**) vaccine, *Mannheimia haemolytica*, *Histophilus somni*, or *Clostridia* spp. was administered before feedlot entry. A producer had to provide a minimum of 10 cattle to be included for these analyses. There also had to be at least 2 different producers that administered the number of vaccines for each outcome evaluated. There were a total of 469 cattle from 7 different cow-calf operations that administered an intranasal MLV vaccine, and these intranasal vaccines were counted the same as subcutaneous MLV administration (Erickson et al., 2020).

Data were imported into a commercial software program (RStudio Team 2016, Boston, MA). Independent models were performed evaluating the number of MLV, *Mannheimia haemolytica*, *Histophilus somni*, or *Clostridia* spp. vaccines. First treatment for BRD was evaluated by the number of vaccines administered before feedlot entry and was analyzed using generalized linear mixed statistical models with binomial link function. Days on feed at first treatment for BRD were evaluated by the number of vaccines administered before feedlot entry and were analyzed using general linear mixed models with Gaussian link function. All data are transformed back as arithmetic means. All models included random effects for producer, year, lot, and covariates for average in weight of lot at feedlot arrival and number of days preconditioned. A P-value ≤ 0.05 was considered statistically significant for main effects of number of vaccinations administered. Pairwise comparisons between the number of times the vaccine was administered before the feedlot were performed when main effect was significant. A P-value ≤ 0.10 was considered statistically significant for pairwise comparisons after adjusting for multiple comparisons using Tukey methods.

Effects of Rate of Gain on Feedlot BRD

A small-scale, prospective longitudinal study was performed to evaluate the backgrounding program on health performance. A total of 112 Angus, Charolais, Hereford crossbred steers from the Noble Research Institute, with known birth dates and BW, were divided into 2 groups and grazed on grass paddocks and small grain cereal pasture. After completion of their respective grazing periods, steers were transported to a commercial feedyard and followed to slaughter. Individual animal health outcomes were evaluated at the feedlot relative to growth rate, allowing individual animal to serve as the experimental unit.

At weaning, both groups of steers were administered a MLV vaccine containing bovine herpesvirus-1 (**BHV-1**), bovine viral diarrhea virus (**BVDV**) types 1 and 2, bovine respiratory syncytial virus (**BRSV**), and bovine influenza

virus (Bovi-Shield Gold 5, Zoetis Animal Health, Parsippany, NJ); an intranasal avirulent live *Pasteurella multocida* and *Mannheimia haemolytica* vaccine (Once PMH IN, Merck Animal Health, Whitehouse Station, NJ), albendazole (Valbazen Suspension, Zoetis Animal Health), a *Clostridium chauvoei*, *Clostridium septicum*, *Clostridium haemolyticum*, *Clostridium novyi*, *Clostridium sordellii*, and *Clostridium perfringens* types C and D vaccine (Vision 8 with Spur, Merck Animal Health); *Fusobacterium necrophorum* bacterin (Fusogard, Elanco Animal Health, Greenfield, IN); and topical permethrin. Steers were revaccinated at 30 d after weaning with a MLV vaccine and *Fusobacterium necrophorum* bacterin (Ultra Boss, Merck Animal Health). All steers were individually weighed at weaning and revaccination and upon completion of the preconditioning period.

Steers were processed the day following feedlot arrival. During arrival processing, steers were administered a MLV vaccine containing BHV-1 and BVDV types 1 and 2 (Pyramid 3, Boehringer Ingelheim, Duluth, GA), moxidectin (Cydectin, Bayer Animal Health, Shawnee Mission, KS), oxfendazole (Synanthic, Boehringer Ingelheim), and a trenbolone acetate (80 mg)/estradiol (16 mg) growth-promoting implant (Revalor-IS, Merck Animal Health). Steers were individually weighed during arrival processing and at 34 DOF for group 1 and 31 DOF for group 2 to evaluate growth rate in the feedlot.

Individual animal data from both groups were aggregated to evaluate growth rates relative to BRD incidence at the feedlot by visual histograms. Outcomes evaluated included birth weight, weaning weight, feedlot arrival weight, shrink, ADG from birth to weaning, ADG from birth through the preconditioning period, ADG during the preconditioning period, ADG during the first 30 DOF (approximate) in the feedlot, and ADG from birth through the first 30 DOF in the feedlot all related to incidence of BRD. All the ADG calculations at the feedlot were calculated compared with the individual steer BW captured during arrival processing.

Data were imported into a commercial software program (RStudio Team 2016). A linear mixed model was used to evaluate ADG during the first 30 DOF by BRD status for individual animal. The model included random effect for arrival group at the feedlot.

Virus and Bacteria Prevalence

A small, prospective case-control study was performed to evaluate the prevalence of viruses and bacteria in cattle with MFP BRD at a cooperating southwest Kansas feedyard (Hy-Plains Feedyard LLC, Montezuma, KS). When pen riders identified an animal with clinical signs of BRD (n = 4), a clinically healthy calf was pulled from the same pen to serve as a control (n = 4). Inclusion criteria for the case-control study were first treatment for BRD ≥45 DOF and pulled from high-performing lots. High-performing lots were defined as being in the top 25% of cattle fed for ADG and low feed conversion with high-quality carcasses that were >90% prime and choice. Two additional clinically normal cattle from 2 different lots in the feedlot with similar DOF and performance potential, clinically healthy, were selected for healthy cohort comparison. Rectal temperatures were collected from all cases, controls, and healthy cohorts. Anterior nasal swabs were collected using a sterile swab applicator and placed inside the nares to collect nasal mucous as previously described (Frank and Briggs, 1992; Frank et al., 2000). Nasal swabs were collected and submitted for PCR testing for BHV-1, BVDV, BRSV, bovine corona virus, bovine influenza virus, *Mannheimia haemolytica*, *Pasteurella multocida*, *Mycoplasma bovis*, *Histophilus somni*, and *Bibersteinia trehalosi*. Cycle threshold values <37 were interpreted as positive for the pathogen, cycle thresholds between 37 and 39 were interpreted as suspect, and cycle threshold values >39 were interpreted as negative for the pathogen. Only descriptive analyses were performed on all nasal swab outcomes.

An additional 22 nasal swabs from a commercial feedyard (feedyard A) and 6 nasal swabs from a second feedyard (feedyard B) were collected from cases of MFP BRD morbidity. Cases from feedyard A were selected from first BRD treatments from 30 to 100 DOF, displayed clinical signs of BRD, and were febrile (≥40°C; 104.0°F). Cases from feedyard B were collected from first BRD treatment at approximately 80 DOF, displayed clinical signs of BRD, and were febrile (≥40°C; 104.0°F). All cases from both feedyard A and feedyard B had no previous respiratory-related treatments at the feedyard. Three to 5 nasal swab samples were pooled and submitted for viral and bacterial (feedyard A) or only viral (feedyard B) PCR testing. Viral PCR was only evaluated in feedyard B to limit diagnostic expense. All pooled PCR results are presented.

RESULTS AND DISCUSSION

There was a great amount of variation in health outcomes evaluated by cow-calf operation (Table 1); however, the overall incidence of first treatment BRD and death loss was greater than expected. All cattle included in the analysis would have been administered herd health protocols and weaning strategies to prepare cattle for the feedlot (Seeger et al., 2008; Richeson et al., 2019). Weaning and preconditioning are still recommended to improve health outcomes in the feedlot.

First treatment for BRD was associated with the number of times cattle received MLV vaccine before the feedlot ($P = 0.02$; Figure 1A). Cattle administered MLV vaccine 3 times before the feedlot had a greater proportion of cattle treated for BRD first treatment compared with cattle vaccinated 1 time before the feedlot ($P = 0.06$). There were no differences between cattle vaccinated 1 and 2 times with a MLV vaccine ($P = 0.91$), 1 and 4 times with a MLV vaccine ($P = 0.94$), 2 and 3 times with a MLV vaccine ($P = 0.15$), or 2 and 4 times with a MLV vaccine

Table 1. Health outcomes of high-performing feedlot steers and heifers by individual cow-calf operation sorted in descending order for bovine respiratory disease (BRD) first treatment

Cow-calf operation	Number of cattle	BRD first treatment (%)	BRD mortality (%)	Total mortality (%)
1	19	78.95	15.79	15.79
2	3	66.67	0.00	0.00
3	2	50.00	0.00	0.00
4	27	40.74	3.70	3.70
5	10	40.00	0.00	0.00
6	8	37.50	0.00	0.00
7	54	37.04	3.70	5.56
8	14	35.71	0.00	0.00
9	17	35.29	0.00	0.00
10	210	32.86	4.76	5.24
11	510	30.59	2.75	3.33
12	214	27.57	1.87	2.34
13	34	26.47	0.00	8.82
14	151	22.52	1.32	3.97
15	37	21.62	5.41	5.41
16	33	21.21	0.00	3.03
17	95	18.95	1.05	1.05
18	138	18.84	0.00	1.45
19	126	17.46	0.79	0.79
20	58	17.24	1.72	3.45
21	105	17.14	1.90	1.90
22	660	15.45	1.36	1.97
23	75	14.67	1.33	4.00
24	75	9.33	1.33	1.33
25	12	8.33	0.00	0.00
26	328	8.23	0.30	0.61
27	134	8.21	0.75	2.24
28	45	6.67	0.00	0.00
29	355	6.20	0.28	1.13
30	200	6.00	0.50	2.50
31	161	5.59	0.00	1.86
32	138	5.07	1.45	3.62
33	141	2.84	0.00	0.71
34	37	2.70	0.00	0.00
35	48	2.08	0.00	0.00
36	72	1.39	0.00	1.39
Total	4,346	16.61	1.38	2.32

($P = 0.80$). There was no difference in BRD morbidity in cattle vaccinated 4 times compared with 3 times with a MLV vaccine before the feedlot ($P = 0.20$); however, it is important to note the relatively few number of cattle and cow-calf operations represented in the 4 MLV vaccines before feedlot (281 cattle from 3 different cow-calf operations). Follow-up research with more observations with the number of MLV vaccines administered is warranted. The number of times cattle were vaccinated with *Mannheimia haemolytica* ($P = 0.15$), *Histophilus somni* ($P = 0.32$), and *Clostridia* spp. ($P = 0.93$) vaccines was not significantly associated with first treatment for BRD at the feedlot (Figure 1). Table 2 shows the number of cattle and cow-calf producers included in final analysis for each of the vaccines evaluated. Average DOF at first treatment for BRD was not associated with the number of MLV ($P = 0.71$), *Mannheimia haemolytica* ($P = 0.99$), *Histophilus somni* ($P = 0.21$), and *Clostridia* spp. ($P = 0.70$) vaccines received before the feedlot (Figure 2).

Both MLV and *Mannheimia haemolytica* vaccines have been shown to reduce morbidity (Larson and Step, 2012; Theurer et al., 2015a). All cattle had to receive at least 1 MLV and *Mannheimia haemolytica* vaccine before the feedlot as part of the herd health protocol; therefore, cattle without these vaccines were not available for comparison. *Histophilus somni* vaccine was an optional vaccine for cow-calf operations to administer, and there was no difference in BRD morbidity between cattle administered 0, 1, or 2 *Histophilus* vaccines before the feedlot, which agrees with published summarized results of *Histophilus* vaccine (Larson and Step, 2012). The authors are not suggesting discontinuing the use of vaccines before feedlot entry, but in this analysis, increasing the number of times cattle were vaccinated with these vaccines did not decrease BRD morbidity. Cattle that were administered 3 MLV vaccines had increased BRD morbidity, indicating more vaccination may not result in improved health outcomes. The authors initially wanted to evaluate health outcomes by specific vaccination products and timing when vaccination occurred (birth, branding, preweaning, weaning, backgrounding, and so on), but due to the limited number of cow-calf operations and other confounding variables, there were not enough observations to appropriately evaluate (White and Larson, 2015; White et al., 2016). It is important to note all 4,346 head of calves were backgrounded for a minimum of 60 d before shipping to the feedlot. The authors do not know if extrapolation of results to unweaned calves would be appropriate. Another factor to consider is cow-calf producers may have been more likely to add additional vaccines if previous health issues were present to reduce morbidity. While the analysis evaluated the different number of vaccines administered, the analysis would have included all management factors on the cow-calf operation. There were 36 different cow-calf operations, which allowed for enough variation and appropriate comparisons to account for these confounding effects; however, a data set with more cow-calf operations or a randomized study would allow for more robust analysis.

To the authors' knowledge, the current study provides the first data evaluating individual animal rate of gain during the first 30 d in the feedlot related to BRD. Only ADG during the first 30 DOF in the feedlot had any relationship with development of BRD (Figure 3; $P < 0.01$). Cattle gaining the least amount of weight were those that developed BRD. Only one steer was treated for BRD before the 30 DOF weight collection. The ability to accurately diagnose BRD is poor (White and Renter, 2009;

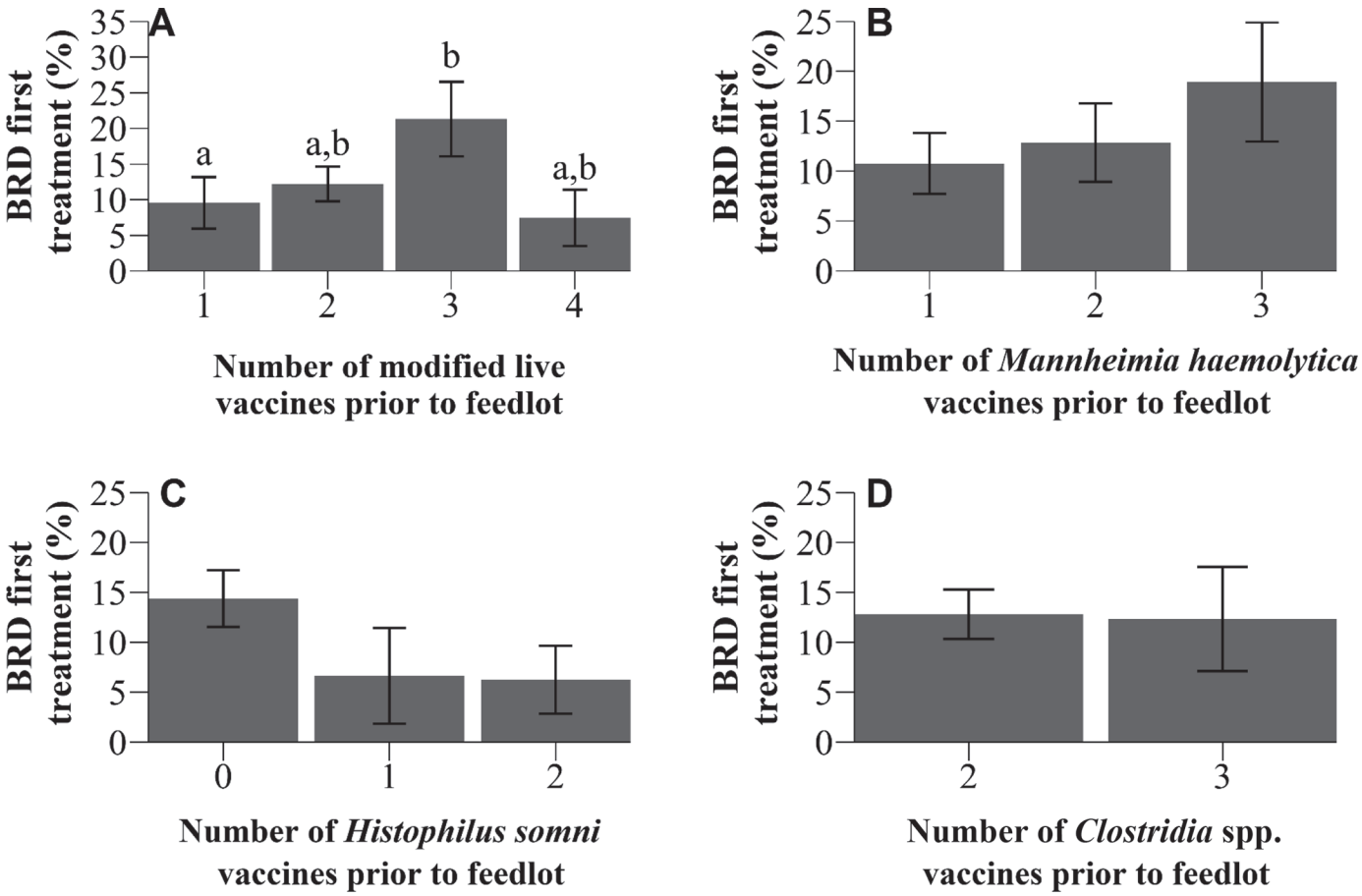

Figure 1. Model-adjusted bovine respiratory disease (BRD) first treatment (±SE) at the feedlot by number of modified-live vaccines (A; $P = 0.02$) and *Mannheimia haemolytica* (B; $P = 0.15$), *Histophilus somni* (C; $P = 0.32$), and *Clostridia* spp. (D; $P = 0.93$) vaccinations received before entering the feedlot. Model included random effects for producer, year, lot, and covariates for average in weight of lot at feedlot arrival and number of days preconditioned. Means without common letters (a, b) differ ($P < 0.10$; adjusted for multiple comparisons). Data were obtained from the Noble Research Institute (Ardmore, OK) cooperator herds.

Theurer et al., 2015c). Cattle are prey animals and make efforts to hide disease. To this point, steers with low ADG at 30 DOF may have had subclinical BRD at the time of weighing, as cattle affected with BRD have decreased performance compared with healthy cohorts (Theurer et al., 2015b; Nickell, 2016). Another hypothesis is that steers with low ADG were not consuming enough ration to support both growth and immune function. Additional

Table 2. Number of cattle and different cow-calf operations included in the retrospective analysis of health outcomes at the feedlot by number of vaccines administered before feedlot arrival[1]

		Number of vaccines				
Outcome	**Vaccine**	**0**	**1**	**2**	**3**	**4**
Number of cattle	Modified live	—	184	2,700	1,141	281
	Mannheimia haemolytica	—	1,420	1,756	607	—
	Histophilus somni	3,136	84	1,086	—	—
	Clostridia spp.	—	—	3,851	433	—
Number of cow-calf operations	Modified live	—	5	26	8	3
	Mannheimia haemolytica	—	19	13	6	—
	Histophilus somni	44	2	6	—	—
	Clostridia spp.	—	—	42	6	—

[1]Data were obtained from the Noble Research Institute (Ardmore, OK) cooperator herds.

research is needed to further evaluate the relationship of feed intake, growth rate, and immune function in feedlot cattle relative to the MFP BRD morbidity issues identified. Follow-up studies with more replications to define the effect of backgrounding and preconditioning practices on health outcomes at the feedlot are needed as well.

Preliminary results do not appear to be related to respiratory viral or bacterial pathogens as positive and negative samples were found in cases, controls, and healthy cohorts for MFP BRD based on PCR results (Table 3). No controls or healthy cohorts sampled developed clinical BRD through the entire feeding period. Nasal swabs from healthy cohorts were collected to determine whether there were differences in prevalence of virus or bacteria among the population experiencing MFP BRD versus populations with no observed disease. Positive findings in cases, controls, and healthy cohorts suggest caution should be used when looking for causative roles viruses and bacteria have on MFP BRD morbidity incidence. Frequently, samples are only collected from clinical cases, creating selection bias and possible misinterpretation and diagnosis due to a lack of comparison group. The viral and bacterial pathogens identified through the nasal swabs may be commensal and not pathogenic pathogens (Clawson and Murray, 2014; Clawson et al., 2016). Other methods to capture and evaluate pathogens, including deep nasopharyngeal swab, transtracheal wash, and bronchoalveolar lavage, may result in identifying and quantifying pathogens (Capik et al., 2017). However, all methods used to evaluate different pathogens depend on the ability of the pathogen to be grown in the diagnostic laboratory for analysis. The use of nasal-swab PCR analysis allowed for a simple, accessible, and affordable quantitative approach to evaluate pathogens. Serology methods captured at the time of BRD morbidity and >21 d later to evaluate acute and convalescent titers may provide a more thorough description that pathogens were involved with disease.

The nasal swabs from the 2 additional feedyards from MFP BRD cases were negative for BHV-1, BVDV, and BRSV, which agreed with the case-control nasal swab results (Table 4). All pooled samples were negative for bovine influenza virus, and only one pool was positive for bovine corona virus. Data do not support revaccinating with MLV vaccine during the feeding period as an effort to

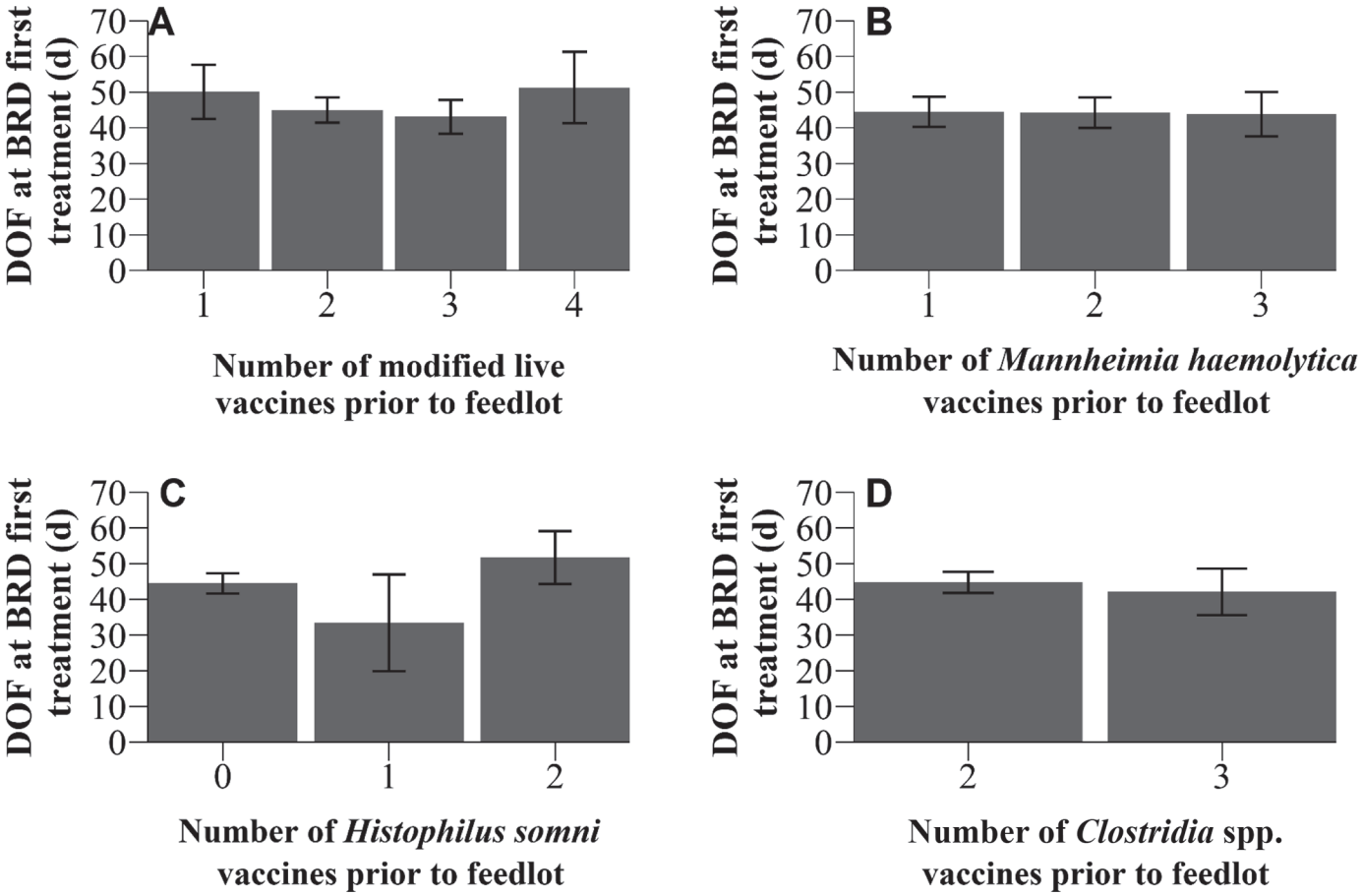

Figure 2. Model-adjusted days on feed (DOF; ±SE) at time of first treatment for bovine respiratory disease (BRD) by number of modified-live vaccines (A; $P = 0.71$) and *Mannheimia haemolytica* (B; $P = 0.99$), *Histophilus somni* (C; $P = 0.21$), and *Clostridia* spp. (D; $P = 0.70$) vaccinations received before entering the feedlot. Model included random effects for producer, year, lot, and covariates for average in weight of lot at feedlot arrival and number of days preconditioned. Data were obtained from the Noble Research Institute (Ardmore, OK) cooperator herds.

Table 3. Viral and bacterial bovine respiratory disease PCR panel cycle thresholds from nasal swabs of cattle with clinical bovine respiratory disease during the mid-portion of the feeding period (n = 4), matched with a healthy calf from the same lot (n = 4), and nasal swabs from healthy cohorts (n = 2) from different lots with no disease[1]

Comparison	Lot	Days on feed	Rectal temperature (°C)	Bovine corona virus	Bovine influenza virus	*Mannheimia haemolytica*	*Pasteurella multocida*	*Mycoplasma bovis*	*Histophilus somni*	*Bibersteinia trehalosi*
Case	8,912	71	40.39	Negative	Positive	Positive	Positive	Positive	Positive	Negative
Case	8,914	71	40.44	Negative	Positive	Positive	Positive	Positive	Positive	Positive
Case	8,916	70	40.22	Negative	Positive	Positive	Positive	Positive	Positive	Negative
Case	8,921	67	41.00	Negative	Negative	Suspect	Positive	Positive	Positive	Negative
Control	8,912	71	39.33	Negative	Positive	Positive	Negative	Negative	Positive	Negative
Control	8,914	71	39.06	Negative	Positive	Positive	Positive	Suspect	Positive	Negative
Control	8,916	70	38.89	Negative	Positive	Negative	Positive	Positive	Positive	Positive
Control	8,921	67	39.33	Positive	Negative	Positive	Positive	Positive	Positive	Negative
Healthy cohort	8,945	53	39.61	Negative	Negative	Negative	Negative	Negative	Negative	Negative
Healthy cohort	8,957	51	38.61	Positive	Negative	Positive	Positive	Positive	Positive	Negative

[1]Cycle threshold values <37 were interpreted as positive for the pathogen, cycle thresholds between 37 and 39 were interpreted as suspect, and cycle threshold values >39 were interpreted as negative for the pathogen. All nasal swabs for bovine herpesvirus-1, bovine viral diarrhea virus, and bovine respiratory syncytial virus were negative.

reduce morbidity. Revaccination of high-risk feedlot cattle at 11 DOF has been shown to increase morbidity compared with single vaccination of cattle upon arrival (Step et al., 2009); however, the authors are not aware of published studies evaluating revaccination later in the feeding period or in low-risk cattle. Follow-up research with more samples is warranted to further evaluate the prevalence and pathophysiological role of the viruses and bacteria in MFP BRD morbidity.

Additional research is needed to identify specific practices performed on the cow-calf operations with low incidence of BRD morbidity and mortality to determine which combination of factors are necessary throughout the entire production system (Hurd, 2011). A limitation of the current study is not evaluating for timing when vaccination occurred as well as product comparison due to limited data. A larger data set with more cow-calf operations is needed to appropriately evaluate. Efforts need to include the entire host, environment, and pathogen disease triad. Bovine respiratory disease has been shown to be low to moderately (13 to 21%) heritable in preweaned Holstein cattle (Neibergs et al., 2014; Van Eenennaam et al., 2014) but only 7 to 8% heritable in beef cattle (Snowder et al., 2007; Schneider et al., 2010). Genetics need to be evaluated to determine potential effect on health outcomes for producers to make informed breeding decisions as well as additional potential risk factors.

APPLICATIONS

There is a large amount of variability in BRD morbidity among cow-calf operations. Increased number of vaccinations administered before the feedlot did not improve

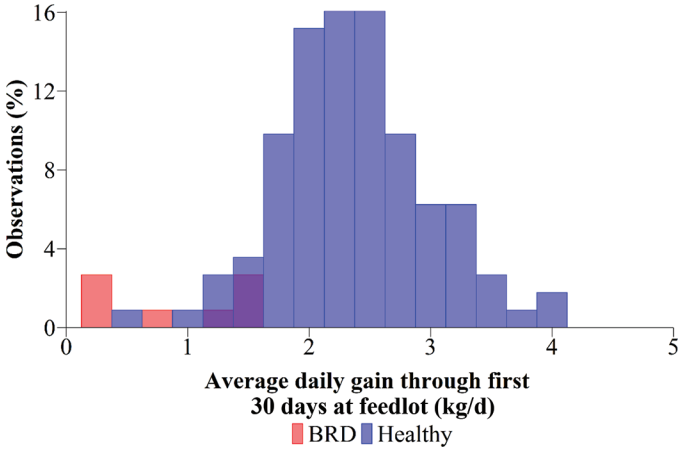

Figure 3. Individual animal ADG histogram through approximately 30 d on feed of 112 steers in 2 separate lots from Noble Research Institute (Ardmore, OK). Red shading represents steers that had bovine respiratory disease (BRD) events, and blue shading represents steers that were clinically healthy throughout the feeding period ($P < 0.01$). The bars shaded in purple show where both BRD and healthy steer observations occurred. The model included the random effect of arrival group at the feedlot.

Table 4. Pooled viral and bacterial bovine respiratory disease PCR panel cycle thresholds from nasal swabs of 28 cattle with clinical bovine respiratory disease during the mid-portion of the feeding period from 2 different feedyards[1]

Feedyard	Pool	Nasal swabs per pool	Bovine corona virus	*Mannheimia haemolytica*	*Pasteurella multocida*	*Mycoplasma bovis*	*Histophilus somni*
A	1	5	Negative	Positive	Positive	Negative	Positive
	2	5	Negative	Positive	Negative	Positive	Positive
	3	4	Negative	Positive	Positive	Positive	Positive
	4	4	Negative	Positive	Positive	Positive	Positive
	5	4	Positive	Positive	Positive	Positive	Positive
B	1	3	Negative	—	—	—	—
	2	3	Negative	—	—	—	—

[1]All nasal swabs for bovine herpesvirus-1, bovine viral diarrhea virus, bovine respiratory syncytial virus, and bovine influenza virus were negative for all pools.

health outcomes and was detrimental to health outcomes. Nasal swab results provide preliminary evidence that respiratory viral or bacterial pathogens are not directly involved with BRD cases during the MFP. Additional research is needed to further evaluate the entire host, environment, and pathogen triad for development of BRD in these high-performing cattle.

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