PEER REVIEWED

Effect of Vaccination and Weaning Timing on Backgrounding Morbidity in Preconditioned Beef Feeder Calves

B.J. White[1], *DVM, MS;* **S. McReynolds**[1], *DVM;* **D. Goehl**[2], *DVM;* **D.G. Renter**[3], *DVM, PhD*
[1]*Department of Clinical Sciences, College of Veterinary Medicine, Kansas State University, Manhattan, KS 66506*
[2]*Canton Veterinary Clinic, Canton, MO 63435*
[3]*Department of Diagnostic Medicine / Pathobiology, College of Veterinary Medicine, Kansas State University, Manhattan, KS 66506*

Abstract

Bovine respiratory disease is the most common illness in post-weaned beef calves, and numerous preconditioning programs have been designed to mitigate the impact of this disease syndrome. Preconditioning programs rely on proper implementation of tools, including vaccination and weaning, to prepare the calf to successfully overcome disease challenges. Our objective was to determine whether backgrounding morbidity was associated with the timing of previous vaccinations and the number of days weaned prior to commingling of beef feeder calves. Data were procured over a six-year period from 85 producers that preconditioned calves and placed them in a commingled backgrounding lot for approximately three months. Generalized linear mixed models were utilized to assess the impact of the number of days between first and second viral vaccinations, number of days between the final viral vaccination and commingling and the number of days weaned prior to commingling. Hypothesis testing was performed using $P<0.10$ due to the relatively small sample size when year and origin farm were considered. Morbidity during the backgrounding phase was significantly higher ($P<0.10$) when the time between initial and booster vaccination was less than 14 days. No morbidity differences were found based on weaning time or the proximity of the final vaccination to commingling. Our results illustrate that the timing of vaccinations influences health outcomes of preconditioning programs, and that further research is necessary to provide definitive recommendations regarding timing of vaccination and weaning.

Keywords: bovine, bovine respiratory disease, backgrounding, vaccination, weaning

Résumé

Les maladies respiratoires bovines sont parmi les plus courantes chez les veaux de boucherie après le sevrage. Plusieurs programmes de pré-conditionnement ont été développés afin de réduire l'impact de ce syndrome de maladies. Les programmes de préconditionnement reposent sur l'implémentation adéquate d'outils, incluant la vaccination et le sevrage, qui préparent les veaux à relever le défi des maladies. Notre objectif était de déterminer si la morbidité en pré-engraissement était associée au choix du moment des vaccinations précédentes et au nombre de jours sevrés avant le regroupement des veaux de boucherie en engraissement. Les données ont été recueillies sur une période de six ans chez 85 producteurs qui préconditionnent leurs veaux et les regroupent en pré-engraissement pendant approximativement trois mois. Des modèles linéaires mixtes ont été utilisés pour déterminer l'impact du nombre de jours entre la première et la seconde vaccination virale, du nombre de jours entre la dernière vaccination virale et le regroupement et du nombre de jours sevrés avant le regroupement. Le seuil alpha a été fixé à 0.10 pour les tests d'hypothèses en raison de la petite taille d'échantillon lorsque l'année et la ferme d'origine étaient prises en ligne de compte. La morbidité en pré-engraissement était significativement plus élevée ($p<0.1$) lorsque l'intervalle entre le premier vaccin et le rappel était de moins de 14 jours. La morbidité n'était pas associée ni au temps du sevrage ni à l'intervalle de temps entre la dernière vaccination et le regroupement. Nos résultats démontrent que le choix du moment des vaccinations influence l'état de santé des individus dans des programmes de pré-conditionnement. D'autres travaux sont nécessaires avant de fournir des recommandations définitives concernant le choix du moment de la vaccination et du sevrage.

Introduction

Bovine respiratory disease (BRD) is the most common and economically important disease complex in the post-weaned beef calf.[6,16,21] The complex occurs in a relatively large percentage of feedlot cattle in the United States, with an average treatment cost of $12.59 per head.[20] The total economic influence of this disease complex is even greater than the sum of treatment cost and death loss due to the impact on animal performance and carcass characteristics. The literature illustrates that BRD-affected calves have a lower rate of weight gain,[14,19,22] lower hot-carcass weights and decreased likelihood to grade USDA Choice.[1,9] McNeill *et al* evaluated Texas A & M Ranch to Rail health data (7,723 head, 27.5% morbidity) to find a $92.26 per head difference in net return between sick and healthy animals in the feedlot,[13] although the difference in net returns due to illness exhibited a wide variation over time, ranging from $49.55 in 1995[11] to $151.18 in 2001.[12]

To avoid losses associated with BRD, significant efforts have focused on creating programs to prevent respiratory disease in cattle. Many preconditioning programs for feeder calves incorporate vaccinations to increase resistance to appropriate pathogens and attempt to reduce cattle stress by weaning prior to shipment.[5,17] Research has illustrated that preconditioning programs can decrease morbidity and mortality.[4,18] Yet well-controlled, large scale, randomized trials evaluating the effects of preconditioning in post-weaned calves are scarce, and the ability of preconditioning programs in general to consistently provide an advantage has been questioned.[3,15] One reason for this apparent disparity in the literature is the widely varied definition of preconditioning. Preconditioning guidelines can range from requiring castration and one viral immunization before sale to more complex management interventions. The most comprehensive programs include initial and booster immunizations, acclimation of calves to eating specific ration types from a bunk and weaning for 45 days on farm of origin prior to sale. Merit of programs may be best assessed by differentiating between on the farm procedures included in the specific protocol.

In addition to specific program requirements, the timing of specific procedures (vaccinations) or management events (weaning) relative to disease challenge may play a role in the overall effectiveness of the program to reduce disease risk. The impact of timing of specific disease prevention management interventions on subsequent morbidity rates has not been evaluated. The objective of our retrospective data analysis was to determine the health implications of timing of immunizations and weaning relative to disease challenge.

Materials and Methods

A dataset of previously vaccinated and weaned calves monitored for BRD morbidity after shipment from the farm of origin for an 80-day backgrounding phase was acquired for this study. Specific farm-level vaccination and weaning timing relative to shipment data were used to evaluate for potential differences in morbidity based on timing of procedures. All animals in the program were managed using a standardized program on all farms with appropriate documentation of procedures. This entailed vaccination and booster with the following antigens: infectious bovine rhinotracheitis, bovine viral diarrhea, parainfluenza-3, bovine respiratory syncytial virus (IBR/BVD/PI3/BRSV); clostridial diseases; and *Mannheimia haemolytica*. Although the program guidelines required specific antigens and at least one modified-live respiratory viral vaccine, producers were allowed to select specific brands and types of vaccines utilized. Products were administered by either the producer or veterinarian on each farm. Calves were required to be weaned a minimum of 30 days prior to shipment for backgrounding between October and December of each year. Owners provided documentation of dates of vaccination, products used and date of weaning on standardized forms used by the Missouri Stocker Feeder Quality Assurance Program.

In each year, calves were transported to a dry-lot backgrounding facility in north-central Missouri where they were fed for a target rate of gain of 2.0 to 2.5 lb (0.9 to 1.1 kg) per head per day. Upon arrival, calves were sorted by weight and commingled between farms to create feed pens based on arrival weight and space allocations. Cattle were fed in a dry-lot and ration ingredients varied by year, but included cracked corn, soybean hulls and corn gluten feed as primary components in most cases. Cattle were observed daily during the backgrounding phase for clinical signs of respiratory disease by the same experienced personnel during each year of the project. The standard disease identification and treatment program for the backgrounding lot was applied. Animals were removed from the pen for evaluation when they presented one or more of the following signs: depression, anorexia, nasal discharge, or lack of rumen fill. Treatments were given if rectal temperature was greater than 104°F (40°C) or the evaluator deemed the calf was severely ill based on calf attitude. All treatments and presumptive diagnoses were recorded. Morbidity numbers were calculated based on the number of animals treated initially with a presumptive diagnosis of BRD.

Descriptive statistics were generated using JMP software, and data were further analyzed using SAS

version 9.1. Hypothesis testing was performed using $P<0.10$ to identify significant differences. The alpha level was selected due to relatively small sample size when year and farm of origin were considered. Proportions of animals treated for BRD from each set of calves from a farm in each year were analyzed using logistic regression models with PROC GLIMMIX in SAS. Least squares means were used to compare levels among significant fixed effects. The year and farm of origin were included as random effects in all models. Fixed effects evaluated included number of days between initial and booster vaccination, number of days between final vaccination and arrival at backgrounding lot, and the number of days between weaning and arrival at backgrounding lot. Each effect was evaluated as a categorical variable with divisions generated from common preconditioning program or vaccine label guidelines. The days between the first viral vaccination and the booster were divided into three categories (< 14 days; equal to 14 and up to 28 days; and > or equal to 28 days). These days were selected based on the common label recommendation for boostering vaccines between 14 and 28 days and the two categories outside of that range. The number of days between the final viral vaccinations and arrival at the backgrounding lot was divided into less than and equal to 14 days or greater than 14 days. This division is based on the premise that effective humoral immunity is generated and measurable two weeks after vaccination.[2] The number of days between weaning and backgrounding arrival was divided into less than 45 days or greater than and equal to 45 days based on common preconditioning program guidelines.

Results

Data were collected from 85 sets of calves from 46 farms that enrolled in a cooperative calf marketing program between 2000 and 2005. The data represented 1,354 head of fall-weaned (born in spring of same year) cattle. Producers utilized a variety of viral products on calves prior to entrance at the backgrounder (Table 1). Calves enrolled in the backgrounding phase entered at a mean arrival weight of 563 lb (256 kg) and were fed for an average of 86 days with a mean ADG of 2.1 lb (0.95 kg)/head/day. Morbidity during the backgrounding phase varied by year. Overall, 239 of the 1,354 animals (17.6%) received an initial treatment for BRD during the backgrounding phase (Table 2). Morbidity by farm of origin ranged from 0 (26 farms) to 100% (one farm with 10 head enrolled).

The number of days between first and second vaccination was known on 73 sets of calves, with each set representing a consignment from an owner in a single year. There were four sets of calves (67 head) with less than 14 days between vaccinations, 47 sets of calves (734 head) with equal to 14 and up to 28 days separating the vaccinations and 22 sets of calves (331 head) with greater than or equal to 28 days between vaccinations. After controlling for year and farm of origin, pens of calves with less than 14 days between vaccinations had a significantly higher (29.8%) level of morbidity than cattle in the 14-28 range (10.6%, $P=0.03$) and the greater than 28 day group (12.3%, $P=0.08$) (Figure 1).

The days between the final vaccination and arrival at the backgrounding lot was known on 73 sets of calves. There were five sets of calves (121 head) with less than or equal to 14 days between the last vaccination and backgrounding arrival. The remainder of animals (68 sets of calves, 1,024 head) arrived at the backgrounding lot greater than 14 days after their final vaccination. There was no significant difference in morbidity between groups of calves with less than or equal to 14 days (13.9%) or greater than 14 days (12.2%) between last vaccination and backgrounding arrival (Figure 2).

The number of days between weaning and backgrounding arrival was known on 46 groups of calves (820 head). Twenty-two groups of calves (452 head) were weaned less than 45 days prior to arrival, and 24 groups of calves (368 head) were weaned more than or equal to 45 days prior to arrival at the backgrounding lot. There was no significant difference in morbidity between groups of calves weaned less than 45 days (11.7%) when compared to morbidity in groups of calves weaned more than 45 days (7.6%) (Figure 3).

Table 1. Distribution of respiratory viral vaccine types utilized by producers at each vaccination time point.

Initial viral vaccination			Booster viral vaccination		
Product type	Number products	Number farms	Product type	Number products	Number farms
Modified-live	7	53	Modified-live	9	69
Killed	5	20	Killed	3	4

Table 2. Number of farms, cattle, initial cases of BRD and associated mortality by year.[a]

			BRD morbidity		BRD mortality	
	Farms	Head	hd	%	hd	%
2000 Fall	8	103	8	7.8%	0	-
2001 Fall	18	224	20	8.9%	1	0.4%
2002 Fall	23	332	78	23.5%	1	0.3%
2003 Fall	20	370	108	29.2%	0	-
2004 Fall	7	139	8	5.8%	0	-
2005 Fall	9	186	17	9.1%	0	-
Total:	85	1354	239		2	

[a]Morbidity and mortality percentages are presented on an annual basis with each percentage representing the number of head diagnosed with BRD or died due to BRD within each year's enrollments.

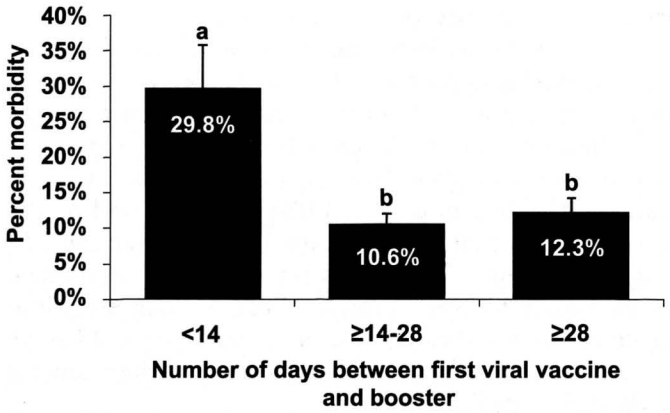

Figure 1. Risk of clinical respiratory disease during the backgrounding phase based on the number of days between first and booster viral vaccination.[c]

[a,b]Columns with different letters were statistically ($P<0.10$) different.
[c]Based on least squares means and standard errors from a logistic regression model accounting for the year and herd of origin.

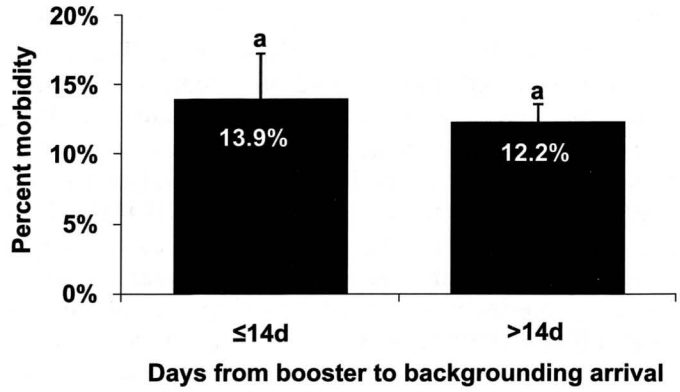

Figure 2. Risk of clinical respiratory disease during the backgrounding phase based on the number of days between the final viral vaccination and arrival at the backgrounding lot.[b]

[a]Results did not differ ($P>0.10$).
[b]Based on least squares means and standard errors from a logistic regression model accounting for the year and herd of origin.

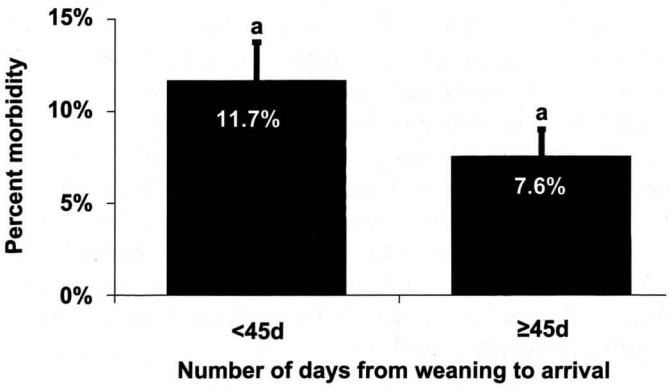

Figure 3. Risk of clinical respiratory disease during the backgrounding phase based on the number of days between weaning and arrival at the backgrounding lot.[b]

[a]Results did not differ ($P>0.10$).
[b]Based on least squares means and standard errors from a logistic regression model accounting for the year and herd of origin.

Discussion

Preconditioning programs are utilized in the beef industry with a variety of options related to weaning and timing of vaccines. Our research was performed on a fairly limited set of calves in a specific region of the country, and the effectiveness of specific program components needs to be further evaluated. However, even in this relatively small study there was evidence that implementation of vaccination and management programs may play a role in the health outcome of the animals.

Vaccination is included in most preconditioning programs. In evaluation of the timing between vaccinations, only four groups of calves had less than 14 days between vaccinations, but these groups had higher morbidity (29.8%) than calves boostered between 14 and 28 days (10.6%) or greater than 28 days (12.3%). Many commonly used respiratory viral vaccines have label recommendations for booster vaccinations to be given within two to four weeks after administration of initial vaccination. Common recommendations include vaccinating calves either at pre-weaning or at weaning and boostering 14 to 21 days later.[5] In our data,

the timing between vaccinations was an important factor in overall morbidity. Disease risks in cattle with a short time between initial and booster vaccinations could be higher due to a lack of time to generate a primary immune response.

The number of days between the last vaccination and arrival at the backgrounding lot is considered an important component of the preconditioning program as the goal is to build adequate immunity prior to disease challenge. For vaccinations to effectively mitigate the disease risk, they should be administered in a time frame to allow adequate building of immunity prior to disease challenge.[2] The time necessary to stimulate an immune response after vaccination varies based on antigen, previous level of exposure, type of vaccine and component of the immune response measured. Previous research with multivalent respiratory viral vaccines illustrates that cattle may respond by production of interferon gamma by five days post-vaccination,[23] yet increased antibody titers may take up to 14 days.[7] To allow management flexibility and accommodate multiple logistic scenarios, preconditioning programs often specify a range of times when the vaccines can be given relative to potential disease exposure. In our data, there was no difference in morbidity based on whether the last vaccination was greater or less than 14 days from arrival at the backgrounding lot. However, the power to detect a difference was limited by the fact that there were relatively few groups of cattle with fewer than 14 days between vaccination and arrival at the backgrounding facility.

In previous work, Fulton *et al* evaluated health status in 417 calves from 24 herds from feedlot arrival through harvest relative to individual farm vaccination schedules prior to arrival.[8] They described that the three herds with highest morbidity received viral vaccines without a booster or with a second dose given immediately prior to shipment, while herds with lowest morbidity gave the second dose three weeks prior to arrival. Our study differed from their work in that cattle groups were listed as less than 14 days prior to arrival, yet all animals were vaccinated a minimum of 10 days prior to arrival at the backgrounding lot. Thus, our research did not evaluate the impact of vaccinating within 10 days of commingling and arrival. In order for the immunization to decrease risk of disease, the appropriate immune response must be reached prior to the disease challenge.

The final parameter evaluated was the number of days calves were weaned prior to arrival at the backgrounding lot. Weaning on the cow-calf farm of origin ranging from a minimum of 21 to greater than 45 days is a component of many preconditioning programs.[17] The length of the weaning period changes feed cost, labor expenses and number of days at risk at the farm of origin. Although length of weaning has definite economic costs, the morbidity implications of the number of days weaned prior to disease exposure has not been well documented.

There were no statistical differences in morbidity based on the length of time calves were weaned when categorized by greater or less than 45 days. The minimum time calves were weaned in this data set was 30 days. Although categorizing the data into two groups based on a 45-day cutoff could reduce statistical power as compared to utilizing the actual days, our goal was to compare morbidity between groups that did or did not follow typical preconditioning program requirements. The variability between years and farm of origin also could impact the statistical power of the analysis. Although we did not find a difference in health outcomes based on number of days weaned, we would point out that a small increase in morbidity based on shorter days weaned may not offset increased costs associated with maintaining the calves for an additional time period.

Preconditioning is an important tool to prevent post-weaning BRD morbidity in beef feeder calves. Recent research focused on one large market illustrates that in the last 10 years, the percentage of non-viral vaccinated calves has decreased relative to calves with some value-added procedure (viral vaccination and/or weaning).[10] Yet, program guidelines vary between preconditioning programs and our research indicates that the specific timing of vaccine administration may impact expected morbidity levels in calves. Variable health outcomes related to timing of procedures may influence price paid for the calves due to uncertainty surrounding health outcomes.

Conclusion/Clinical Relevance

Pre-arrival health programs target prevention of disease at the feedlot by employing specific practices to enhance calf immunity prior to disease challenge (commingling). In most programs, the timing of vaccinations is based on an acceptable range, and our research illustrates that the timing may be an important influence on the health outcome. Our research did not find a difference in the morbidity rate between calves weaned 30-45 days and calves weaned greater than 45 days. However, statistical power to detect differences was likely limited due to relatively small sample size and variation between farms of origin and the six years included in the study. The goal of preconditioning programs is to reduce disease risk at arrival, and our research indicates that the implementation (timing) of vaccinations may influence that outcome. More research needs to be performed to evaluate preconditioning health and performance impacts and to more

specifically define costs and benefits of specific preconditioning management procedures.

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Endnote

[a]SAS Institute, Cary, NC

References

1. Busby WD, Strohbehn DR, Beedle P, Corah LR: Effect of postweaning health on feedlot performance and quality grade. *Iowa State University Animal Industry Report,* 2004.
2. Callan RJ: Fundamental considerations in developing vaccination protocols. *Proc Am Assoc Bov Pract* 34:14-22, 2001.
3. Cole NA: Preconditioning calves for the feedlot. *Vet Clin North Am (Food Anim Pract)* 1:401, 1985.
4. Cravey MD: Preconditioning effect on feedlot performance. *Proc Southwest Nutrition and Management Conference,* 1996.
5. Duff GC, Galyean ML: Board-Invited Review: Recent advances in management of highly stressed, newly received feedlot cattle. *J Anim Sci* 85(3):823-840, 2007.
6. Edwards AJ: Respiratory diseases of feedlot cattle in the central USA. *Bov Pract* 30:5-7, 1996.
7. Fulton RW, Confer AW, Burge LJ, *et al*: Antibody responses by cattle after vaccination with commercial viral vaccines containing bovine herpesvirus-1, bovine viral diarrhea virus, parainfluenza-3 virus, and bovine respiratory syncytial virus immunogens and subsequent revaccination at day 140. *Vaccine* 13(8):725-733, 1995.
8. Fulton RW, Cook BJ, Step DL, *et al*: Evaluation of health status of calves and the impact on feedlot performance: assessment of a retained ownership program for postweaning calves. *Can J Vet Res* 66(3):173-180, 2002.
9. Gardner BA, Dolezal HG, Bryant LK, Owens FN, Smith RA: Health of finishing steers: effects on performance, carcass traits, and meat tenderness. *J Anim Sci* 77(12):3168-3175, 1999.
10. King ME, Salman MD, Wittum TE, *et al*: Effect of certified health programs on the sale price of beef calves marketed through a livestock videotape auction service from 1995 through 2005. *J Am Vet Med Assoc* 229(9):1389-1400, 2006.
11. McNeill JW: 1994-95 Texas A&M Ranch to Rail North/South Summary Report. 1995 [cited June 25, 2008]; Available from: http://animalscience.tamu.edu/ansc/publications/rrpubs/9495.pdf.
12. McNeill JW: 2000-2001 Texas A&M Ranch to Rail - North/South Summary Report ASWeb-O84. 2001 [cited June 25, 2008]; Available from: http://animalscience.tamu.edu/ansc/publications/rrpubs/ASWeb084-2001summary.pdf.
13. McNeill JW, Paschal JC, McNeill MS, Morgan WW: Effect of morbidity on performance and profitability of feedlot steers. *J Anim Sci* 74(Suppl 1):135, 1996.
14. Pinchak WE, Tolleson DR, McCloy M, *et al*: Morbidity effects on productivity and profitability of stocker cattle grazing in the Southern Plains. *J Anim Sci* 82(9):2773-2779, 2004.
15. Pritchard RH, Mendez JK: Effects of preconditioning on pre- and post-shipment performance of feeder calves. *J Anim Sci* 68(1):28-34, 1990.
16. Smith RA: Impact of disease on feedlot performance: a review. *J Anim Sci* 76(1):272-274, 1998.
17. Speer NC, Young C, Roeber DL: The importance of preventing bovine respiratory disease: a beef industry review. *Bov Pract* 35:189-196, 2001.
18. St Louis DG, Engelken TJ, Little RD, Edwards NC: Case study: Systems to reduce the cost of preconditioning calves. *Prof Anim Sci* 19:357-361, 2003.
19. Thompson PN, Stone A, Schultheiss WA: Use of treatment records and lung lesion scoring to estimate the effect of respiratory disease on growth during early and late finishing periods in South African feedlot cattle. *J Anim Sci* 84(2):488-498, 2006.
20. USDA, Part III: *Health Management and Biosecurity in U.S. Feedlots, 1999*. USDA:APHIS:VS, Ed. Fort Collins, CO: National Animal Health Monitoring System, 2000.
21. Vogel GL, Parrott JC: Mortality survey in feedyards. The incidence of death from digestive, respiratory and other causes in feedyards in the Great Plains. *Comp Cont Ed Pract Vet* 16:227-234, 1994.
22. Wittum TE, Woollen NE, Perino LJ, Littledike ET: Relationships among treatment for respiratory tract disease, pulmonary lesions evident at slaughter, and rate of weight gain in feedlot cattle. *J Am Vet Med Assoc* 209(4):814-818, 1996.
23. Woolums AR, Siger L, Johnson SK, Gallo GF, Conlon J: Rapid onset of protection following vaccination of calves with multivalent vaccines containing modified-live or modified-live and killed BHV-1 is associated with virus-specific interferon gamma production. *Vaccine* 21(11-12):1158-1164, 2003.