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Assessment of on-arrival vaccination and deworming on health and growth performance in high risk stocker cattle

By

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Assessment of on-arrival vaccination and deworming on health and growth performance in high risk stocker cattle

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The study objective was to evaluate the effects of vaccination (respiratory and clostridial vaccination or no vaccination) and deworming (fenbendazole and levamisole or no deworming) of high risk stocker calves on-arrival on health and growth performance. Eighty sale barn origin calves were purchased three separate years (n=240) from local order buyer. Steers (n=61) and bulls (n=179) were received over three days (d -3 to -1). On d 0 calves were stratified by arrival BW and FEC into 20 pens of 4 calves each, and treatment was applied to pens in 2 x 2 factorial. Vaccination increased the likelihood of BRD 1.7 times (P=0.07) versus calves not vaccinated. Vaccination did not affect gain, but calves receiving dewormer had greater ADG than those not receiving dewormer. Calves that arrived uncastrated or with high fever (≥40.0°C) gained less and were 1.7 and 4.3 times more likely (P<0.10) to be treated for disease, respectively.

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ADG	Average Daily Gain
BW	Body Weight
BRD	Bovine Respiratory Disease
BHV-1	Bovine Herpesvirus 1
BVDV	Bovine Viral Diarrhea Virus
EPG	Eggs Per Gram
FEC	Fecal Egg Count
MLV	Modified Live Virus
PI	Persistently Infected
SN	Serum Neutralizing

CHAPTER I

INTRODUCTION

The segmented nature of the beef industry offers both opportunity and risk for each of its various components. Stocker operators add value to calves that have been recently weaned by improving health, adding weight, increasing uniformity in marketing groups, and preparing calves for a feedlot setting. Calves arriving at stocker facilities experience one or more stressors including: weaning, commingling, handling, and transportation. Calves experiencing multiple stressors are considered to be at high risk for bovine respiratory disease (BRD; Wilson et al., 2017). Once calves arrive at a stocker facility, they will often undergo more management related stressors such as castration, dehorning, vaccination, and deworming, which further increase risk.

Financial losses due to BRD morbidity and mortality in cattle newly received or weaned continue to be a detriment to the beef industry, in spite of improvements in preventative and treatment measures (Gaylean et al., 1999). The multifactorial nature of the disease often requires the presence of bacterial and viral agents along with predisposing factors for the onset of disease. These predisposing factors can include transportation, weather, abrupt weaning, commingling, lighter body weight, parasitism, dehorning, and castration. Calves undergoing multiple stressors are considered to be immunosuppressed on arrival to the facility and are more vulnerable to disease.

Producers often use vaccination as the primary mode of respiratory disease prevention. A vaccine is administered to elicit an immunological response that mimics the response to the natural exposure to an antigen to provide later protection against a particular pathogen (Wilson et al., 2017). The practice of vaccinating healthy, unstressed calves is believed to be effective at reducing BRD and producing an immunological response (Edwards, 2010); thus, vaccination is commonly utilized in most receiving protocols of stocker and feedlot cattle. Studies utilizing a non-vaccinated or control treatment group are limited, with most studies comparing vaccines or vaccination protocols (Wilson et al., 2017). There is little evidence of the health benefits of vaccinating recently weaned, high risk calves on arrival to feedlots (Taylor et al., 2010b; Wilson et al., 2017). Vaccination has consistently been shown to elicit an antibody response, but vaccine-induce titers do not necessarily provide disease protection (Loan et al., 1998). Richeson et al. (2008) found high risk calves vaccinated at 14 d after arrival had higher ADG than calves vaccinated on arrival during the receiving period. However, in the same study, no differences were seen in health parameters. Other studies have shown no differences in ADG and health in calves that were vaccinated on arrival or with delayed vaccination protocols (Richeson et al., 2009; Poe et al., 2013).

Administering dewormer to reduce the effects of gastrointestinal parasites is another commonality with processing protocols of stocker cattle. Parasitism can not only reduce performance, but also reduce the immune response to non-parasitic antigens. Although morbidity did not differ in stocker cattle grazed in various regions of the United States, Ballweber et al. (1997) saw increased ($P < 0.05$) ADG in cattle that were dewormed compared to those not dewormed. Cattle treated with fenbendazole before and during the grazing period and at arrival to the feedlot had lower morbidity and mortality than negative controls (Smith et al., 2000).

Evidence of the effects of the interaction of vaccination and deworming are surprisingly limited. In colostrum deprived Holstein calves, deworming 2-weeks before or at vaccination effectively reduced parasite burden and did not impact antibody titers or cytokine response to IBR challenge (Schutz et al., 2012). The relationship between parasite burden and vaccine efficacy merits further research. Also, the effects of other predisposing stress factors on vaccine efficacy, health, and growth need to be further explored.

CHAPTER II

LITERATURE REVIEW

Introduction

The stocker industry adds value to recently weaned calves by improving health, adding body weight, increasing uniformity of marketing groups, and preparing cattle for feedlot setting. The southeastern United States provides many opportunities for stocker production given the regions ability to produce large quantities of quality cool-season forages and lower feeder cattle prices compared to the Midwest (Starnes et al., 2010). Profitability in this sector of the industry is driven by the risk of receiving vulnerable calves that have an unknown background, and potentially high rates of illness and death.

The number of stressors a calf or group of calves experience often dictates their risk level for disease. Cattle of unknown origin or history and experiencing multiple predisposing factors are deemed “high risk” on arrival to stocker or feedlot operations (Wilson et al., 2017; Taylor et al., 2010a). Although stressors such as transportation and commingling are inevitable, the timing of management related stressors (e.g. vaccination, castration, or dehorning) can be mitigated. Ultimately, any stressors may cause depression of the immune system, allowing for pathogen replication within the respiratory tract and subsequent infection. Calves of sale barn origin fall into the high risk category as they undergo multiple stress factors and exposure to new pathogens from commingling, traveling, and marketing (Taylor et al., 2010a). Through various management practices, stocker operators attempt to mitigate the repercussions of these predisposing factors.

Vaccination and deworming are common items on processing protocols for receiving cattle. Although vaccination of healthy, non-stressed cattle is well supported in literature, evidence of vaccine efficacy in immunostressed calves is minimal (Edwards, 2010). Even though there is little justification for vaccination on arrival of high risk cattle it is a widespread and accepted management practice (NAHMS, 2013).

Gastrointestinal parasites are known to reduce gain and immune function, and large parasite burdens are thought to be indicative of poor management (Corwin, 1997). Anthelmintics are used to reduce parasite burden and increase production. The proper scheduling of these management practices upon entry to stocker or feedlot to ensure optimum health and performance has yet to be determined.

Various management practices after the arrival of stocker cattle can improve profitability, and it is important to determine the proper timing of these practices to optimize effectiveness of the practice. The objective of this literature review is 1) review the impact of BRD on the stocker industry 2) identify the predisposing factors that increase disease 3) discuss the effects of vaccination and deworming on stocker cattle growth and health performance.

Animal Health and Immunity

The health of an animal describes its overall well-being and condition (Gaylean et al., 1999). Health of an animal is often a subjective matter based on visual appraisal coupled with clinical measurements such as rectal temperature, serum profiles, lung lesions and other measures (Galyean et al., 1999). With the subjective nature of determining animal health and instinctive ability for calves to mask disease, it can be challenging for producers and care takers to correctly identify disease (Noffsinger and Locatelli, 2004).

Immunity is the reaction of the animal's body to foreign microbes or pathogens regardless of the physiological or pathological result of such reaction (Abbas et al., 1991). Immune response can be classified as innate or acquired. Innate immunity describes various physical, chemical, and cellular barriers that allows for a quick, non-specific defense against pathogens. An acquired immune response is antigen specific and includes immunological memory which is shaped by previous natural exposure or vaccination (Abbas et al., 1991).

Bovine Respiratory Disease

Bovine respiratory disease is the most common disease in cattle post weaning, even with improvements in prevention and treatment (Edwards, 2010). It is responsible for 70%-80% of morbidity and 40%-50% of mortality in feedlots (Smith, 1998). Financial losses equated with BRD morbidity and mortality in cattle newly received or weaned continue to be a detriment to the beef cattle industry (Gaylean et al., 1999). Direct impacts such as death loss and treatment cost, as well as indirect losses such as a decrease in performance measures, are estimated to cost the beef industry more that $800-900 million annually (Chirase and Green, 2001).

Bovine respiratory disease complex is a multifactorial syndrome brought on by various environmental and pathogenic stressors. Bacterial and viral agents are necessary contributors to pathogenesis of BRD (Booker et al., 2008). Viral components considered to precede BRD include bovine herpesvirus 1 (BHV-1), infectious bovine rhinotracheitis

(IBR), parainfluenza virus type 3 (PI-3), bovine viral diarrhea virus (BVDV), and bovine respiratory syncytial virus (BRSV; Cusack et al., 2003). *Mannheimia haemolytica, Pasturella multicoda, Histophilus somni,* and *Mycoplasma bovis* are the bacterial agents most commonly associated with BRD (Taylor et al., 2010a), with *M. haemolytica* being the most prominent (Fulton et al., 2002). Bacteria enters the lower respiratory tract when innate immune barriers are weakened due to stress, the final component of the multifactorial disease. The variety of agents responsible for disease makes determining an effective vaccination protocol complicated.

Shipping and processing exposes calves to increased predisposing causes and environmental risk factors. Predisposing agents can include age and weight, stressors (nutritional changes, castration, weaning, and other factors) and immunoincompetence (Callan and Garry, 2002). Environmental factors include climate, ambient temperature, stocking density, humidity, ventilation, and shipping distance (Snowder et al., 2006). Transportation is the most accepted non-infectious stressor for BRD, leading to the layman's term "shipping fever" (Taylor et. al., 2010a). Stocker operators implement many strategies to minimize these stressors although they can never be fully eliminated.

Methods of diagnosing BRD are subjective and potentially inaccurate (Galyean et al., 1999). Visual appraisal of the following clinical signs is the traditional and primary method of detection: nasal or ocular discharge, depression, lethargy, lack of rumen fill, anorexia, labored breathing and cough (Taylor et al., 2010b). Animals displaying any or a combination of these symptoms are often separated for further evaluation. A variety of opinions exist regarding the rectal temperature that defines an animal as morbid and in need of treatment. Duff and Galyean (2007) in a review article of managing high risk calves suggested treating symptomatic animals with rectal temperature ≥39.7°C. Gallo et al. (1995) used a higher rectal temperature of >40.5°C to define cases of BRD. The authors found an overall morbidity of 23.0% with 2.37% relapse rate during 56 d receiving period. It should be noted these calves did not receive metaphylaxis and received respiratory and clostridial vaccination at arrival. More recent research suggests rectal temperature ≥40.0°C to consider symptomatic animals morbid and requiring treatment (Richeson et al., 2015; Rogers et al., 2016). Richeson et al. (2015) found an overall morbidity of 34.7% and 32.5% relapse rate. Rogers et al. (2016) observed 24.5% morbidity and 41.8% relapse rate. In both studies calves received metaphylaxis and were comparing arrival and delayed vaccination. Utilizing rectal temperature of ≥40.0°C seems to be the most accepted parameter to determine treatment in current research.

The incidence of BRD is most often the highest in the first two weeks after arrival. Babcock et al. (2009) compiled data from Midwestern US feedlots over a five-year period consisting of 37,078 cattle treated for BRD. The authors observed 74% of morbidity occurred within the first 42 d in the feedlot with the mean day of first treatment being 30 d after arrival, but new cases peaked within 14 d after arrival. This aligns with Snowder et al. (2006) who suggested BRD incidence substantially increased after 5 d on feed, peaking at 14 d into the feeding period. The authors predicted the risk of BRD remained high until 80 d on feed (Snowder et al., 2006). It should be noted this 15-year retrospective study utilized health records for cattle from a singular farm source. When thinking in the terms of stocker operations, the risk for BRD then remains throughout much of the grazing period, which typically consists of 90 to 120 days.

A stocker operation's bottom line can be directly and indirectly affected by the repercussions of BRD including increased labor and treatment costs and reduced performance (Wilson et al., 2017). In stocker cattle grazing the southern plains, morbid cattle had lower ADG and total gain than healthy cattle (Pinchak et al., 2004). Holland et al. (2010) used 360 calves assembled from Kentucky auction markets then shipped to Stillwater, Oklahoma to evaluate effects of BRD during preconditioning on successive feedlot performance. At the end of a 63-d preconditioning period, final BW decreased linearly as number of BRD treatments increased from 0 to 3. Calves that were not treated for BRD gained 1.14 kg/d compared to calves treat 1, 2, or 3 times which gained 0.92, 0.86, and 0.46 kg/d, respectively (Holland et al., 2010). The indirect effects of reduced performance due to BRD can significantly affect end weight of calves after the preconditioning or receiving period, especially for calves that do not compensate for the effects of BRD by the end of the receiving phase.

Ranges in morbidity can be broad for various stages of production and regions of the country. In a 15-yr retrospective study, Snowder et al. (2006) saw an annual BRD incidence range from 5% to 44%, averaging 14% in years 1993 to 2001, in feedlot calves that had been vaccinated preweaning. Cattle of Florida and Mississippi origin grazed in the southern plains had morbidity of 26% and 34%, respectively (Pinchak et at., 2004). Holland et al. (2010) showed preconditioning morbidity and mortality attributed to BRD were 57.6% and 8.6%, respectively. Auction market derived cattle are at greater risk for BRD as well as have a large amount of variability in morbidity (Step et al., 2008).

High Risk Calves

Exposure to predisposing factors dictates the amount of risk expected in a group of calves. On arrival or prior to arrival, cattle may be given an empirical risk classification based on probable incidence of BRD morbidity and mortality (Wilson et al., 2017). A classification (low, medium, high) should be based on previous management practices, vaccination history, amount and duration of stress, and probability of BRD (Wilson et al., 2017). High risk calves are typically younger and lighter weight, recently weaned, commingled, transported long distances, have unknown history, have not been castrated or dehorned, and are highly stressed upon arrival (Wilson et al., 2017; Taylor et al., 2010a).

Transportation of calves is unavoidable due to the segmented structure of the beef industry (Taylor et al., 2010b). During transport, cattle are often exposed to social stress and to new viral and bacterial pathogens. Additionally, cattle are deprived from feed and water while in transit resulting in shrink and dehydration. Sanderson et al. (2008) evaluated 122 pens of cattle over 12 weeks in commercial feedlots in various locations across the United States. Calves in the study came from a variety of sources including auction markets, farm source, and cattle arriving from other feedlots for the final phase of feeding, and ranged in shipping distance from 0 to 2,833 km. The authors found that every 160 km increase in transport distance increased BRD risk 10% (Sanderson et al., 2008). In a retrospective study, researchers found that in 14,601 groups of auction purchased feeder cattle weighing 332.8 ± 0.34 kg arriving at 21 feedlots, distance traveled increased morbidity and mortality and decreased ADG (Cernicchiaro et al., 2012b). The work evaluating transportation distance in stocker cattle has been minimal.

Wilkins et al. (2015) found distance had no effect on BRD incidence in stocker cattle, but stated there was a lack of variation of distance traveled in the study. Calves arriving at stocker operators are generally lighter weight than calves entering straight into the feeding phase, but calves entering stocker facilities, particularly in the southeast, are often shipped shorter distances.

Season and weather may also impact BRD morbidity (Taylor et al., 2010a). Typically, the greatest incidence of BRD occurs in the fall (Ribble et al., 1995; Loneragan et al., 2001). It is important to note that the traditional marketing period for most beef cattle in North America occurs in the fall season, resulting in more at risk cattle being traded that time of year (Taylor et al., 2010). The potential for exchanging pathogens is much higher due to the higher volume of cattle exacerbating crowding, commingling, and competition for food and water (Taylor et al., 2010). Sudden or extreme changes of weather patterns can also predispose cattle to illness. Ribble et al. (1995) found that a spike in BRD incidence occurred approximately at the same time as the greatest mean decrease in ambient temperature. In the same 4-year study, of the 2 years with greatest morbidity, one year had the most extreme weather, yet the other year was deemed the mildest weather. Temperature fluctuations commonly observed in the fall and early spring could impact health and performance of newly received cattle experiencing shrink from transport (Cernicchiaro et al., 2012a). Although abrupt changes in weather patterns are accepted predisposing factors for BRD, more research is needed to determine the effect of weather changes on BRD.

While environmental factors, such as weather, may affect BRD incidence, many predisposing factors originate from the lack of proper management. Cattle origin can indicate some level of risk. In a receiving trial preformed in Oklahoma, calves assembled from Mississippi auction markets had greater morbidity ($P < 0.001$) than those of ranch origin (41.9% vs. 11.1%; Step et al., 2008). Cattle entering the auction system are exposed to a greater number of pathogens and added stress due to multiple bouts of traveling, marketing, and commingling (Taylor et al., 2010). Risk associated with calves originating from sale barns could be in part due to commingling of calves at the sale barn and order buyer facility. In cattle arriving at feedlots, calves commingled from multiple sources have been found to have increased BRD incidence (Sanderson et al., 2008). Step et al. (2008) saw intermediary morbidity in market and ranch commingled calves compared to those of just market or ranch origin. It was noted in commingled calves, market origin steers had greater morbidity than ranch calves (Step et al., 2008).

Lighter weight cattle that have been managed on lower plane of nutrition are appealing to stocker operations due their potential for compensatory gain, yet come with greater risk for BRD (Ackerman et al., 2001). In Midwestern feedlots, cattle arriving at a lighter weight (227 to 271 kg) had greater BRD incidence than heavier weight (> 272kg) calves (Cernicchiaro et al., 2012c). In stocker calves with southeastern origin, lighter weight cattle had greater incidence of BRD (Pinchak et at., 2004). Heavier weight calves grazing native summer pastures in Oklahoma had greater ADG than lighter weight calves; although, lighter weight cattle offered more gain/hectare (Ackerman et al., 2001). Calves entering stocker operations are often light weight due to their ability to efficiently add weight offering more profit potential than heavier weight calves.

Castration is necessary for handling safety and improving meat quality, but the stress caused by castration is well documented (Ballou et al., 2013; Earley and Crowe, 2002). Daniels et al. (2000) found calves castrated on arrival had 92% greater incidence of respiratory disease than those that arrived already castrated. In the same study, previously castrated calves had more than twice the ADG compared to calves castrated on arrival over a 21-d receiving period. Calves arriving intact could be more prone to disease because of lack of prior management rather than the single event of castration. This speculation would be hard to prove without knowing prior history (Taylor et al., 2010a).

Effects of Vaccination on Gain and Health

Producers utilize vaccination to stimulate an immunological response to provide protection to bacterial and viral pathogens that may cause disease in cattle. Vaccination against viral pathogens (IBR, BVDV, PI-3, and BRSV) is a common industry practice and to lesser extent bacterial pathogens associated with BRD as well. (Taylor et al., 2010b). Providing vaccination to calves deemed clinically healthy, unstressed and immunoprimed has provided an optimal immune response (Edwards, 2010). Due to proven efficacy on healthy cattle, viral and clostridial vaccines are a commonality in processing protocols in all receiving cattle. A 2011 U.S. feedlot survey concluded that most feedlots vaccinate cattle for pathogens associated with the prevention of BRD (NAHMS, 2013). As a percentage of feedlots, 96.6% vaccinated for BVDV, 93.7% vaccinated for IBR, 85.1% vaccinated for PI3, and 89.5% vaccinated for BRSV (NAHMS, 2013). It was also noted that 84.4 % of feedlots administered a clostridial vaccine and two-thirds of feedlots vaccinated for bacterial agents commonly associated with BRD (NAHMS, 2013). Although this survey failed to mention the history or risk level of cattle receiving vaccination, the study did account for 82.1% of cattle on feed as of January 1, 2011 (NAHMS, 2013).

Although vaccination of healthy calves is widely accepted, there is very little evidence to support administration of vaccines on arrival in calves that may be immunoincompentent. Most vaccine research compares different antigen strains within different modified live vaccines and does not contain a non-vaccinated or a negative control group (Wilson et al., 2017). Although vaccination exposes the immune system to the pathogen, it does not always induce a protective immune response (Edwards, 2010). In various reviews, the evidence supporting the health benefit of vaccinating high risk, immunostressed cattle on arrival to feedlots has been minimal (Taylor et al., 2010b; Wilson et al., 2017). Although vaccination has not consistently reduced morbidity in high risk cattle, vaccination has consistently engaged an antibody response, thus vaccine-induced titers do not necessarily mean disease protection. (Loan et al., 1998) Taylor et al., (2010b) suggested vaccine failure may result from the timing of vaccination, the immunostressed calf not responding to vaccination, the multifactorial nature of BRD, or the stressed animal's vulnerability to all pathogens.

Richeson et al., (2008) evaluated the effect of on-arrival MLV respiratory vaccination versus delayed (14-d) MLV respiratory vaccination on health, growth, and serum IBR titers of newly received high-risk stocker cattle. On d 0 all cattle received a clostridial bacterin with tetanus toxoid along with treatment for internal and external parasites. Average daily gain was greater ($P < 0.05$) from 0 to 14 d (1.16 vs. 0.88 ± 0.22 kg) and 0 to 42 d (0.75 vs 0.65 ± 0.09 kg) for delayed vaccination vs arrival vaccination. Yet during the subsequent grazing period no difference ($P = 0.15$) was found in ADG.

Morbidity for arrival and delayed vaccination (71.5 vs 63.5%, respectively) was generally high, yet there were no differences between treatments (P = 0.12). Delayed vaccination calves showed greater (P= 0.01) IBR titers at the conclusion of the 42-d receiving period. Result indicate that delaying vaccination increased ADG and IBR titers compared to vaccinating on arrival, suggesting an improved acquired immune response when delaying respiratory vaccination (Richeson et al., 2008). This study has some limitations, like similar studies, as there was no control or non-vaccinated group. Also, this study just evaluated the effects of delaying MLV respiratory vaccination as clostridial vaccination was administered on arrival across all treatments.

In a second study, Richeson et al. (2009) evaluated the effects of delaying (14-d) both respiratory and clostridial vaccination on health and growth performance. Researchers found no difference in ADG during any period throughout the trial. Overall 69% of the calves were treated once for disease, yet neither vaccination nor timing had an effect on sickness. Authors suggested timing of vaccination did not affect ADG or health in high-risk stocker calves. Similarly, Poe et al., (2013) saw no benefits or detriments of delaying (d-14) BRD vaccination on growth or morbidity. In a more recent evaluation of delaying respiratory viral vaccination by 30 days, Rogers et al., (2016) found somewhat differing results. Although there was no difference (P = 0.70) in percentage of initial treatments for BRD, delaying vaccination reduced (P = 0.04) the number of second treatments. There was no difference in ADG of heifers at the end of the feeding period which ranged from 196 to 221 days. A receiving period was not established in this study in regards to growth performance (Rogers et al., 2016).

Richeson et al., (2015) utilized a negative control, non-vaccinated group to compare on-arrival or delayed pentavalent MLV respiratory vaccination. Calves were received in the fall and spring and housed in a dirt lot for the 42 d receiving period, and then grazed for 98 and 62 days for fall and spring calves, respectively. Cattle receiving delayed vaccination had increased ADG in the subsequent grazing period and although there were short-term improvements in gain during the 42 d receiving period, there was no difference in overall receiving ADG. Morbidity was not affected by vaccination or timing of vaccination; however, non-vaccinated calves had a higher second treatment rate (Richeson et al., 2015). The literature varies as to the proper timing of vaccination, and if on-arrival vaccination is beneficial or detrimental to health and performance. Delaying vaccination until d 14 could be ineffective in reducing disease as cattle are in still in active stages of disease. More research needs to be conducted to determine if other factors at processing are reducing vaccine efficacy.

Effects of Deworming on Gain and Health

Gastrointestinal parasites are a leading concern for grazing cattle and stocker operations in North America resulting in reduced performance and immune function (Ballweber, 2006). The genera *Trichostrongylus, Haemonchus Ostertagia, Cooperia* and *Nematodirus,* are responsible for most subclinical and clinical parasitism in United States beef production systems (Yazwinski and Tucker, 2006). Clinical infections are often indicative of poor management, particularly with modern day management schemes. Anthelmintics are often recommended to reduce the impact of parasite burden, yet it is known that anthelmintic effects can differ based on geographical region (Baltzell et al., 2015).

In earlier decades, anthelmintics were used to individually treat unhealthy calves, where currently anthelmintics are used widespread to improve production. Fenbendazole has been used effectively to reduce brown stomach worms (*Ostertagia ostetagi*), intestinal worms (*Cooperia* sp., *Bunostomum* sp. and *Nematodir*us sp.) and tapeworm (*Monezia*; FDA, 2003). The most commonly measured productivity trait associated with parasitism is weight gain, where other parameters associated with health are harder to directly link to parasitism. Reinhardt et al. (2006) found sale barn origin calves treated with both fenbendazole and ivermectin pour-on had greater ADG than those treated with just ivermectin pour-on (1.54 vs 1.45 kg/d). A meta-analysis of studies done in the northern United States found increased ADG in cattle receiving dewormer, but the magnitude of this increase could not be determined (Batzell et al., 2015).

Parasite site burden can be measured by rectal fecal collection and analyzed in eggs per gram (epg) of feces (Corwin et al.,1997). Large FEC of greater than 500 epg combined with visual indicators such as gauntness and rough hair coat are representative of inadequate parasite control (Corwin et al., 1997). In auction market derived cattle, fenbendazole was found to effectively reduce FEC throughout a 30 d grazing period and at subsequent necropsy (Yazwinski et al., 2009). Walker et al. (2013) saw a significantly higher FEC in nontreated summer grazing calves compared to cattle receiving initial anthelmintic treatment through d 59, yet when second treatment was applied at d 73 there was no difference in FEC.

The host's ability to develop an effective immune response against parasites is responsible for the decrease in FEC over time (Gordon, 1948). After a parasite inoculation, parasite antigens cause T and B lymphocytes to react providing the gastrointestinal tract protection from parasites (Kullberg et al., 1992). Cytokines aid in controlling parasitic infection and can help in the reduction of adult worms. Therefore, after a prolonged period of parasite infection FEC can be reduced (Claerebout and Verdruysse, 2000).

Gastrointestinal parasites induce a variety of immune responses within a host; specifically *Ostertagia* evokes the most distinguishing changes to the host immune system (Gasbarre 1997). Gasbarre (1997) observed reduced numbers of *Haemonchus* sp. and *Trichostrongylus* over a 3-4 month grazing period suggesting cattle do appear to become more resistant to other abomasal nematodes. The equivalent immune response is not observed toward *Ostertagia* or possibly *Ostertagia* eludes or suppresses immune response.

The effects of parasite burden on immune response or health outcomes have not been adequately determined. Although large animals serve as a more representative model, Kullberg et al. (1992) found in rodents that parasite infection could alter the immune response to non-parasitic antigens. This leaves the question if heavily parasitized animals are more likely to get sick and can adequately mount an immune response against BRD pathogens.

There has been minimal research on the health outcomes due to differing anthelmintics or comparing deworming versus a negative control. Although morbidity did not differ, fenbendazole and ivermectin pour on-cattle treated cattle had reduced ($P < 0.05$) repull rate at 47.7% compared to cattle receiving with ivermectin pour-on only at 58.8% (Reinhardt et al., 2006). Smith et al. (2000) evaluated the effects of deworming or not during the grazing phase on the subsequent feedlot phase. Not deworming calves during the grazing phase resulted in a greater ($P < 0.001$) number of treated calves during feeding phase compared to those that were dewormed during the grazing period. Unfortunately, this study did not report health records during the grazing phase. Also, "number treated" was defined as number of steers treated for any health reason including BRD, pinkeye, gastrointestinal issues, and other health issues (Smith et al., 2000). More research needs to be conducted to determine if deworming has beneficial effects in terms of reducing the occurrence of BRD in a stocker setting.

Effect of Vaccination and Deworming on Gain and Health

Research evaluating the interaction of two common processing practices, vaccination and deworming, is scarce, particularly when evaluating receiving cattle. In mice, Noland et al. (2007) noted anthelmintic treatment administered before vaccination reversed the negative immunological effects of parasite infection. Urban et al. (2007) inoculated swine for 3 weeks with common migrating larvae, *Ascaris suum*, before being immunized with killed *M. hyponeumonia* vaccine to observe response to a *Mycoplasma hyponeumonia* challenge. Investigators found pigs vaccinated yet not inoculated with the parasite had 100% serum conversion at 3 weeks after vaccination and throughout the remainder of the study. In contrast, only 33% of vaccinated and parasite infected pigs had a significant antibody response to *M. hyponeumonia* after 3 weeks. (Urban et al., 2007). The results under these particular circumstances show a parasite infection can alter vaccine efficacy. In colostrum deprived Holstein calves, Schutz et al (2012), found different effects of parasite burden on clinical signs following an IBR challenge. Deworming 2 weeks before vaccination (5-way MLV respiratory vaccine) or at vaccination reduced parasite burden and rectal temperature after an IBR challenge compared to cattle not receiving dewormer. Although, the timing of deworming did not impact serum antibody titers or cytokine response to IBR challenge, the authors suggested more understanding was needed of the relation of parasite burden and efficacy of vaccination as it pertains to economic implication for the cattle industry (Schutz et al. 2012).

Conclusion

Calves arriving at stocker facilities are often light weight, recently weaned, commingled, and of unknown origin, and are considered to be immunocomprimised. These calves are at high risk for BRD, the most costly disease in recently weaned calves, despite improved management practices, vaccines, and antibiotics (Galyean et al., 1999). After arrival at a backgrounding facility, calves often undergo more management related stressors such as castration, dehorning, vaccination, and deworming that may modify their risk for BRD.

Due to multifactorial nature of BRD, preventing and reducing disease utilizing vaccination is not always achieved for producers receiving high risk calves. The literature evaluating vaccination on arrival of auction market sourced calves is varied. Some studies have reported vaccination on-arrival negatively impacted health and performance (Richeson et al., 2008; Rogers et al., 2016), while others showed no benefit to vaccinating calves on arrival versus delayed vaccination (Richeson et al., 2009; Poe et al., 2013) So, the questions remain of what is the proper timing of vaccination and is vaccination of high risk calves helping the health or growth of stocker cattle.

Deworming is another common management practice utilized to reduce the effects of parasite burden. Parasite burden, or the lack of deworming, has consistently been shown to reduce gain (Ballweber et al., 1997; Batzell et al., 2015), but the understanding of their impacts on health is limited. Gastrointestinal parasites produce an immune response within the host (Gasberre, 1997), but it is unclear if parasite burdens affect the ability for the host to respond to non-parasitic antigens, particularly those utilized in vaccines.

Managing health risk is of economic importance for stocker producers; therefore, it is vital to properly manage calves on arrival to reduce the effects of BRD. Identifying predisposing characteristics of calves and providing proper attention could positively impact health outcomes. Utilizing the most effective receiving protocol ensures the efficacy and sustainability of best management practice for years to come.

CHAPTER III

ASSESSMENT OF ON-ARRIVAL VACCINATION AND DEWORMING ON HEALTH AND GROWTH PERFORMANCE IN HIGH RISK STOCKER CATTLE

Objectives

The objectives of this study were: (1) to evaluate the effects of on-arrival vaccination (respiratory and clostridial vaccination or no vaccination) and deworming (fenbendazole and levamisole or no deworming) of high risk stocker calves on health and growth performance; and (2) to evaluate the effects of arrival characteristics such as fever, distance traveled, castration status, and FEC on health and growth performance of high risk stocker calves.

Material and Methods

All procedures in this study were approved by the Institutional Animal Care and Use Committee at Mississippi State University (IACUC # 16-604).

Animals and Management

The 84 d receiving trial was repeated over 3 years during the following dates: February 27, 2015 to May 25, 2015, February 28, 2017 to May 24, 2017 and March 6, 2018 to May 30, 2018. In the fall previous to each year, pastures were burned and turned under. Study pens were 1.01 hectare and planted with a 70/30 blend of ryegrass and wheat. Seed was drilled in a prepared seed bed at 78.4 kg/ha. When forage was determined adequate for grazing, cattle were purchased.

Eighty calves were received each year (n=240; initial BW=221.5 ± 23.3 kg), both bulls (n=179) and steers (n=61), of sale barn origin and were purchased by an order buyer. Calves originated from Mississippi, Alabama, Tennessee, Georgia, and South Carolina sale barns. Cattle were then shipped and housed at the Mississippi Agricultural and Forestry Experiment Station H.H. Leveck Animal Research Center located in Mississippi State, MS. Cattle were primarily English based and black or black white face with some Charolais-cross calves present in year 1.

Due to market constraints at the time of the year the study was conducted, cattle were received over 1 to 3 days (d -3 to -1) depending on year. On arrival, all calves were individually identified, weighed, and feces obtained via manual rectal collection, as well as all bulls were castrated. Calves were notched from the left ear for persistent BVD infection (PI) testing using antigen capture ELISA (IDEXX BVDV PI X2 Test, IDEXX Laboratories, Inc., Westbrook, ME). Ear notches were sent to Prairie Livestock, LLC for analysis within four hours of sample acquisition, and all calves were negative. After initial processing cattle were all placed in a receiving pasture with free choice hay and water for 1 to 3 days depending on day of arrival. Calves were stratified by arrival body weight and FEC into 20 pens. Treatment of vaccination (VAC) or not (NOVAC) and deworming (DWM) or not (NODWM) were applied in a 2 x 2 factorial arrangement.

On d 0 weight, blood, and rectal temperature were collected and treatments were applied. Treatment of VAC received a modified live respiratory vaccination for infectious bovine rhinotracheitis (IBR), bovine virus diarrhea (BVD) type 1 and 2, bovine respiratory syncytial virus (BRSV), and parainfluenza 3 (PI3; Express 5, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO). Also, VAC received a 7-way killed clostridial vaccination for *Clostridium chauvoei* (Blackleg), *septicum* (Malignant edema), *novyi* (Black disease), *sordellii* and *perfringens* Type C & D (Enterotoxemia; Vision 7, Intervet Inc./Merck Animal Health, Madison, NJ). Treatment of DWM received fendendazole at 5 mg/kg orally (Safeguard® 10% suspension, Intervet Inc./Merck Animal Health, Madison, NJ) and levamisole at 8 mg/kg orally (Prohibit, Agri Laboratories, Ltd., St. Joseph, MO). Cattle in year 1 were weighed on d 14, and cattle in year 2 and 3 were weighed on d 12 and then every 14 days following in all years. Feces and serum were collected on d 28, 56 and 84 in year 1 and d 26, 54 and 82 in years 2and 3. All cattle were vaccinated with previously described products at d 54 or 56 depending on year. Cattle were provided free choice mineral containing monensin to provide 54 to 198 mg monenesin/hd/d. (CS Balancer R1200 Medicated, Purina Animal Nutrition, LLC, Shoreville, MN). No other supplement was provided.

Cattle were examined by trained observers on horseback at 0600 to 0800 h daily for visual signs of BRD (e.g. nasal or ocular discharge, depression, lethargy, emaciated body condition, anorexia, labored breathing and cough). Pen riders were blinded to treatment throughout the trial, yet tag color differentiated treatment groups. Case definition of BRD was assessed according to the guidelines in Appendix A. The BRD treatment protocol included administering ceftioflor (Excede, Zoetis Inc., Parsippany-Troy Hills, NJ) for initial treatment with 7 d post-treatment interval, florfenicol (Nuflor, Merck Animal Health, Madison, NJ) for second treatment with 3 d post treatment interval, and oxytetracycline (Noromycin 300 LA, Norbrook Laboratories, Overland

Park, KS) for third treatment. Cattle were returned to original pen following antimicrobial treatment.

Morbidity was measured as incidence density and calculated as: number of new BRD cases divided by calf days at risk. Days at risk were defined as the number of days from when treatment was applied (d 0) until a calf: 1) was diagnosed with BRD; 2) died; or 3) finished the trial.

Auction barn codes were collected from each individual sale tag (n=215) to determine distance traveled. It should be noted that some cattle lost sale tags during the marketing process or during transport. Distance traveled was calculated by adding distance from sale barn to order buyer facility and from the order buyer facility to the Mississippi Agriculture and Forestry Experiment Station H. H. Leveck Animal Research Center. Distance was classified as short (< 236 km), moderate (236 to 383 km), or long (> 383 km). Rectal temperature on d 0 was categorized as normal (<39.4°C), moderate fever (39.4°C to 39.9°C), or high fever (≥40°C).

Serum samples were submitted to the University of Nebraska Veterinary Diagnostic Laboratory in year 1 and University of Georgia Diagnostic Laboratory in years 2 and 3. Serum neutralizing (SN) antibodies against BHV1 and BVDV1 were quantified using standard methods described in Rosenbaum et al. (1970). Briefly, heat-inactivated serum was diluted in a series of 1:2 minimum essential medium (MIM) and incubated in the presence of 300 $TCID_{50}$ of cytopathic stock assay virus (BVDV or BHV-1) for 1 hour at 37°C in a 5% CO_2 atmosphere. Following incubation, diluted and incubated serum samples were mixed with 4000 washed *Bos taurus* turbinate cell (BT) per well. Cells were incubated for 4 (BHV-1) or 5 (BVDV) days at 37°C in a 5% CO_2

atmosphere and evaluated for the presence of cytopathic effect by inverted light microscopy. Externally validated control serums were included on each assay run and assay viruses were back titered onto cells to ensure infectivity at appropriate dilutions. Antibody titers were log (2) transformed prior to analysis.

Feces was submitted to the Kaplan lab at the University of Georgia College of Veterinary Medicine for gastrointestinal nematode FEC and evaluated at 5-egg per gram (EPG) sensitivity using the Mini-FLOTAC technique (Barba et al., 2013). For Mini-FLOTAC analysis, five grams of feces were placed into a Fill-FLOTAC homogenizer (Dr. Giuseppe Cringoli, University of Naples, Italy) and suspended in 45 mL of sodium nitrate flotation solution (specific gravity = 1.25 − 1.30, FECA-MED, Vedco, Inc., St. Joseph, MO). Homogenization of sample and sodium nitrate solution, slide preparation, and counting were completed as previously described (Noel et al., 2017). Fecal egg counts plus 1, to account for 0 counts, were natural log transformed prior to analysis.

Statistical Analysis

All data was analyzed using SAS software version 9.4 (SAS Institute Inc., Cary, NC). Pen served as the experimental unit. The effects of vaccination, deworming, d 0 fever, and castration status on BRD incidence were evaluated by Poisson regression in a linear mixed model (PROC GLIMMIX). The effects of vaccination, deworming, d 0 fever, and initial BW on mortality were tested in a log-binomial model (PROC GLIMMIX). The effects of vaccination, deworming, d 0 fever, and castration status on ADG were evaluated in a multilevel linear regression model (PROC MIXED). The effects of vaccination, deworming, d 0 fever, and castration status on log transformed FEC were tested using linear regression model (PROC MIXED). The effects of vaccination, deworming, initial FEC, and castration status on log transformed BHV-1 and BVDV titers were tested using repeated measures in a linear regression model (PROC MIXED). All models accounted for clustering by pen and year and significance was defined as $P \leq 0.05$. with trends being defined as $P \leq 0.10$.

Results and Discussion

There was no interaction between vaccination and deworming ($P > 0.10$) thus results will be presented separately. Tables 3.1 and 3.2 outline descriptive statistics by year. Numerically cattle in year 1 arrived with higher occurrence of fever and and a greater amount of morbidity and mortality. The variable year was treated as a random effect in the model to account for variation across years.

Animal Performance

Average weight of all calves on arrival was 221 ± 23.3 kg. The effects of on arrival vaccination and deworming on growth are presented in Table 3.3. There were no differences ($P > 0.10$) in ADG for 0 to 14 d, 0 to 56 d or 0 to 84 d when comparing VAC to NOVAC. These findings are consistent with similar receiving studies where respiratory vaccination was delayed 14 d (Richeson et al., 2008; Richeson et al, 2015; Poe et al., 2013) or 30 d (Rogers et al., 2016). In contrast, Richeson et al. (2008) saw an increase in ADG from 0 to 14 d and 0 to 42 d in high risk calves that received delayed 14 d modified live (MLV) respiratory vaccination. Chirase et al. (2001) conducted an experiment evaluating effects of four different clostridial vaccines and injection site lesions on performance. Calves receiving saline injection subcutaneously (control) gained similarly to those receiving the clostridial vaccine Alpha 7. Control steers had greater (P

< 0.05) ADG than calves receiving Vision 7, the clostridial vaccine used in the current study. In summary, the results from the current study and previous literature do not consistently indicate a performance advantage for vaccinating high risk stocker calves on arrival.

Calves receiving dewormer on arrival tended to have increased ADG (0.09 kg/d, P = 0.09) over the entire 84 d trial, yet no difference in ADG at 0 to 14 d and 0 to 56 d compared to calves not receiving dewormer. In stocker cattle grazing in various regions of the United States, Ballweber et al. (1997) saw increased (P < 0.05) ADG ranging from (0.15 to 0.27 kg/d) in cattle that were dewormed compared to those not dewormed. A meta-analysis of studies done in the northern United States found increased ADG in cattle receiving anthelmintic (Batzell, et al., 2015). Although the current study saw differences in ADG due to dewormer, the magnitude of difference was not as great as previously mentioned literature. It is not clear as to why this occurred; possibly, the increase in FEC of dewormed calves following d 28 combined with the natural immunity developed by non-dewormed calves over the grazing period decreased impact of deworming. Due to pasture management, the residual effect of parasites should have been minimal. Combined, these trends could account for the less drastic difference in gain seen in the current study.

The effects of fever at arrival on performance are displayed in Table 3.4. Cattle exhibiting rectal temperatures greater than 39.4°C on arrival had reduced (P < 0.05) ADG compared to calves with normal rectal temperature at 0 to 14 d, 0 to 56 d, and 0 to 84 d. Cattle that exhibited moderate (39.4°C to 39.9°C) or high (> 40.0°C) fever at arrival gained less during the initial 14 d and were not able to compensate by the end of the 84 d trial. The effects of fever at arrival on performance are limited in literature. Galyean et el. (1995) evaluated the effects of mass medicating febrile cattle (rectal temperature >39.7°C) only versus mass medicating the whole group or utilizing no mass medication. In both groups of cattle that were administered medication on arrival gained approximately 0.31 kg/d more than calves not administered antibiotics. Reduced performance of febrile cattle could be attributed to the fact that these cattle were already morbid or more likely to get sick causing negative effects on performance.

Table 3.5 presents the effect of castration status on arrival on performance traits. Cattle that were previously castrated had greater ($P < 0.05$) ADG than those castrated on arrival from both 0 to 14 d and 0 to 84 d. Although there was no difference ($P > 0.05$) in ADG during 0 to 56 d, castration's effect on performance in the initial 14 d had a prolonged impact on overall ADG. Similarly, Daniels et al. (2000) concluded previously castrated calves had more than twice the ADG of calves that were castrated on arrival during a 21-d period. Massey et al. (2011) noted similar results in feedlot cattle, as calves castrated before arrival gained 0.23 kg/d more than calves castrated at arrival. The reduction in performance due to castration could indicate there are metabolic costs due to castration.

Animal Health

Eighty-two of the 240 calves (34.2%) were diagnosed with BRD with 14 deaths (5.83%) attributable to BRD. There were a total of 13,591 days at risk and overall incidence density was 6.03 cases per 1,000 calf days. In non-vaccinated calves there were 39 new cases of BRD over a total of 6,971 days at risk, resulting in an incidence density of 5.59 BRD cases per 1,000 calf days. BRD cumulative incidence for non-vaccinated cattle was 32.5% with 5.83% mortality. Throughout the trial, 43 vaccinated calves were treated for BRD over 6,620 calf-days, giving an incidence density of 6.50 cases per 1,000 calf days (Figure 3.1). Cumulative incidence of BRD for vaccinated cattle was 35.8% with 5.83% mortality. Vaccinated calves were 1.76 times more likely to be treated for BRD (P=0.07). There were no differences (P > 0.10) in relapse rate or mortality for VAC and NOVAC (Table 3.7).

Previously, vaccination on arrival of high risk stocker cattle has not been clearly shown to be a benefit or detriment on health in the subsequent receiving period (Richeson et al., 2008; Richeson et al., 2009; Poe et al, 2013). Richeson et al. (2015) also found no difference in first time treatment rate in vaccinated and non-vaccinated cattle; yet, non-vaccinated cattle tended to have greater (P=0.08) relapse rate for BRD. Contrasting, Rogers et al. (2016) found differing resulting in comparing high risk feeder heifers that received MLV respiratory vaccine on arrival or 30 days after arrival to feedlot. Researchers found no difference (P = 0.70) in morbidity, but second time treatment rate was reduced (P = 0.04) in high risk calves that were delay vaccinated. It could be possible other factors are reducing vaccine efficacy such as the multifactorial nature of BRD or increased susceptibility to other pathogens during an immunostressed time.

There were no differences (P = 0.54) in BRD incidence for deworming, as shown in Figure 3.2. In non-dewormed calves there were 38 new cases of BRD over 7,046 days at risk, resulting in an incidence density of 5.39 BRD cases per 1,000 calf-days. BRD cumulative incidence for non-dewormed cattle was 31.67%. Throughout the trial, 44 dewormed calves were treated for BRD over 6,545 calf-days, giving an incidence density of 6.72 cases per 1,000 calf-days. Cumulative incidence of BRD for dewormed cattle was

36.67%. This is contrasting of cattle treated with fenbendazole before and during the grazing phase and at arrival to the feedlot had lowered morbidity and mortality than negative controls (Smith et al., 2000). It should be noted that Smith et al. (2000) included all sickness (BRD, pinkeye, gastrointestinal issues, and other health issues) observed during the feeding phase. The difference in results between the two studies may be related to differences in how sickness parameters were defined and risk level of calves.

Figure 3.3 displays the effects of fever on arrival on health. Thirty calves that arrived with normal rectal temperature (n=106, <39.4°C) were treated for BRD (28.3%) over 6,466 days at risk resulting in an incidence density of 4.64 cases per 1,000 calf-days. Twenty-two calves that arrived with moderate fever (n=81, 39.5 to 39.9°C) were treated for BRD (27.16%) over 5,079 days at risk resulting in an incidence density of 4.33 cases per 1,000 calf-days. Thirty calves that arrived with high fever (n=53, ≥40°C) were treated for BRD (56.6%) over 2,046 days at risk resulting in an incidence density of 14.7 cases per 1,000 calf-days. Cattle with rectal temperature greater than 40.0°C at arrival were 4.3 times more likely to get treated for BRD ($P < 0.0001$). Cattle exhibiting high fever had a greater ($P < 0.05$) relapse rate than cattle exhibiting moderate fever (9.14% v. 36.6%), but the relapse rate of cattle with a normal rectal temperature (23.3%) was not different ($P > 0.05$) versus cattle considered to have moderate or high fever. Number of deaths attributable to BRD for calves arriving with normal, moderate and high fever were 2, 1, and 11 resulting in 1.89 %, 1.23%, and 20.75% mortality, respectively. Calves arriving with rectal temperature greater than 40°C were more likely to die ($P = 0.0046$) due to BRD. Galyean et al. (2005) saw febrile cattle not treated at arrival had greater morbidity than febrile cattle that were given antibiotics. Cattle entering facilities with high fever may already be in the active stages of disease thus requiring treatment shortly after arrival if no metaphylactic treatment is administered.

Effects of castration status on BRD incidence density is displayed in Figure 3.4. Calves that were castrated on arrival had an incidence density of 6.89 BRD cases per 1000 calf days and calves previously castrated had an incidence density of 3.9 cases per 1000 calf-days. Calves that were castrated on arrival were 1.7 times more likely to be treated for BRD ($P=0.07$). The effects of castration on-arrival are well documented in literature. Daniels et al. (2000) found calves castrated on arrival had 92% greater incidence of respiratory disease than those that arrived already castrated. Similarly, Massey et al. (2011) reviewed 11 different receiving studies, and reported calves arriving as bulls had a greater probability of being treated for BRD initially and requiring multiple treatments. Calves arriving to a facility still intact are generalized as receiving less management prior to entering the marketing system. Prior poor management could leave calves more vulnerable to disease more so than the single event of castration, but that would impossible to separate without prior history.

Serology

Treatment of deworming had no effect on BHV-1 or BVDV titers. There was a vaccination x day interaction ($P < 0.001$) thus results will be presented separately. Figures 3.8 and 3.9 depict BVDV and BHV-1 titers, respectively. At d 0, there were no differences in BVDV and BHV-1 titers for the treatment of vaccination. Vaccinated cattle had greater ($P < 0.05$) BVDV titers at d 28 and 56 compared to non-vaccinated calves. BVDV titers were not different at d 84 between VAC and NOVAC. Calves castrated on arrival had lower ($P < 0.0001$) BVDV titers than calves that were castrated on arrival. In reference to BHV-1, VAC had greater ($P < 0.05$) BHV-1 titers than NOVAC at all time points following d 0. Calves with higher initial FEC had lower BHV-1 titers

BVDV titers of vaccinated cattle increased similarly to high risk calves vaccinated on arrival in Poe et al. (2013); whereas Richeson et al. (2008) saw no difference in BVDV tiers in arrival vaccinated cattle and delay (d 14) vaccinated calves at the end of the 42 d trial. Although cattle in the current study marked a response to vaccination, it did not improve the health of vaccinated calves versus those that were not vaccinated.

Fecal Egg Count

The average FEC on arrival was 309 ± 312 epg, with a large amount of variation with FEC ranging from 0 to 5,605 epg. Initial parasite load had no effect ($P > 0.10$) on gain, performance, or BRD outcomes. VAC and NOVAC did not differ at any time point for log transformed FEC. Cattle administered deworming on arrival had lower ($P< 0.002$) log-transformed FEC at each time point post treatment through the end of the trial. The effectiveness of dewormer reducing FEC is well documented. In auction market derived cattle, fenbendazole was found to effectively reduce FEC throughout the 30 d grazing period and at subsequent necropsy (Yazwinski et al., 2009). Walker et al. (2013) saw a significantly higher FEC in nontreated calves compared to cattle receiving initial anthelmintic treatment through d 59, yet when second treatment was applied at d 73 there was no difference in FEC. In this study, non-dewormed cattle had a downward trend in log-transformed FEC without receiving anthelmintic. The host ability to develop an effective response against parasites is responsible for the decrease in FEC over time (Gordon, 1948).

Figure 3.7 displays the fever x castration status interaction on initial natural log transformed FEC. Log transformed FEC of cattle with high fever at arrival did not differ from those deemed normal or moderate at arrival at any time points following deworming. Calves that exhibited moderate fever at arrival had higher ($P = 0.02$) log transformed FEC at d 28 than cattle with no fever. The effects of fever at arrival on FEC are somewhat inconsistent and lack explanation, but it does appear that calves with high fever do respond to deworming as FEC is effectively reduced.

Calves previously castrated had reduced ($P=0.0001$) log transformed FEC (2.13) compared to calves castrated at arrival (2.50). At d 28, previously castrated calves had lower log transformed FEC than calves castrated on arrival, but no differences at d 56 and 84. Once again calves arriving uncastrated could be indicative of lacking other prior best management practices such as deworming during the cow-calf phase. This holds true in the current study as calves that were not castrated prior to arrival had larger parasite loads.

Distance Traveled

Calves on average traveled 372 ± 171 km before arriving to stocker facility. Effect of distance travel on performance and health are presented in Table 3.6 and Figure 3.5, respectively. Distance traveled had no effect ($P > 0.10$) on health outcomes or growth performance. This differs from other studies that concluded morbidity increased linearly with distance traveled (Sanderson et al., 2008; Cernicchiaro et al., 2012b). Cernicchiaro et al (2012b) also found calves that traveled further distance had decreased ADG. The differences could be attributed to the lack of variation of distance traveled in the current study compared to the previous mentioned research.

Conclusion

This study showed vaccinating high risk calves on arrival to stocker facility can increase likelihood of calves being treated for BRD even though cattle mounted an antibody response to vaccination. On-arrival vaccination offered no advantages for performance over an 84 d grazing period. Deworming on arrival increased ADG, had no impact on calf health, and effectively reduced FEC. Calves that arrive uncastrated or experiencing fever are more likely to be treated for BRD and also gain less than their counterparts already castrated or with normal rectal temperature. It appears that initial parasite burden could affect immunological response to vaccination. Helminth infections can alter the cell mediated immune response to nonparasitic antigen such as those in vaccines in some animals (Kullberg et al., 1992). This immune response suppression could be inhibiting efficacy of the vaccines, which could be indicative of the differences seen in occurrence of BRD in the current study.

Implications

Managing high risk calves with unknown origin is challenging for stocker producers, but mitigating these risks is a necessity. Calves arriving with fever and uncastrated can be considered more vulnerable to disease and could require different management, such as antibiotic administration or separation from original group, to reduce disease and its effects. This study suggests that vaccination of high risk stocker calves on arrival is not advantageous during the receiving phase, but vaccination could provide later protection in the feeding phase; although, that was not an objective of the current study. With this thought process further research should be conducted to determine the most effective time to vaccinate high risk calves during the receiving period in order to best manage health, cost and to provide later protection in the production cycle.

Table 3.1 Descriptive statistics by year of health and performance data of newly received auction sources calves during 84 d receiving period

	Year		
Item	1	2	3
Initial BW, kg	204±1.81	213±1.80	246±1.97
Final BW, kg	278±3.49	312±3.18	328±3.51
ADG, kg/d			
0 to 14	0.08±0.13	0.87±0.12	1.44±0.13
0 to 56	0.75±0.04	1.44±0.04	1.33±0.04
0 to 84	0.85±0.03	1.20±0.03	1.00±0.03
Morbidity, %	46.3	33.8	22.5
Mortality, %	16.3	0.00	1.25

Table 3.2 Descriptive statistics by year of arrival characteristics of high risk calves (n=240)

	Year			
Item	1	2	3	Total
Fever[1]				
Normal	30	30	53	115
Moderate	27	34	20	81
High	23	16	7	46
Castration Status				
Previously	16	23	22	61
On-arrival	64	57	58	179
Distance Traveled[2*]				
Short	17	2	23	42
Moderate	30	32	19	81
Long	24	32	36	92

[1] Fever at-arrival, Normal = <39.4°C, Moderate = 39.4°C to 39.9°C, High = ≥40°C

[2] Distance traveled, Short = <236 km, Moderate = 236 to 383 km, Long = >383 km

[*] 35 calves arrived at facility without sale barn tag therefore distance traveled could not be calculated

Table 3.3 Effect of on arrival vaccination and deworming on growth for 84 day receiving period in high risk stocker calves

	Treatment[1]					
Item	VAC	NOVAC	P-value	DWM	NODWM	P-value
Initial BW, kg	221±3.58	222±3.48	0.88	222±3.54	221±3.51	0.88
Final BW, kg	304±4.71	309 ± 4.40	0.37	310±4.57	302±4.51	0.17
ADG, kg/d						
0 to 14	0.68±0.15	0.87±0.14	0.33	0.77±0.15	0.79±0.15	0.91
0 to 56	1.11±0.07	1.25±0.07	0.16	1.21±0.07	1.15±0.07	0.46
0 to 84	0.99±0.04	1.06±0.04	0.19	1.07±0.04	0.98±0.04	0.09

[1] Treatments of vaccination (5-way modified live BRD and clostridial vaccine, VAC) or not (NOVAC) and deworming (oral fenbendazole and levamisole, DWM) or not (NODWM) were randomly assigned in 2 x 2 factorial arrangement on d 0 to each pen.

Table 3.4 Effect of fever at arrival on growth for 84 day receiving period in high risk stocker calves

	Fever At-arrival[1]		
ADG, kg/d	Normal	Moderate	High
0 to 14	1.04±0.12[a]	0.74±0.14[b]	0.55±0.18[b]
0 to 56	1.28±0.05[a]	1.16±0.06[b]	1.10±0.08[b]
0 to 84	1.10±0.03[a]	1.01±0.04[b]	0.98±0.05[b]

[1] Fever at-arrival, Normal = <39.4°C, Moderate = 39.4°C to 39.9°C, High = ≥40°C

[a,b] Means within row with differing subscripts differ ($P < 0.05$)

Table 3.5 Effect of castration status on growth for 84 day receiving period in high risk stocker calves

	Castration Status	
ADG, kg/d	Previously	On-arrival
0 to 14	0.96±0.15[a]	0.60±0.11[b]
0 to 56	1.22±0.06	1.13±0.05
0 to 84	1.07±0.04[a]	0.98±0.03[b]

[a,b] Means within row with differing subscripts differ ($P < 0.05$)

Table 3.6 Effect of distance traveled on growth for 84 day receiving period in high risk stocker calves

	Distance Traveled[1]		
ADG, kg/d	Short	Moderate	Long
0 to 14	0.79±0.17	0.74±0.14	0.75±0.14
0 to 56	1.18±0.08	1.19±0.06	1.16±0.06
0 to 84	1.01±0.05	1.05±0.04	1.00±0.04

[1] Distance traveled, Short = <236 km, Moderate = 236 to 383 km, Long = >383 km

Table 3.7 Effect of on arrival vaccination and deworming on health for 84 day receiving period in high risk stocker calves

	Treatment[1]					
Item	VAC	NOVAC	P-value	DWM	NODWM	P-value
Relapse rate, %	16.3	33.3	0.32	22.7	26.3	0.66
Mortality, %	5.83	5.83	0.35	5.00	6.67	0.34

[1] Treatments of vaccination (5-way modified live BRD and clostridial vaccine, VAC) or not (NOVAC) and deworming (oral fenbendazole and levamisole, DWM) or not (NODWM) were randomly assigned in 2 x 2 factorial arrangement on d 0 to each pen.

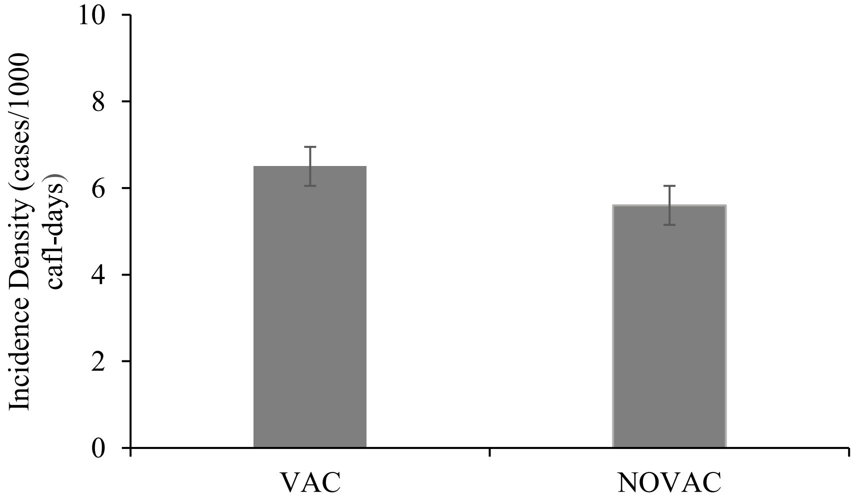

Figure 3.1 Effect of on arrival vaccination on bovine respiratory disease incidence density for 84 day receiving period in high risk stocker calves

[1] VAC = 5-way modified live BRD and clostridial vaccine, NOVAC = no vaccination
[2] P=0.07

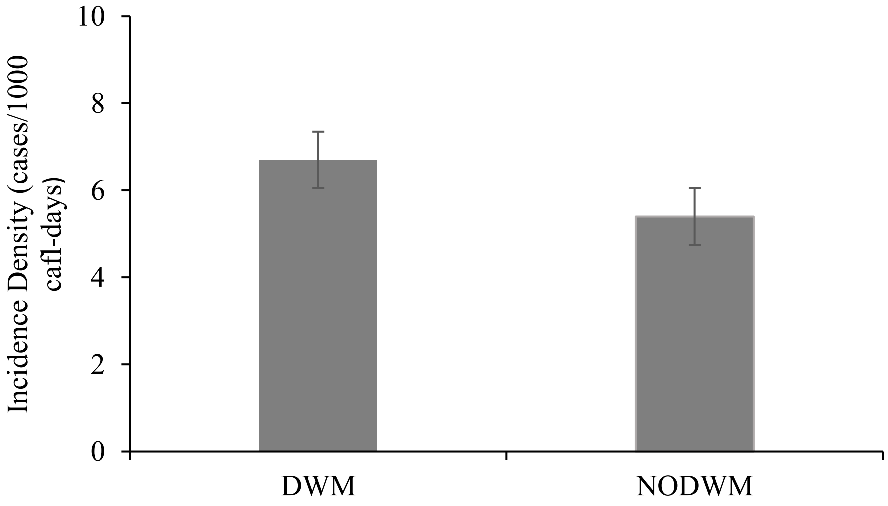

Figure 3.2 Effect of on arrival deworming on bovine respiratory disease incidence density for 84 day receiving period in high risk stocker calves

[1] DWM = oral fenbendazole and levamisole, NODWM = no dewormer
[2] P = 0.54

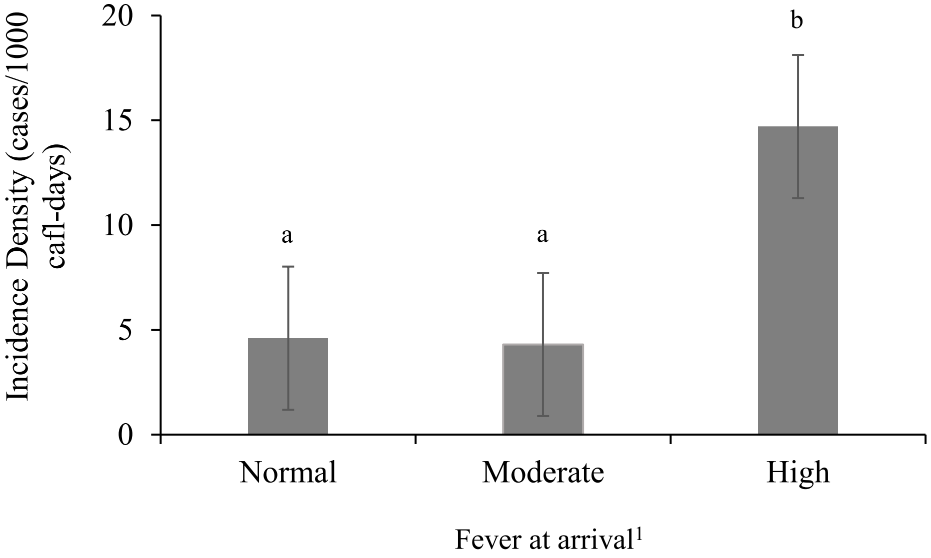

Figure 3.3 Effect fever on arrival on bovine respiratory disease incidence density.

[1] Fever at-arrival, Normal = <39.4°C, Moderate = 39.4°C to 39.9°C, High = ≥40°C
[a.b] Means with differing superscripts differ ($P < 0.05$)

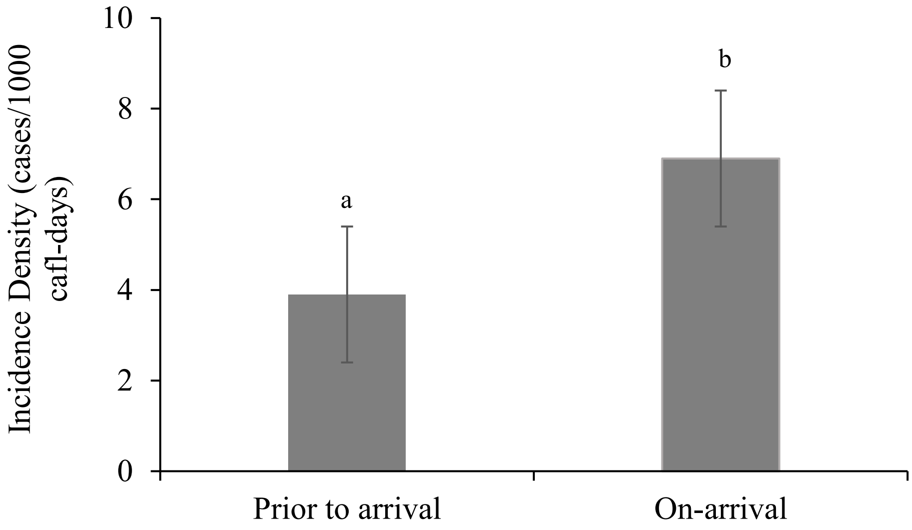

Figure 3.4 Effect of castration status on bovine respiratory disease incidence density for 84 day receiving period in high risk stocker calves. Means with differing superscripts differ ($P < 0.05$)

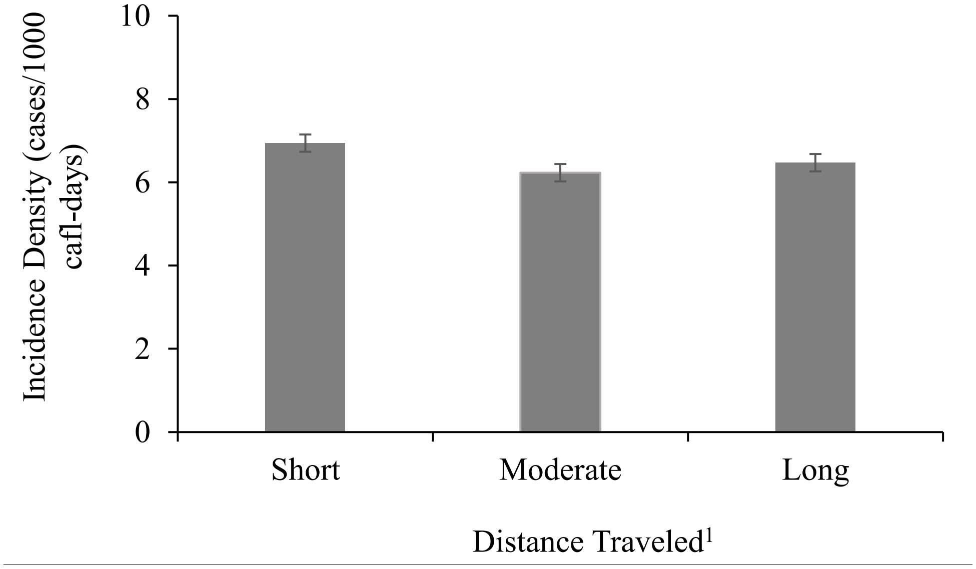

Figure 3.5 Effect of distance traveled on bovine respiratory disease incidence density for 84 day receiving period in high risk stocker calves.

[1] Distance traveled, Short = <236 km, Moderate = 236 to 383 km, Long = >383 km

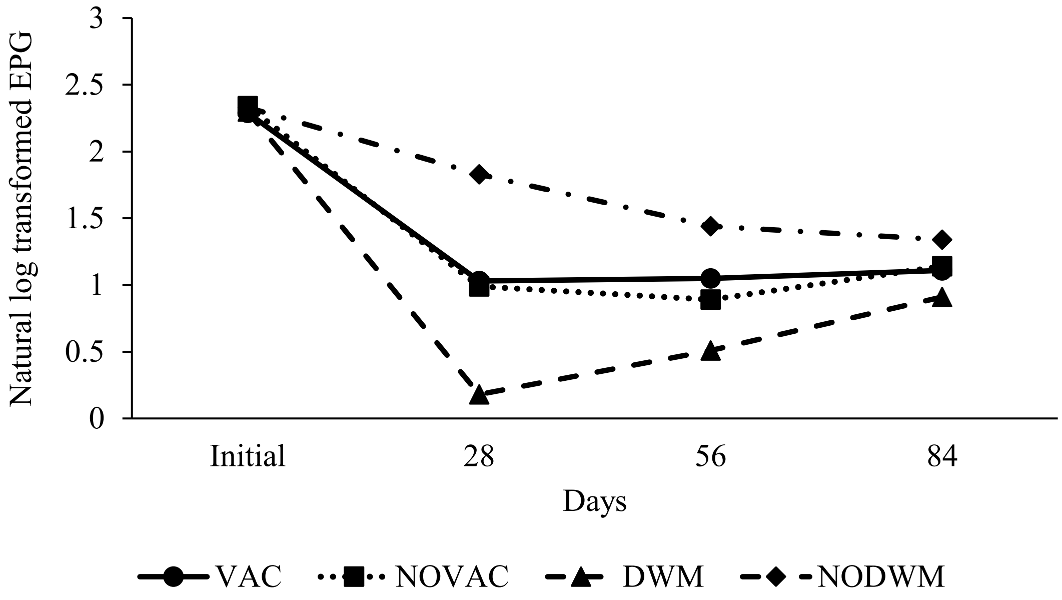

Figure 3.6 Log transformed FEC for calves receiving vaccination (5-way modified live BRD and clostridial vaccine, VAC) or not (NOVAC) and deworming (oral fenbendazole and levamisole, DWM) or not in 2 x 2 factorial fashion on arrival to stocker facility.

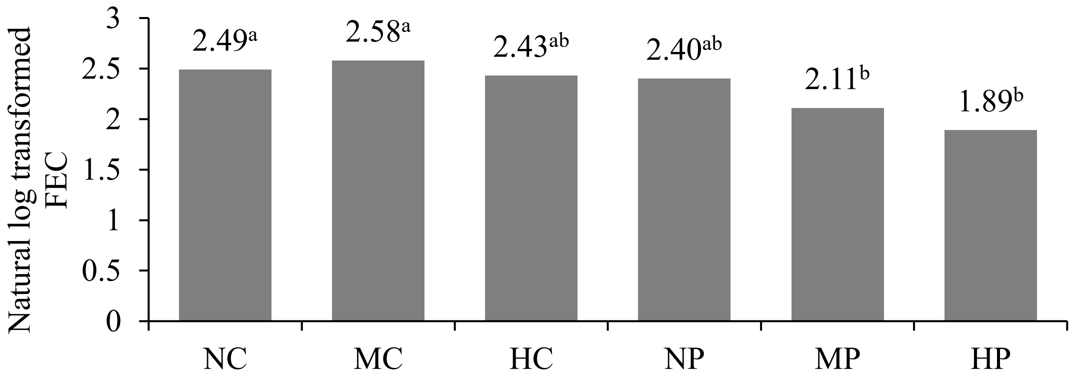

Figure 3.7 Initial natural log transformed FEC for interaction of fever at arrival and castration status.

[1] NC, Normal rectal temperature and castrated on-arrival; MC, Moderate fever and castrated on-arrival; HC, High fever and castrated on-arrival; NP, normal and previously castrated; MP, Moderate fever and previously castrated; HP High fever and previously castrated

[a,b] Means within row with differing subscripts differ ($P < 0.05$)

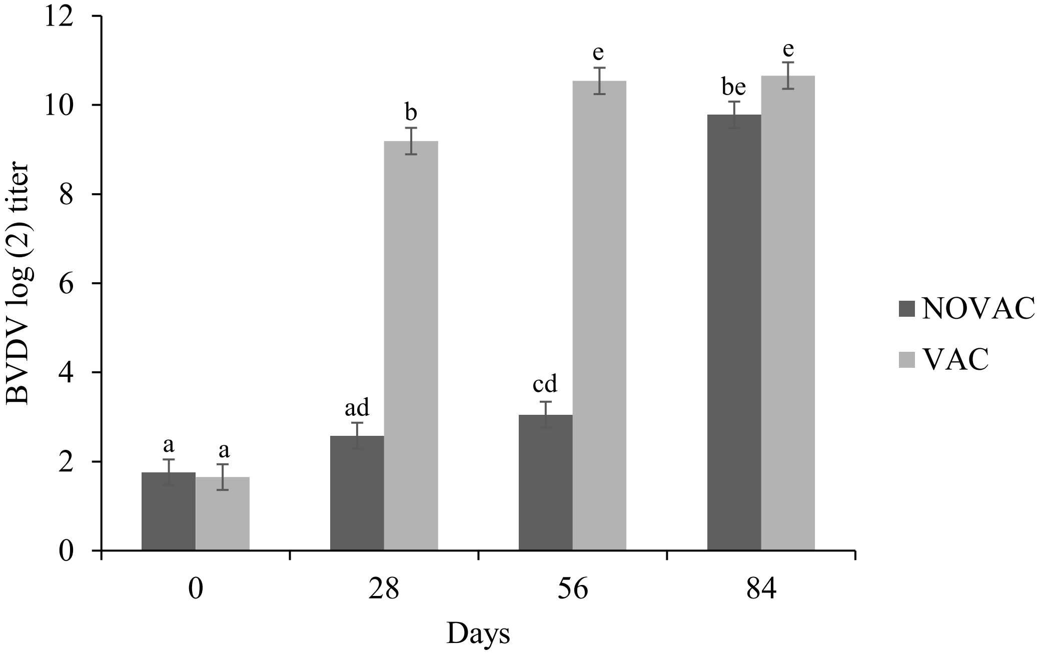

Figure 3.8 Log transformed BVDV titers for calves receiving arrival clostridial and respiratory vaccination or no vaccination until d 56. Differing subscripts determine differences within day (P < 0.05).

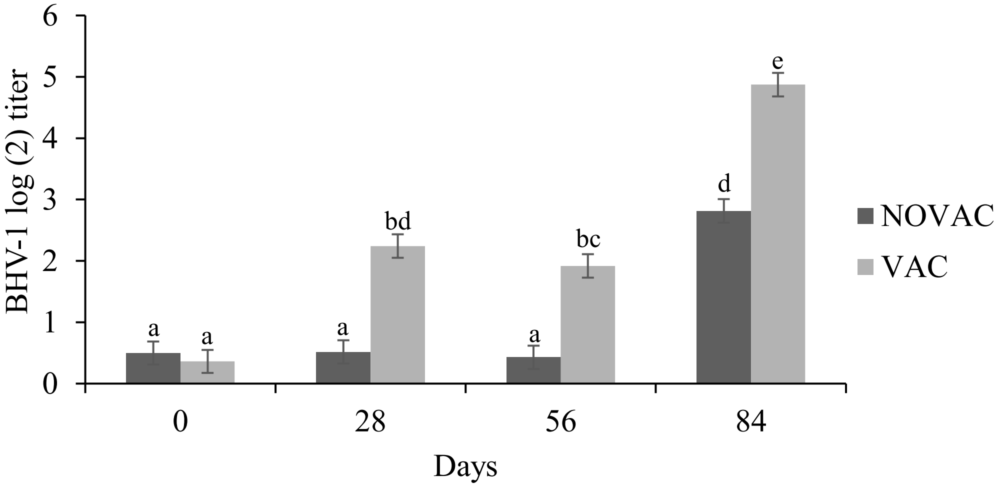

Figure 3.9 Log transformed BHV-1 titers for calves receiving arrival clostridial and respiratory vaccination or no vaccination until d 56. Differing subscripts determine differences within day (P < 0.05).

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APPENDIX A

BOVINE RESPIRATORY DISEASE SCORING SYSTEM

BRD Scoring system

0 = Normal

1 = Mild BRD including one or more of the following signs:

- elevated respiratory rate for the environmental conditions
- mild to moderate gauntness
- mild depressed attitude: not as alert as expected when viewed from a distance becomes alert when animal sees human observer
- shallow or dry cough

Cattle with score of 1 may also have cloudy, white, or yellow nasal discharge. **Nasal discharge in the absence of any other abnormalities is not enough for a score of 1.**

2 = Moderate BRD including one or more of the following signs:

- mild or moderate depression
  - lethargic, but may look alert when approached
  - head carriage lower than normal, but returns to normal when approached
  - hiding behavior: tends to stay behind other cattle, relative to the observer
- mild to moderate muscle weakness
  - stepping slowly when walking, or mild incoordination
  - droopy ears
- repeated coughing
- moderate gauntness
- breathing with mild to moderately increased abdominal effort

Cattle with a score of 2 may also have:
elevated respiratory rate for environmental conditions
clear, cloudy, white, or yellow nasal discharge.

3 = Severe BRD including one or more of the following signs:

- severe depression or weakness
  - lethargic and does not look more alert when approached
  - low head carriage, does not return to normal when approached
  - does not move away from examiner as expected when approached
  - cross stepping
- Repeated deep cough
- Severe breathing effort
  - open mouth breathing or panting
  - moderately to markedly increased abdominal effort

Cattle with a score of 3 may also have:
elevated respiratory rate for the environmental conditions
clear, cloudy, white, or yellow nasal discharge
and/or moderate to extreme gauntness.

4 = Moribund (near death)

- recumbent and does not rise when approached or directly stimulated
  OR
- standing but does not move unless directly stimulated
  - if the animal moves, it is very weak: drags feet, sways, stumbles, falls down
- eyes may be very sunken, abdomen may be very gaunt

Moribund animals may also have signs described for score of 1, 2, or 3.
Coughing may be heard from animals with any score.

NOTE: sometimes animals near death may act aggressively, trying to charge an observer

BRD Case Definition

BRD score = 1 or 2 AND have a rectal temperature ≥104 ºF
OR
a BRD score ≥ 3 regardless of rectal temperature.
WITH
no other obvious signs of disease (lameness, diarrhea, swollen legs, strange behavior, etc.)