

EFFECTS OF DELAYED STEROID IMPLANTING ON HEALTH, PERFORMANCE, AND  
CARCASS QUALITY IN HIGH HEALTH RISK, AUCTION MARKET SOURCED  
FEEDLOT STEERS

by

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## Abstract

Auction derived feeder calves ( $n=1,601$ ; initial BW =  $273.5 \pm 4.7$  kg) were used to examine the effects of delayed administration of the initial steroid implant on health, performance, and carcass characteristics of feedlot cattle. Steers were procured from multiple-source auction markets in the southeastern United States and shipped to a central Kansas feedyard over a 6 week period from December 2009 to January 2010. Steers were rested overnight prior to processing, then were randomly assigned, within arrival block, to 1 of 2 treatments: 1) implanted with Revalor-XS (40 mg estradiol and 200 mg trenbolone acetate) immediately upon arrival (ARRIVAL); or 2) implanted with the same implant after 45 d (DELAYED). Cattle were weighed on a group scale immediately following processing of each block. Feed deliveries were measured using load cells on feed trucks and recorded daily. Cattle were evaluated daily for morbidity and mortality by trained feedyard health personnel. Sick or injured cattle were removed from the home pen for further diagnosis and treatment. Individual animal health data were obtained and recorded daily. Final BW was calculated by dividing HCW by the average dressing percent of the pen. Carcass data (quality grade and yield grade) were obtained by USDA personnel; presence of lung lesions, pleural adhesions, and liver abscesses was evaluated by trained university personnel. Delaying the initial implant tended to reduce morbidity (24.7 vs. 28.5%;  $P = 0.13$ ) and reduced railer rates (1.8 vs. 3.3%;  $P = 0.02$ ); however, there were no effects of timing of implant administration ( $P \geq 0.31$ ) on rates of retreatment, mortality, lung lesions, or pleural adhesions. Implanting immediately upon feedlot arrival resulted in numerical improvements in ADG and feed conversion, but these differences were not statistical ( $P \geq 0.56$ ). Cattle implanted upon arrival had numerically greater HCW and yield grade vs. cattle implanted on d 45; however, these differences were not statistical ( $P \geq$

0.16). Delaying the initial implant 45 d did not influence animal health, performance parameters or carcass characteristics in high risk feeder calves.

# Table of Contents

List of Tables .....	vi
Acknowledgements.....	vii
Dedication .....	viii
Chapter 1 - Effects of delayed steroid implanting on health, performance, and carcass quality in high health risk, auction market-sourced feedlot steers – A Literature Review.....	1
Introduction.....	1
Hormone implants in feedlot cattle.....	4
Bovine respiratory disease in feedlot cattle .....	7
Chapter 2 - Effects of delayed steroid implanting on health, performance, and carcass quality in high health risk, auction market sourced feedlot steers .....	13
Introduction.....	13
Materials and Methods.....	14
Results and Discussion .....	16
References.....	23

## List of Tables

Table 2.1 Health data for high-risk steers implanted either immediately upon feedlot arrival (ARRIVAL) or 45 d post-arrival (DELAYED). .....	19
Table 2.2 Liver and lung abnormalities for high-risk steers implanted either immediately upon feedlot arrival (ARRIVAL) or 45 d post-arrival (DELAYED). .....	20
Table 2.3 Feedlot performance and cost of gain for high-risk steers implanted either immediately upon feedlot arrival (ARRIVAL) or 45 d post-arrival (DELAYED). .....	21
Table 2.4 Carcass traits and carcass value for high-risk steers implanted either immediately upon feedlot arrival (ARRIVAL) or 45 d post-arrival (DELAYED). .....	22

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## **Dedication**

I dedicate this thesis to my parents, David and Linda Munson; my sister, Jaclyn Munson; and my future bride; Brittany Burger. There are many people to thank for their unwavering support throughout my life, but none as important as those I have just listed. Through the good times and the bad, the late nights and early mornings, phone calls that were returned in a less than timely fashion, and the encouragement to be the best student, brother, son, husband, and friend. I thank you for always loving me and believing in me.



# **Chapter 1 - Effects of delayed steroid implanting on health, performance, and carcass quality in high health risk, auction market-sourced feedlot steers – A Literature Review**

## **Introduction**

The world human population reached 7 billion people in 2012. It is estimated that in 2025 there will be 8 billion people in the world and by 2050 the global human population will be 9.4 billion people (US Census Bureau, 2013). As continents become more populous, the economic wealth or living standards increase (Bloom, 2011) which results in increased consumption of meals with animal protein sources. As part of the solution to feeding the world by 2050, the United States will need to provide the world with a sustainable, safe, wholesome, and affordable food supply.

The United States set a beef export record of 3 billion pounds of beef and is currently the world's largest producer of beef with over 41.2 billion pounds produced in 2012 (Ag Marketing Resource Center, 2013). Domestically, beef is the 2nd largest agriculture industry for total cash receipts in the United States (Ag Marketing Resource Center, 2013). Beef production in the United States is important to feeding a growing population worldwide and has become a highly scrutinized industry for many societal concerns.

Beef production in the United States is very diverse with many different management systems utilized to raise cattle. Even though management and resources may differ throughout the United States, beef producers universally face diminishing operating margins and must adopt efficient, safe, and affordable technologies along with adaptation of forward-looking management practices to remain competitive on a global scale with competing protein sources.

Technology adaptation will be essential for beef producers to continue to improve cattle health, performance and carcass characteristics.

Considerable research has been conducted to increase efficiency throughout the beef feeding industry. Research has focused on increasing the rate at which cattle grow and deposit muscle mass while decreasing external inputs. It is imperative to improve cattle growth efficiency and decrease the time to get animals to market. One particular technology, hormone implants, have been FDA approved for use in beef cattle production since 1957 (Raun, 2002) and are considered the single best management tool to improve feed efficiency and average daily gain in beef cattle (Wileman, 2009; Hermesmeyer, 2000; Johnson, 1998; Lawrence, 2007). The use of hormonal implants in cattle improve ADG, DMI, HCW and lower feed-to-gain ratios when compared to non-implanted cattle (Reinhardt, 2014).

As domestication of cattle has evolved over the centuries, greater scientific knowledge has been discovered on the ailments that affect cattle. One disease in particular, bovine respiratory disease, has been studied in depth since the late 1800s (Taylor, 2010) and ongoing research is performed today. Bovine respiratory disease is the most prevalent infectious disease in beef cattle and BRD is the most costly disease affecting cattle worldwide (Snowder, 2007; Cusack, 2007; Apley, 2006; Griffin, 2009). Even though prevalence of bovine respiratory disease has been found to affect 14-52% of cattle (Snowder, 2006), and accounts for 70-80% of morbidity and 40-50% of mortality in US feedlots, it is extremely challenging to diagnose. As a result, many cattle suffering from BRD may go undiagnosed and untreated in beef herds (Thompson, 2006). Cattle from birth to final feeding phase can acquire bovine respiratory disease through a number of different etiologies. No matter the BRD etiology, cattle stress is a common factor involved (Duff, 2006). When cattle become stressed, they are at a much greater

chance of contracting bovine respiratory disease. Respiratory disease decreases immune function, decreases feed intakes, and also results in loss of body weight, decreased body condition, and mortality. The greatest challenge facing the feedlot cattle health and well-being is preventing BRD among newly received cattle (Edwards, 2010).

Newly arrived cattle at a feeding facility are at an elevated risk for developing BRD due to stress. Mismanaged cattle that have not been properly prepared to transfer from the ranch to the feedlot succumb to stress from adjusting to new environmental conditions along with comingling cattle from multiple ranch or auction market sources. Cattle can become anorexic due to being unfamiliar with a new feeding routine or how to eat out of a bunk. Maternal separation along with a new social order from comingling can also lead to stress for newly arrived calves. Feedlot managers continuously work to improve cattle care and comfort to sustain feed intake that could be lost due to behavioral, physiologic, pathologic, and environmental changes occurring simultaneously for newly received calves (Bruns, 2006).

Decreased feed intakes in cattle inhibit the ability of hormonal implants to improve calf performance (Hermesmeyer, 2000). Cattle that are sick due to BRD have depressed intakes. Recently, feedlot veterinary and nutrition experts in the field have questioned whether applying hormonal implants at the time of arrival in stressed calves could negatively impact the immune response in beef cattle. Hormonal implants improve the anabolic muscle metabolism of protein in cattle that would be excreted in waste or used in other metabolic processes (Dalke, 1992). Does application of a steroid implant in high health risk cattle that are simultaneously experiencing depressed intakes and undergoing stressors from many different origins cause more undue stress and become counter-efficient for the original intention of its use? This literature

review will set the groundwork to understand the possible implications of delaying the steroid implant on health, performance, and carcass parameters in high-health risk feedlot cattle.

### **Hormone implants in feedlot cattle**

Hormone implants are considered the single best management tool to improve feed efficiency and average daily gain in beef cattle (Wileman, 2009; Hermesmeier, 2000; Johnson, 1998; Lawrence, 2007). Hormones were first researched in food animal production systems in 1947 with the advent of diethylestilbesterol (DES) and have been FDA approved for use orally in beef cattle production since 1954 (Raun, 2002) to increase feed utilization, stimulate growth, and increase leanness of the animal. In 1957, DES became available as an injectable implant and set the stage for many more products to enter the market over the next 6 decades. Since the advent of DES, many different hormonal implants have entered the market place with different target hormones, different strength or potencies, and also different management practices to utilize them efficiently and correctly. Today, most hormonal implants can be categorized into either estrogen-based or androgen-based. The estrogenic hormones currently marketed for feedlot cattle are estradiol, estradiol benzoate, and zeranol. The androgenic hormones used in feedlot implants are trenbolone acetate (TBA) and testosterone. Combination estradiol and TBA implants are also available, and these implants have shown to be additive, as compared to individual hormone use, and have also shown synergism when using the two hormones combined into a single implant (Mader, 1998; Reinhardt, 2014; Reinhardt, 2007; Anderson, 1991).

Muscle satellite cells provide the nuclei for the muscle fibers during postnatal muscle growth. In mature muscle bodies, the size of the muscle is limited by both the number and the activation of satellite cells within the muscle fiber (Johnson, 1998). The satellite cell must be activated or progress out of dormancy ( $G_0$  phase) in order to undergo muscle growth and

development (Johnson, 1998). Trenbolone acetate and estradiol combination implants exhibit a shorter lag phase from  $G_0$  to activation than satellite cell cultures isolated from non-implanted steers. This finding indicates activation of quiescent satellite cells has a role in enhanced muscle growth in mature feedlot steers (Johnson, 1998). This has resulted in significant increases in growth, efficiency, and muscle deposition of steers and heifers (Anderson, 1991; Reinhardt, 2007; Reinhardt, 2014; Mader, 1994).

The use of TBA alongside estradiol hormones have been shown to be additive when compared to using each hormone individually. Estradiol hormones increase the release of somatotropin (also known as growth hormone) (Anderson, 1991). The increase in growth hormone due to estradiol implantation leads to an increase in release of the secondary messenger IGF-1 from the liver (Johnson, 1998). Insulin-like Growth Factor-1 directly impacts muscle growth in growing cattle by increasing protein synthesis and decreasing protein degradation. This growth factor also aids in the development in muscles, bones, and cartilage in adult tissues (Gonzalez, 2013). Alternatively, androgen based hormones work directly on the muscle by binding to both estrogen and testosterone receptors in skeletal muscle increasing protein synthesis and decreasing protein degradation (Anderson, 1991).

Hormone implants are utilized by 92% of feedlots across the United States to promote weight gain (USDA, 2000). Growth promoting implants increase average daily gain (ADG) and feed-to-gain (FG) ratio when used on cattle in a feedlot. Lawrence (2007), Mader (1994), Mader (1998), and Wagner (2007) have all reported implants increasing ADG by 5-15% and decreasing the FG by 5-10%.

Carcass quality is very important to beef consumers. Previous research has indicated steroid implants have no change, or very limited change, in cattle body composition or quality

grade compared to non-implanted cattle (Griffin, 2009; Johnson, 1996; Gerken, 1995). Conversely, recent literature recognizes the administration of multiple implants requires additional days on feed, when compared to nonimplanted or singly implanted cattle, in order to reach similar body compositional end points (Reinhardt, 2014; Reinhardt, 2007; Selk, 2006). This increase requires an additional 12-15 days on feed and can result in an increase of HCW of 55 pounds, or 8-14% body weight (Reinhardt 2007). The discrepancies on carcass composition following implant are likely to be multi-factorial and could be influenced by implant type, implant timing, implant potency, and other external factors. Steroid implants have a substantial economic benefit when used in the commercial feedlot setting. Implant use compared to non-use will result in approximately 6.5% per head in cost savings; or roughly \$68/head (Lawrence, 2007), or \$77/head less production costs compared to non-implanted steers (Wileman, 2009).

Widespread use of hormone implants can use numerous available products on the market and has given rise to many different management techniques for beef cattle. Beef producers may change the type of hormone, timing of implantation, or number of implants to administer based on animal sex, weight, genetic potential, available feedstuffs, diet, history of implant use, or environmental conditions to reach performance goals. Implants are routinely administered in beef production systems to cattle from suckling calves to cattle within 80-90 days of slaughter; a time period that encompasses over 14 months and includes multiple implants throughout the different feeding and growing phases.

In 2007, Revalor-XS (Merck Animal Health, Madison, NJ) entered the market as a 200 day long-lasting steroid implant. Each implant contains 200mg of TBA and 40mg of Estradiol and dispenses this regulated dose through a combination of 4 uncoated pellets for early release, and 6 uniquely coated pellets for extended release. Formerly, it was common for users of implants to

place one implant upon arrival of new animals to a feeding facility, and then re-implanting them again 80-100 days prior to slaughter (Duckett, 2001). With the advent of this new product, animal stress due to processing and handling, along with labor costs, can be reduced and still allow hormone supplement to be provided throughout the entire feeding period.

When cattle have multiple-source origins, comingling at auction markets, long-haul transportation, and unknown health or immune status, they are especially prone to developing bovine respiratory disease (Hutcheson, 1986; Hoerlein, 1957; Duff, 2007). Recently, speculation has surfaced on the benefits, or potential detriments, to implanting steers with hormone implants upon arrival to a feeding facility.

### **Bovine respiratory disease in feedlot cattle**

Newly arrived feeder cattle are at an elevated risk for developing BRD due stress from adjusting to their new environment, comingling with cattle from multiple sources, decreased feed intakes due to new feeding routine, recent weaning, new social order, and many other changes occurring simultaneously (Hoerlein, 1957; Hutcheson, 1986). Bovine respiratory disease complex is characterized by an infection of the lungs by a viral and/or bacterial agent. Viral pathogens associated with bovine respiratory disease complex are infectious bovine rhinotracheitis (IBR), bovine viral diarrhea virus (BVDV), bovine respiratory syncytial virus (BRSV), and parainfluenza virus (PI3) (Duff, 2007). Vaccine and preventative programs for viral BRD agents focuses on IBR, BVDV, and BRSV (Apley, 2006; Griffin, 2009). Bacterial pathogens involved in the BRD complex include *Mannheimia haemolytica*, *Pasteurella multocida*, *Histophilus somni*, and *Mycoplasma bovis* (Apley, 2006; Griffin, 2009; Edwards 2010). *Mycoplasma bovis* is still debated by many authors as a primary BRD pathogen (Apley, 2006; Griffin, 2009; Edwards 2010).

Many of the bacterial pathogens involved in BRD are normal inhabitants of the bovine upper respiratory tract and *M. haemolytica* is the most common bacteria isolated from respiratory disease in feedlot cattle (Apley, 2006). *Mannheimia haemolytica* is an opportunist bacterium that gains access to the lungs when host defenses are compromised by stress or infection (Rice, 2007). Stress and infection have shown to negatively affect nutrient status, nutrient metabolism, and feed intake in cattle (Cole, 1986). During stress and/or infection, severe weight loss can occur due to a hyper-metabolic state mediated by an increased release of catecholamines. This release of catecholamines is proportional to the severity of the stress and/or infection (Cole, 1986). Typically, the development of BRD involves the combination of an immunocompromised or stressed animal that is exposed to an immunosuppressive viral agent, such as BVD or IBR. This immunosuppression allows commensal bacterial pathogens, such as *M. haemolytica*, to colonize the respiratory tract and cause disease (Edwards, 2010).

Controlling BRD among newly received cattle is the greatest challenge facing the feedlot industry (Edwards, 2010). Successful detection of BRD has historically depended on detecting signs of depression and anorexia then confirming that diagnosis with an elevated rectal temperature (Apley, 2006). It is known that rumen bacteria grow slowly at temperatures >40C, and as a result of the undifferentiated fever, rumen temperature may be high enough to decrease rumen fermentation, and therefore a reduction in digestibility (Cole, 1986). During an infection with bovine respiratory disease, cattle are observed to be depressed and have decreased feed intake. Despite improved management practices and extensive use of vaccination programs, BRD continues to be a major cause of death loss in feedlot cattle (Rice, 2007).

Bovine respiratory disease is the most common and costly disease of beef cattle in North America (Taylor, 2010) and the incidence of BRD at a single cattle feeding facility can vary



greatly over the course of many years. It has been estimated that 5 to 44% of all cattle on feed are treated for BRD at some point during the finishing period (Snowder, 2006). Bovine respiratory disease is responsible for 70 to 80% of feeder cattle morbidity and 40-50% of feeder cattle mortality (Snowder, 2006). The incidence of BRD in feeder cattle can have substantial negative effects in performance, health, and carcass quality (Smith, 1998). Costs of decreased performance and carcass value in diseased cattle have been studied at length, but applying a dollar amount to the cost over an entire group of cattle during an entire feeding period has proved to be much more difficult (Apley, 2006).

Stress related activities such as weaning, comingling, and transport have been implicated as primary contributors in the pathogenesis of BRD. These stressors are potentially additive and work synergistically to weaken the host defense mechanisms and promote development of disease (Edwards, 2010). Alterations in immune function could impact the ability of the calf to maintain normal homeostasis with the commensal organism (Rice, 2007). Transportation stress was found to be a cause of transient elevation of plasma cortisol levels which lead to suppression of lymphocyte blastogenesis (Filion, 1984). One transportation study evaluating the effects of transport stress on calves hauled 12 hours had significantly higher morbidity and mortality compared to calves not transported (Cole, 1988). Calves that were transported for 12 hours or longer had higher morbidity and mortality, became ill earlier, and became ill or died during a longer feeding period than did calves not transported (Cole, 1988). Transport stress has also been shown to affect cattle ADG and GF during the first 28 days on feed. This effect, however, was not a significant factor after 56 days on feed (Cole, 1988). This illustrates stress can significantly impact the performance, and possibly health, during the first 45 days on feed, but animals can typically recover by 56 days on feed.

The first 45 days on feed has been identified as the most critical time in the development of BRD. Approximately 65 to 80% of total morbidity in feeder cattle occurs within the first 45 d on feed (Edwards, 1996). Morbidity after 45 d of feed has been observed to be less than one-third the rate compared to cattle during the first 45 days on feed in a feeding facility (Edwards, 1996). Calves sick with BRD suffer from poor weight gains in the first month of the feeding period in comparison to the calves that don't get sick, but this difference was eliminated when the gains were compared over the entire feeding period (Bateman, 1990). Calves that relapsed after their initial first treatment were treated for the first time at 6.1 days on feed. These animals had significantly impaired rates of gain over the entire feeding period when compared to the non-treated control animals (Bateman, 1990).

Feed intake has been studied as an indicator for response to BRD treatment in feeder cattle. During 28-d receiving periods, Smith (1996) reported that sick calves experienced a decrease of 0.23 kg ADG, and Bateman (1990) reported a decrease in 0.14 kg ADG less for calves sick with BRD compared to non-ill cattle cohorts. In these studies, calves losing body weight after BRD therapy were 2.7 times more likely to be treated for BRD again as compared with calves that gained 0-5% of initial body weight during the first BRD treatment regimen. Calves gaining greater than 5% of their body weight were 11 times less likely to be treated a second time for BRD (Apley, 2006).

In a study with electronic behavior monitors, healthy steers reportedly spent more time at the feed bunk and had more feeding bouts than sick steers (Sowell, 1999). Healthy calves averaged 0.9 more daily drinking bouts than sick calves in the first 4 days on feed and 0.7 more drinking bouts per day throughout a 32 day feeding period (Sowell, 1999). This data agrees with

work done by Basarab where sick steers treated for BRD spent 23.7% less time at the water trough than healthy steers (Basarab, 1996).

Research has examined the correlation between ante mortem diagnosis of BRD and post mortem evaluation of lung lesions at time of slaughter (Thompson, 2006). Fewer animals having lung lobe pathology at time of slaughter were previously treated for BRD at some point in their lives (Wittum, 1996). In one study, 35% of 469 steers received treatment for BRD at some point between birth and slaughter; 78% of the animals treated actually had lung lesions when examined at slaughter. Interestingly, 68% of the steers that were never diagnosed with BRD during their life had lung lesions at slaughter (Wittum, 1996). Gardner (1998) found steers with lung lesions at the time of slaughter had 2% lighter carcasses at slaughter and lower carcass quality compared to cattle not exhibiting BRD lung lesions at slaughter (Gardner, 1998). This underlines the fact that diagnosing BRD in cattle is an extremely challenging task. As a result, many cattle may go undiagnosed and untreated in beef herds (Thompson, 2006).

If immunity is not initiated before entry into the feedlot, it may be difficult to achieve protective immunity upon arrival at the feeding facility, resulting in higher morbidity, mortality, and lost performance (Edwards, 2010). Therefore, the goal of improving cattle health centers on improved diagnosis of BRD. Current methods of BRD diagnosis are subjective observation of clinical signs of depression, anorexia and irregular respiratory rates in cattle.

Cattle can acquire bovine respiratory disease through a number of different etiologies from birth to final feeding phase. No matter the etiology that causes BRD, the common factor all variables share is stress (Cole, 1988). When cattle become stressed, they are at a much greater risk of contracting bovine respiratory disease. Respiratory disease decreases immune function, decreases feed intakes, and results in loss of body weight, decreased body condition, and

mortality. Until a better method for detecting and diagnosing BRD is developed for US feeding facilities, we must focus on our husbandry and management of newly received feedlot cattle. Recently, the stress from increased metabolic modification in feeder cattle during the first 45 days on feed due to steroid implants administration at arrival processing has been questioned by expert veterinarians and nutritionists.

During the feeding phase, Bruns (2006) found delaying the steroid implant application in cattle until they were able to consume enough feedstuffs to meet the demand of both muscle and intramuscular fat tissue increased the end-value of the beef carcass compared to not delaying implant application in cattle (Bruns, 2006). Delaying the time of initial steroid implant was not observed to have a negative impact on feeder cattle performance or feed efficiency (Mader, 1994). Cattle are implanted upon arrival to align with other processing practices such as vaccination, dehorning, castration, antibiotic administration, and deworming. No studies have been conducted to observe if utilization of a steroid implant in newly received cattle with high risk for developing BRD may cause undue stress and become counter-efficient for the original intention of its use. Implanting cattle on arrival may be counter-productive and catabolic if cattle become sick with BRD and have suppressed feed intakes. Delaying implant application until cattle are healthy in the feeding phase could have positive health implications while also improving performance and carcass characteristics.

The objectives of this research are to examine the effects of delaying the initial steroid implant by 45 days and assess the performance, health, and carcass quality impacts on feeder cattle in a commercial feedyard setting.

## **Chapter 2 - Effects of delayed steroid implanting on health, performance, and carcass quality in high health risk, auction market sourced feedlot steers**

### **Introduction**

Bovine Respiratory Disease (BRD) is the most costly disease in the beef industry (NAHMS, 2000; Snowder, 2006). This syndrome is very common but is difficult to diagnose and subsequently many cattle go untreated (Thompson, 2006). The negative impacts of BRD have been shown to cause a decrease in finished weights in affected cattle and decreased quality grades compared to healthy cattle (Gardner, 1999; Reinhardt, 2009).

In high-risk cattle there are many stressors that can influence post-arrival health and nutrient intake as described by Taylor (2010), such as lack of pre-conditioning (i.e. castration, dehorning), long distance shipping and transportation, source of cattle (sale barn origin), weather, genetics, and nutrition. These stressors can negatively affect the immune system (Blecha, 1984) at a time when the animal is more likely to be exposed to infectious agents within the BRD complex. Cattle suffering from Infectious Bovine Rhinotracheitis (IBR) have a decrease in protein synthesis and an increase in protein degradation (Boyles, 1989). Feed intake by stressed calves is low (Galyean, 1995; Cole, 1996) and low nutrient intake likely augments the negative effects of stress on the immune system.

Growth-promoting implants are routinely used in beef cattle production to increase growth and efficiency and decrease production costs (Montgomery, 2001). Delaying the time of initial steroid implant has no negative impact on feeder cattle performance (Mader, 1994) and may actually improve carcass quality in feedlot cattle (Bruns, 2005). By delaying the initial implant, there is also potential value in not adding additional stress to high-risk cattle which leads to

disease and decreased carcass weights and carcass quality. This study is designed to examine the effects of delaying the timing of the initial steroid implant on the health, performance and carcass characteristics in high-risk feeder calves.

## **Materials and Methods**

All procedures conducted in the present experiment were approved by the Kansas State University Institutional Animal Care and Use Committee.

This study was completed at a commercial feedyard in central Kansas. High-risk calves ( $n = 1,601$ ;  $273.5 \pm 4.7$  kg) were shipped to a commercial feedyard and were allowed to rest overnight prior to processing. Cattle arrived at the feedyard 5 dates between December 3, 2009 and January 16, 2010 and were blocked by arrival date. Steers were rested overnight prior to processing, and then were randomly assigned, within arrival block, to 1 of 2 treatments. Cattle were either (1) implanted with Revalor-XS (40 mg estradiol and 200 mg trenbolone acetate; Merck Animal Health, Summit, NJ) immediately upon arrival (ARRIVAL); or (2) implanted with the same implant 45 d after arrival (DELAYED) resulting with approximately 80 animals per pen with 10 replicates per treatment ( $n = 1,601$  in 20 pens). Cattle were randomly assigned to either ARRIVAL or DELAYED treatment in groups of 5 animals as they were moved through the processing barn.

Cattle were weighed individually on d 0 and d 45 and their final BW was calculated by dividing HCW by the average dressing percent of the pen. A pen weight was also measured before cattle were shipped to harvest. All scales were calibrated with known weights prior to weighing cattle. Average daily gain, DM intake and feed efficiency were recorded.

Weight of all feed was captured by load cells on the feed trucks and was recorded daily. Cattle were fed using a clean bunk system; that is, bunks were managed such that all feed was

consumed prior to the next morning feeding. Diet DM was measured using the microwave oven technique described by Pitt (1993), and subsequently recorded. Any feed that was removed from the bunk was recorded. Feed consumption for cattle placed in the hospital system was calculated as 50% of the DM intake of the cattle in that animal's home pen for the duration of their hospital residence.

All cattle were observed daily by trained feedyard personnel for morbidity or mortality. Cattle deemed sick or injured were removed from the home pen for further diagnosis by the feedyard health personnel. Reason for removal, date, BW, rectal temperature, treatment, and d spent in hospital or recovery pen were recorded for all cattle removed from the home pen and placed into the feedyard hospital system. Necropsies were conducted on any cattle that died during the feeding period. Reason for death or removal, date and BW were recorded. These data were used to determine rates of morbidity, retreatment, mortality, respiratory mortality and chronicity.

Cattle were shipped by replicate to a commercial slaughter facility. Trained abattoir personnel recorded HCW, and USDA personnel evaluated quality grade and yield grade for all cattle. Trained university personnel recorded lung lesions, liver abscess lesions and pleural adhesions at the time of slaughter.

Continuous variables were analyzed using the Mixed procedure of SAS (v. 9.1.3, SAS Institute, Cary, NC) with treatment included as a fixed effect and arrival date as a random effect. Categorical variables were analyzed using the GLIMMIX procedure of SAS using a similar model. Pen was considered the experimental unit for all variables. Treatment means were considered different using a protected F-test with  $\alpha = 0.05$ ;  $P$ -values between 0.05 and 0.15 were considered a trend.

## Results and Discussion

In the present data set (Table 1), there is a large discrepancy between total mortality rate and respiratory mortality rate. This is due to a severe heat stress event that occurred at approximately 180 d on feed and resulted in 59 mortalities.

Delaying administration of the steroid implant in high risk feeder cattle resulted in minimal differences in health parameters compared to cattle that received their implant upon arrival (Table 1). Delaying implant administration tended to decrease morbidity ( $P = 0.13$ ) and decreased the percentage of cattle railed due to chronic BRD ( $P = 0.02$ ); however, there were no treatment effects on total out cattle ( $P = 0.80$ ) or total out cattle due to respiratory disease ( $P = 0.85$ ), which is perhaps a more complete indicator of disease outcome. Moreover, there were no differences in retreatment rate, total death loss, or death loss solely due to respiratory disease ( $P \geq 0.31$ ) for cattle that received their implant on arrival vs. cattle in which implant administration was delayed.

Delaying implant administration had no effects on incidence of pleural adhesions, lung lesions, or liver abscesses in feeder cattle ( $P \geq 0.41$ ; Table 2). Over 50% of all cattle enrolled in the study had lung lesions at slaughter which indicates that these cattle experienced a severe BRD challenge during the study. These results are similar to those of Thompson (2006), who found that 43% of all cattle on trial were inflicted with lung lesions at slaughter. Pleural adhesion rates have not been well documented, but the cattle in this study averaged 20.7% pleural adhesion rates ( $P = 0.63$ ). Thompson (2006) found that 38.8% of cattle enrolled on that particular trial had pleural adhesions at time of slaughter.

Implanting immediately upon feedlot arrival resulted in numerical improvements in ADG and feed conversion, but these differences were not significant ( $P \geq 0.56$ ; Table 3). Griffin (2009) reported a numerical 10 kg decrease in the final BW of steers after delaying implant



administration 32 d compared to implanting upon arrival. Bruns (2005) reported a significant reduction in ADG during the first 56 d on feed for cattle in which the initial implant was delayed; however, differences in ADG were eliminated when performance for the entire feeding period was reported.

There was a 5 kg numerical decrease in HCW for DELAYED cattle vs. ARRIVAL cattle (383 vs. 388 kg;  $P = 0.20$ ; Table 4). This concurs with the results of previous research (Mader, 1985; Bruns, 2005; Griffin, 2009) which reported no effect on HCW by delaying initial implant administration. Cattle which had the implant delayed in this study had numerically lower yield grades (2.10 vs. 2.24;  $P = 0.16$ ; Table 4). Bruns (2005) also reported numerically lower yield grades for cattle in which the implant was delayed 56 d. Whereas Bruns (2005) reported a statistical increase in the percentage of carcasses grading Premium Choice and a numerical increase in marbling score for cattle in which the implant was delayed, the present study showed no differences ( $P \geq 0.44$ ) in percentage of cattle grading Choice, Upper 2/3 Choice, or ungraded. Mader (1985) and Griffin (2009) similarly reported no effect of delayed implant administration on quality grades. Due to slight numerical increases in the percentage of carcasses grading Choice and Upper 2/3 Choice, and a slight decrease in percentage of ungraded carcasses for DELAYED cattle, delayed implant administration tended to increase carcass value per pound ( $P = 0.09$ ). This did not translate to a difference in total value per carcass ( $P = 0.94$ ), due to the slight numerical increase in HCW for ARRIVAL cattle vs. DELAYED cattle.

In conclusion, delaying the initial implant 45 d after arrival did not influence animal health, performance, or carcass measures in feeder calves at high risk to develop BRD. Delaying administration of the growth promoting implant had no benefits to health status in the high risk calves utilized in this study. Depending on other management considerations, such as the

potential need for revaccination or mass medication, there appears to be no advantage to handling cattle a second time post-processing simply in order to provide the growth promoting implant.

Table 2.1 Health data for high-risk steers implanted either immediately upon feedlot arrival (ARRIVAL) or 45 d post-arrival (DELAYED).

Table 3	ARRIVAL	DELAYED	SEM	<i>P</i> -value
Pens, n	10	10		
Animals, n	801	800		
Morbidity, %	28.5	24.7	2.35	0.13
DOF at 1st treatment	30	27	5.6	0.58
Retreatment, %	9.4	8.2	1.18	0.31
Medicine cost, \$/head	22.33	21.74	1.24	0.64
Mortality, % <sup>1</sup>	7.9	9.0	2.07	0.61
Respiratory mortality, %	3.3	4.5	1.49	0.43
Railed, %	3.3	1.8	0.63	0.02
Total out cattle, % <sup>2</sup>	15.7	15.1	2.14	0.80
Total out cattle –				
Respiratory, % <sup>3</sup>	11.1	10.6	2.22	0.85

<sup>1</sup> A severe heat-stress event occurred at approximately 180 d on feed which resulted in 59 dead animals.

<sup>2</sup> Total Out Cattle: Includes all mortalities, animals with chronic respiratory disease, and railed cattle.

<sup>3</sup> Total out cattle - Respiratory: Includes only animals which died of respiratory disease, animals with chronic respiratory disease, and railed cattle

Table 2.2 Liver and lung abnormalities for high-risk steers implanted either immediately upon feedlot arrival (ARRIVAL) or 45 d post-arrival (DELAYED).

Table 4	ARRIVAL	DELAYED	SEM	<i>P</i> -value
Pens, n	10	10		
Animals, n	801	800		
Pleural adhesions, %	20.1	21.3	2.45	0.63
Lung Score	0.88	0.89	0.055	0.84
Lung lesions, %	55.5	58.1	2.94	0.41
None	42.3	41.3	3.22	0.77
Minor	26.7	27.6	3.63	0.80
Severe	28.9	30.5	3.20	0.63
Liver Score	0.22	0.26	0.04	0.34
Abscesses livers, %	17.1	19.7	3.54	0.46
A-, %	13.8	15.3	3.62	0.69
Ao, %	2.1	3.2	1.20	0.40
A+, %	1.1	1.3	0.53	0.78

Table 2.3 Feedlot performance and cost of gain for high-risk steers implanted either immediately upon feedlot arrival (ARRIVAL) or 45 d post-arrival (DELAYED).

	ARRIVAL	DELAYED	SEM	<i>P</i> -value
Pens, n	10	10		
Animals, n	801	800		
Initial BW, kg	274	273.5	10.5	0.97
Final BW, kg	591	587.8	12.2	0.56
ADG, kg	1.44	1.40	0.59	0.56
DMI, kg	8.82	8.73	0.24	0.40
F:G	6.21	6.30	0.309	0.77
DOF	187	187	3.6	0.96
COG, deads in, \$	76.24	77.50	4.01	0.76
COG, deads out, \$	69.87	70.42	1.92	0.78

Table 2.4 Carcass traits and carcass value for high-risk steers implanted either immediately upon feedlot arrival (ARRIVAL) or 45 d post-arrival (DELAYED).

Table 2	ARRIVAL	DELAYED	SEM	<i>P</i> -value
Pens, n	10	10		
Animals, n	801	800		
HCW, kg	386.9	381.9	8.0	0.20
Quality Grade				
Choice, %	42.8	44.1	3.00	0.67
Upper 2/3 Choice, %	3.6	4.4	1.03	0.44
Select, %	52.7	52.2	3.24	0.87
Ungraded, %	4.1	3.8	1.11	0.73
AVG YG	2.24	2.10	0.098	0.16
YG 1, %	19	24.7	4.42	0.21
YG 2, %	44.1	45.3	5.04	0.82
YG 1+2, %	63.1	69.9	5.53	0.23
YG 3, %	31.5	25.8	4.59	0.23
YG 4, %	4.9	4.3	1.36	0.65
Price, \$/cwt	92.21	93.62	0.79	0.09
Total sales, \$/head	1109.1	1111.31	29.4	0.94

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