AN EVALUATION OF WEANING STRATEGIES FOR GREAT PLAINS COW-CALF PRODUCERS

by

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B. S., West Texas A&M University, 2007
M.S., Kansas State University, 2010

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Animal Sciences and Industry
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Abstract

We evaluated effects of preconditioning on performance and health of beef calves raised and finished in the Great Plains. In experiment 1, calves were preconditioned for 0, 15, or 45 d and vaccinated against BRD-causing pathogens 14 d before maternal separation or after feedlot arrival. During receiving and finishing, preconditioned calves had greater DMI and ADG than non-preconditioned calves; however, timing of BRD vaccination did not affect animal health. In experiment 2, calves were vaccinated against BRD pathogens 0, 1, 2, or 3 times during a 30-d preconditioning program. Vaccination for BRD, regardless of degree, improved health during preconditioning; however, DMI, ADG, and G:F during preconditioning, receiving, and finishing were unaffected by degree of vaccination. In experiment 3, calves were preconditioned for 30 d, shipped 4 h to an auction facility, commingled for 12 h, and transported 4, 8, or 12 h to a feedlot. Feedlot performance and health of beef calves were not affected by transport of up to 12 h following auction-market commingling. In experiment 4, beef calves were subjected to 1 of 3 ranch-of-origin preconditioning programs: drylot weaning + abrupt dam separation, pasture weaning + fence-line contact with dams, and pasture weaning + fence-line contact with dams + supplemental feed delivered in a bunk. Drylot-weaned calves gained more weight during preconditioning. Unsupplemented, pasture-weaned calves had the least ADG during receiving but had greater ADG during finishing and had carcass characteristics similar to other treatments. In experiment 5, we evaluated performance of early-weaned beef calves fed grain-based diets with DMI adjusted to achieve ADG of 0.45, 0.91, or 1.36 kg/d during an 84-d growing period. Calves fed at restricted rates did not exhibit improved G:F relative to full-fed counterparts. In addition, there appeared to be limitations associated with predicting DMI and ADG of light-weight, early-weaned calves fed a grain-based diet.

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Chapter 1 - A Review of Literature

Introduction

Preconditioning is a management strategy executed on the ranch of origin designed to improve the health and performance of beef calves as they transition from their dam to other phases of beef production (e.g. feedlot, heifer development, or stocker). This transition is stressful to calves and can reduce growth, increase the incidence of illness, and increase mortality, primarily due to increased susceptibility to bovine respiratory disease (BRD; Thrift and Thrift, 2011). Bovine respiratory disease is one of the the most important health issues facing the beef industry today (Duff and Galyean, 2007). It is the primary cause of morbidity and mortality in feedlots in the United States and affects feedlot performance, health, and carcass attributes (Smith, 1998). Cattle treated for BRD in the feedlot had lower harvest body weight (BW), average daily gain (ADG), hot carcass weights (HCW), less external and internal fat, and a higher proportion of carcasses grading U.S.D.A. Standard than cattle not treated for BRD (Gardner et al., 1999; Roeber et al., 2001).

Overview of Preconditioning Programs

Numerous preconditioning programs exist, each with specific management requirements. Common components of preconditioning programs include weaning and holding on the ranch of origin for a period of time (15-60 days), a vaccination program, deworming, castration of intact male calves, dehorning, training calves to eat from a bunk, and beginning the transition from a forage-based diet to a grain-based diet.

Widely-adopted programs such as the Value Added Calf program (Anonymous, 2005) recommend that calves be preconditioned for 45 d or more. This recommendation is based on the data generated by the Texas A&M Ranch to Rail Program (McNeill and McCollum, 2000), which showed that preconditioning programs less than 30 d did not produce enough BW gain to offset costs. Conversely, Bolte et al. (2008) reported that health of calves during receiving was similar for ranch-direct calves weaned 15, 30, 45, or 60 d prior to feedlot placement. Longer preconditioning periods may increase BW gain, if the calves are fed a high-quality diet, but the total cost of preconditioning is directly related to its length, which may decrease the profitability of preconditioning programs (Mathis et al., 2008). More research is needed to determine how calf health during preconditioning and receiving is impacted by the length of the preconditioning phase.

Vaccination against viral pathogens associated with BRD is another common aspect of preconditioning programs. Calves will be confronted with multiple stressors and novel pathogens during the journey from their ranch of origin to the feedlot. Reviews of preconditioning management found that vaccination typically reduced the incidence and severity of BRD in feedlot steers (Cole, 1985; Galyean et al., 1999). Vaccination timing varied across programs; moreover, timing of vaccination may have impacts on health and performance of preconditioned calves. Richeson et al. (2009) reported that delaying vaccination for 14 d after arrival at the feedlot improved ADG and increased titer seroconversion during receiving. Studies examining the timing of vaccination within a preconditioning program were not found and more research on the timing of vaccination during preconditioning is warranted.

There are other management practices that have potential to improve health and performance of newly-weaned calves; however, many of these are not required by preconditioning programs. Training calves to eat from a bunk during preconditioning improved calf performance during receiving (Walker et al., 2007). Conversely, not all producers are equipped to drylot-wean calves and, instead, precondition calves on pasture. Pasture preconditioning has been effective in maintaining health and performance of beef calves (Price et al., 2003; Mathis et al., 2008). Castration of male calves is a best-management practice, independent of enrollment in a preconditioning program. It is recommended that castration be executed when calves weigh less than 200 kg to minimize stress (Bretschneider, 2005)

Stressors Associated with Calf Weaning

Preconditioning allows a producer to temporally separate the stressors associated with weaning, marketing, and transfer to other phases of beef production. Marketing stressors include transport and commingling with calves from other sources. Transfer to other phases of production include dietary transition from forage to grains, facility changes from pasture to drylot, eating from a bunk, and drinking from a novel water source. These stressors were listed as major contributors to increased susceptibility to BRD in newly-weaned beef calves in a recent review of preconditioning practices (Thrift and Thrift, 2011).

Calves in the U.S. are commonly weaned from their dams at 7 mo of age. Generally, separation from dams occurs abruptly, which causes signals of distress from the calf, including vocalizing and pacing (Newberry and Swanson, 2008). In addition, there are physiological responses to weaning such as increases in concentrations of plasma cortisol (Lay et al., 1998), norepinephrine (Hickey et al., 2003), and acute-phase proteins (Arthington et al., 2008). Behavioral and physiological responses to weaning are associated with reduced performance and impaired health (Price et al., 2003; Arthington et al., 2008). Alternative weaning methods have been developed, which include allowing fence-line contact with dams for a period of time after weaning (Stookey et al., 1997) and using nose clips to prevent calves from sucking before maternal separation (Haley et al., 2005).

Price et al. (2003) reported that allowing calves fence-line contact with dams after weaning decreased weight-loss in calves 14 d after maternal separation. In addition, calves allowed fence-line contact with their dams after weaning spent more time eating than calves abruptly weaned from their dam. Similarly, Boyles et al. (2007) found that weaning calves on pasture and allowing them fence-line contact with dams decreased morbidity during feedlot receiving compared to calves abruptly weaned and placed in a drylot.

Haley et al. (2005) fitted calves with nose clips 14 d before maternal separation. The nose clips were designed to be a physical barrier to prevent calves from nursing their dams. Calves were separated from dams after wearing nose clips for 14 d; authors termed this technique 2-stage weaning. Following separation, calves vocalized 97% less and spent 79% less time walking than calves weaned without aid of nose clips.

Boland et al. (2008) compared fence-line weaning and 2-stage weaning to traditional abrupt weaning. Fence-line weaned calves spent less time eating and more time walking than either 2-stage weaned or abruptly-weaned calves. Calves with nose clips had reduced serum creatinine kinase (a measure of stress) but greater serum NEFA concentrations. In addition, calves with nose clips gained less BW during the experiment than other treatments. Alternative methods of breaking the mother-offspring bond appear to improve calf performance but additional factors must be considered when developing a preconditioning program.

Up to the time of weaning, a calf's diet typically consists of milk from its dam and forage. Upon arrival at the feedlot, calves must transition from a forage-based diet to a grain-based diet. Beef calves are selective eaters, particularly during periods of dietary change (Pritchard and Bruns, 2003). Galyean et al. (1999) reported that DMI by recently-received calves during the first 2 wk after arrival was generally less than 1.5% of BW daily. Providing highly palatable, familiar feedstuffs during the receiving period minimized fasting, improved weight gain, and reduced stress (Lalman et al., 2007).

Beginning the dietary transition from forage to grain on the ranch-of-origin is a component of some preconditioning programs and may benefit cattle performance upon arrival at the feedlot; however, the impact of diet type on morbidity during preconditioning and receiving remains a subject of controversy. Fluharty and Loerch (1997) reported that ADG and morbidity of newly-received cattle were not affected by the proportion of dietary concentrate. In contrast, Lofgreen et al. (1981) found that calves fed a 75% concentrate diet tended to have more sick days when compared to those fed hay only. Galyean et al. (1995) also indicated that high-quality hay fed *ad libitum* was associated with decreased morbidity of recently-weaned calves compared to a high-concentrate diet. The statistical relationship between BRD and dietary roughage concentration in lightweight, stressed cattle was analyzed by Rivera et al. (2005). Morbidity decreased slightly as the dietary roughage level increased; however, ADG and DMI also decreased. A cost-benefit analysis of these data demonstrated that decreased morbidity associated with greater levels of roughage was insufficient to offset greater profit associated with increased ADG. Rivera and colleagues (2005) concluded that high-concentrate diets were of greater overall benefit to lightweight, stressed calves than forage-based diets.

Data comparing the effects of diets on health during preconditioning and receiving may be confounded by the fact that eating from a bunk is novel to newly-weaned calves and may be a source of stress in itself. Hutcheson and Cole (1986) cited stress associated with learning to eat from a bunk as a causative feature of poor initial feedlot performance. Calves preconditioned on pasture may not learn how to eat from a bunk and drink from an automated watering device. Walker et al. (2007) weaned calves either in a drylot or on pasture without supplement for 21 d.

All calves were subsequently moved into a feedlot. Drylot-weaned calves in that study exhibited more vigorous feeding behavior during the first 4 d in the feedlot than pasture-weaned calves. In addition, BW gain was greater for drylot-weaned calves than for pasture-weaned calves during a 30-d feedlot receiving period.

In contrast, other studies reported that morbidity increased when calves were kept in a drylot during preconditioning (Boyles et al., 2007; Mathis et al., 2008). Boyles et al. (2008) reported that pasture weaning for 30 d prior to shipment, where calves had fence-line contact with dams, resulted in greater ADG and less respiratory disease during the first 7 d in a feedlot than complete maternal separation and drylot weaning for 30 d prior to shipment. Only 15% of the pasture-weaned calves were treated for respiratory disease compared to 30% of calves shipped directly after weaning and 37% of calves weaned in a drylot for 30 d.

Similarly, Mathis et al. (2008) compared performance of calves weaned using a low-input pasture system or high-input drylot system for 45 d prior to shipment to a feedlot. They reported that drylot-weaned calves had greater ADG, greater death loss, greater feed costs, and less net income than calves weaned using the low-input pasture system. Further research is needed to determine when to make the change in diet and when is best to transition calves to a confinement setting.

Commingling of cattle from different sources is common in the beef industry upon entry into marketing channels and can occur in multiple places, from the auction market to the feedlot. Commingling has been associated with increased incidence of BRD (Alexander et al., 1989, Sanderson et al., 2008). Step et al. (2008) evaluated the effect of commingling on health and performance of calves from different sources. Three groups were used: (1) ranch-direct calves; (2) calves purchased at auction markets; and (3) a combination of ranch-direct calves and auction market calves commingled. Incidence of morbidity was less in ranch-direct calves than in auction-market calves or commingled calves; moreover, ranch-direct calves tended to gain more BW during the 42-d study than did auction-market calves. Commingling is a stressor that beef producers have little control over, due to the structure of the beef industry and the small average size of cow herds in the United States. Thus, it is important to minimize the stressors that can be controlled, because their effects are additive in nature.

Transporting calves is a stressor and can negatively affect animal performance during the subsequent phase of production (Grandin, 1997; Taylor et al., 2010). Arthington et al. (2003) reported that calves shipped immediately after maternal separation lost more BW than calves that were weaned on their ranch of origin prior to shipping. In contrast, Pritchard and Mendez (1990) noted differences in shrink between preconditioned calves and non-preconditioned calves transported for the same length of time; however, treatment effects were inconsistent between experiments. Barnes et al. (1990) reported that calves preconditioned for 22 d before auction market commingling and transport lost less BW than calves weaned and transported to the auction market the same day. In these experiments, it appeared that preconditioning mitigated the stress of transport.

The greatest benefit of preconditioning on transport stress may lie in temporal separation of stressful events over time. Cole (1985) argued this point by suggesting that the major benefit of preconditioning is separating the occurrence of stressors such as castration, dehorning, weaning, vaccination, transport, and marketing over time. Unfortunately, the majority of research in the area of transport stress focused on calves hauled long distances (i.e., > 20 h; Knowles, 1999; Swanson and Morrow-Tesch, 2001; Fike and Spire, 2006). Calves reared in areas such as the Great Plains are not likely to be subjected to transport > 20 h. However, Cernincchcaro et al. (2012) reported that cattle from the central region of the United States that were hauled > 250 km had greater incidence of BRD morbidity and mortality upon arrival at the feedlot than calves hauled < 250 km. It is unclear if any of the calves in this retrospective observational study were preconditioned. More research is needed to assess the effects of preconditioning on transport stress in beef calves.

Castration is another stressful event that commonly occurs around weaning. The timing of castration relative to weaning can affect performance and health of recently-weaned cattle. Calves that were castrated at feedlot arrival had a morbidity rate of 35.8% and a mortality rate of 3.5% compared to an 18.6% morbidity rate and a 0% mortality rate for calves castrated prior to feedlot arrival (Daniels et al., 2000). In addition, cattle castrated prior to feedlot arrival had 0.31 kg/d greater ADG during the receiving period than those castrated upon arrival. Bretschneider (2005) indicated that castration conducted well in advance of weaning allowed adequate time to recover completely and avoided compounding the stress of weaning with the trauma of castration. Calves should be castrated as young as possible, to minimize stress and performance loss.

Conclusions

Beef calves are confronted with many and varied stressors on the journey from their respective ranches of origin to harvest as a meat animal. Understanding the interactions amongst stressors may allow cow-calf producers to develop preconditioning strategies that minimize the economically-meaningful effects of stress, that improve the performance of the animals, and that make a quantifiable impact on the welfare of newly-weaned beef calves.

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Chapter 2 - The Importance of Weaning Management and Vaccination History on Performance by Ranch-Direct Beef Calves during Weaning and Receiving

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Abstract

Angus × Hereford calves (n = 437; average initial BW = 208 ± 25 kg) were stratified by BW, sex, and age and assigned randomly to be weaned on 1 of 3 dates to vary the length of a ranch-of-origin preconditioning period (45, 15, or 0 d) before shipment to the feedlot. Within each preconditioning period length, calves were assigned randomly to 1 of 2 bovine respiratory disease (BRD)-vaccination treatments: vaccinated 14 d prior to weaning and again at weaning (PRE) or vaccinated on the day of arrival at the feedlot and again 14 d later (POST). On a common shipping date, calves were transported 3 h to an auction market and held for 12 h. Calves were then transported 1 h to a feedlot. Calves were fed the same diets ad libitum throughout the study. Incidence of undifferentiated fever 15 d after weaning tended to be greater ($P = 0.09$) for calves weaned 45 d before shipping than for calves weaned 15 d before shipping; however, ADG before shipping was greater ($P < 0.01$) for calves weaned 45 d than those weaned 15 d. Incidence of undifferentiated fever and ADG before shipping were similar ($P > 0.44$) between PRE and POST. Average DMI before shipping by 45-d calves was greater ($P < 0.01$) than that by 15-d calves. Conversely, DMI by PRE calves was not different ($P = 0.84$) than that by POST calves. Incidence of undifferentiated fever during receiving was similar ($P \geq 0.37$) between weaning and vaccination treatments. Calf ADG during the first 30 d of receiving was greater ($P = 0.03$) for 45- and 15-d calves than for 0-d calves. Receiving DMI increased ($P < 0.01$) as time between weaning and shipping increased. Conversely, the timing of vaccination did not affect ($P \geq 0.20$) ADG or DMI during receiving. Growth efficiency was similar ($P \geq 0.23$) among weaning and vaccination treatments. Weaning more than 15 d before shipping did not improve health or growth of cattle that were moved from their ranch of origin to a feedlot within 16 h and were not commingled with market-sourced cattle. Pre-shipment BRD vaccination may not change health or performance of ranch-direct cattle relative to BRD vaccination deferred until feedlot arrival.

Keywords: health, preconditioning, weaning

Introduction

Preconditioning is a term used in the beef industry to describe management practices that are applied during the weaning period in order to optimize calf nutrition, health, and growth performance during the feedlot receiving period (Duff and Galyean, 2007). The primary goal of preconditioning is to maximize growth potential and carcass merit while minimizing the negative effects associated with the bovine respiratory disease (BRD) complex. Cole (1985) reported that preconditioned cattle had reduced mortality and morbidity and increased feedlot performance compared with cattle that were not preconditioned. Conversely, Pritchard and Mendez (1990) indicated that the effects of preconditioning on calf growth and health were variable due to interactions between management, year, and ranch of origin. The leading cause of morbidity and mortality according to a survey of U.S. feedlots is BRD (Woolums et al., 2005).

Many BRD-vaccination strategies are utilized by cow-calf producers in the U.S. The most cautious strategy involves vaccination against BRD pathogens 2 to 4 wk prior to maternal separation followed by a booster at weaning. This strategy is used in instances where time, labor, and facilities are available to gather and process calves prior to maternal separation. Another BRD-vaccination strategy is to defer vaccination until after calves have been shipped to a feedlot. Deferring BRD vaccination to the receiving period is thought to increase BRD incidence compared to vaccination that is implemented on the ranch of origin; however, this assumption has not been widely scrutinized for cattle that are moved directly from their ranch of origin to a feedlot and undergo little or no commingling with market-sourced cattle.

Bolte et al. (2008a, 2008b, 2009a, 2009b) reported that length of the ranch-of-origin weaning period influenced growth and health of beef calves during the receiving period at a feedlot. Therefore, it is reasonable to expect that vaccination strategy and the length of the ranch-of-origin weaning period may have synergistic effects on calf performance during the receiving phase. The objective of our experiment was to compare the effects of BRD vaccination administered prior to weaning on the ranch of origin or after arrival at a feedlot for calves weaned 45, 15, or 0 days prior to feedlot arrival.

Materials and Methods

Animal care practices used in this study were approved by the Kansas State University Animal Care and Use Committee (protocol no. 2978.1).

Angus × Hereford calves (n = 437; average initial BW 208 ± 25 kg) were used for this experiment. Calves originated from Kansas State University commercial cow-calf herds at Manhattan, KS (n = 263) and Hays, KS (n = 174). Steer calves were castrated prior to 60 d of age and if necessary, calves were dehorned at the time of castration. Dehorning was administered to less than 25% of the calves.

Approximately 60 d before weaning, animals were stratified by BW, sex, and birth date and assigned randomly to a pre-shipment weaning period (i.e., 45, 15, or 0 d). Maternal separation did not occur at a common date across treatments. At the time of maternal separation, calves assigned to the weaning period of 45 d were 174 ± 17 d of age. Calves assigned to the weaning period of 15 d were 202 ± 18 d of age and calves assigned to the weaning period of 0 d were 216 ± 17 d of age. Within each pre-shipment weaning period, calves were assigned randomly to 1 of 2 BRD-vaccination treatments. One group was vaccinated 14 d prior to maternal separation and again at weaning. A second group was vaccinated on the day of arrival at the feedlot and again 14 d later. Vaccines were acquired in one purchase as a single lot for both locations to limit potential variation in the vaccine.

Initial and booster vaccinations against IBR, BVD, PI3, and BRSV were administered using a modified live product (Bovi-Shield Gold FP®, Pfizer Animal Health Exton, PA). All calves were treated for internal and external parasites using Dectomax® (Pfizer Animal Health Exton, PA) and were vaccinated against clostridial diseases (Vision 7 with SPUR®, Intervet Inc., Millsboro, DE) at the time of weaning. Calves from each location were then transported a short distance (< 25 km) to a central home-ranch weaning facility.

Calves were housed in earth-floor pens (minimum area = 18.6 m^2/calf; bunk space = 0.46 m/calf; n = 4 pens / treatment combination at each location) and fed a common weaning diet formulated to achieve 0.91 kg/d ADG of 0.91 kg at a DMI of 2.5% of BW daily (Table 1). Feed intake was recorded daily on a pen basis. We transitioned calves onto the weaning diet over a 6 day period. Hay was provided at a constant rate of 0.5 % of BW (DM basis) per animal daily for 6 d, and the amount of the weaning diet provided increased from 0.5 % of BW (DM basis) on d 1 to 2.5 % of BW (DM basis) on d 6. Hay was not provided to the cattle after d 6. Bunks were read daily at 0600. After the initial 6-d transition period, an additional 0.1 to 0.2 kg/hd was provided when feed was consumed by 0600 until the calves were consuming the weaning diet at a rate of 2.5 % of BW daily.

Calves were monitored for symptoms of respiratory disease at 0700 and 1400 daily during the ranch-of-origin weaning period. Calves with clinical signs of BRD, as judged by trained animal caretakers, were removed from home pens, restrained using a hydraulic squeeze chute, and evaluated. Upon evaluation, calves were weighed, rectal temperature was determined using a digital thermometer, and assigned a clinical illness score (scale: 1 to 4; 1 = normal, 4 = moribund). Calves with a clinical illness score > 1 and a rectal temperature > 40.0 ºC were considered morbid and treated. Antibiotic therapy was administered per label directions following a predetermined treatment protocol (1st incidence = Baytril®, Bayer Animal Health, Shawnee Mission, KS; 2nd incidence = Nuflor®, Merck Animal Health, Summit, NJ). Cattle were evaluated 72 h post-treatment and re-treated based on observed clinical signs.

On a common shipping date that marked the end of preconditioning, all calves were individually weighed and transported 4 h from their respective ranch-of-origin weaning facilities to an auction market located in Hays, Kansas. Calves from both locations were commingled with respect to gender and treatment and were maintained on the premises of the auction market for 12 h. This commingling was employed to simulate the pathogen exposure typically encountered by market-ready calves.

After 12 h at the auction market, calves were shipped a short distance (< 25 km) to the feedlot at the Western Kansas Agricultural Research Center in Hays, KS. Upon arrival, calves were individually weighed and assigned to a receiving pen based on their weaning and vaccination treatments (minimum area = 57.1 m^2/calf; bunk space = 0.40 m/calf; n = 4 pens / treatment combination). Animals were fed a common diet (Table 2) once daily at 0700 h and bunks were evaluated each morning at 0630 h. If the previous days feed was consumed, total feed delivered was increased by approximately 2% of the previous days feed delivery. Bunks were managed using a slick-bunk management method to minimize feed refusals (Pritchard and Bruns, 2003).

During receiving, calves were monitored for symptoms of BRD daily at 0700 and 1400. Clinical symptoms of disease were evaluated and treated in a similar manner as the ranch-of-origin weaning phase. Calf BW was measured 60 d after arrival at the feedlot, which marked the end of receiving.

Preconditioning performance, receiving intake, and receiving performance were analyzed as a completely randomized design with pen as the experimental unit (PROC MIXED; SAS Inst. Inc., Cary, NC). Incidence of undifferentiated fever during preconditioning and receiving was analyzed using PROC GLIMMIX (SAS Inst. Inc., Cary, NC). All models included terms for treatment and location. No interactions between weaning and vaccination treatments or locations were detected ($P \geq 0.10$); therefore, main effects of treatments were reported. When protected by a significant F-test ($P < 0.05$), least squares treatment means were separated using the method of Least Significant Difference. Treatment differences were discussed when $P \leq 0.05$; trends and tendencies were discussed when $P > 0.05$ and ≤ 0.10.

Results and Discussion

Health. Incidence of undifferentiated fever during the 15-d period immediately following maternal separation were numerically greater ($P = 0.12$; Table 3) for calves assigned to the 45-d weaning treatment compared to those assigned to the 15-d weaning treatment. Reasons for this response were unclear. In contrast, length of the ranch-of-origin weaning period did not affect ($P = 0.37$; Table 4) incidence of undifferentiated fever during the receiving period. Similarly, Bolte et al. (2008a and 2008b) reported that health of calves during receiving was similar for ranch-direct calves weaned 15, 30, 45, or 60 d prior to feedlot placement.

Undifferentiated fever during the 15-d period immediately following maternal separation was similar ($P = 0.69$; Table 5) between calves that were vaccinated and calves that were not. Evidently, the pathogen challenge and the stress associated with maternal separation were insufficient to increase incidence of BRD among unvaccinated calves during the ranch-of-origin weaning periods.

Incidence of undifferentiated fever during the receiving period was similar (*P* = 0.97; Table 6) between calves that were vaccinated against BRD-causing organisms on the ranch of origin and those that were not vaccinated until feedlot arrival. Richeson et al. (2009) indicated that delaying vaccination for BRD for 14 d after feedlot arrival improved receiving performance compared with vaccinating at the time of feedlot arrival. Only 4 of 437 calves on our study were treated for undifferentiated fever during this period. This result was surprising and seemed to indicate that labor and time savings might be realized by deferring BRD vaccination until feedlot arrival without sacrificing animal performance; however, more research is needed to confirm this finding.

Step et al. (2008) reported that, during the receiving period, performance of ranch-direct calves weaned on the ranch of origin for 45 d without preshipment vaccinations was similar to that of ranch-direct calves weaned on the ranch of origin for 45 d with preshipment vaccinations. This report called into question the relative importance of pre-shipment vaccination on pre-shipment weaning-to-receiving growth and health. The calves in our study had excellent overall health during the receiving period; however, these ranch-direct calves would be considered to be at lower risk for BRD than is typical for market-sourced cattle.

Growth Performance. Calf BW at weaning and at shipping increased as the length of preconditioning period increased (*P* < 0.01; Table 3). The calves were weaned on separate dates, which would explain differences in weaning BW. Pre-shipment ADG was greater (*P* < 0.01) for calves weaned 45 d before shipping to the feedlot compared to calves weaned either 15 or 0 d before shipping to the feedlot. This occurred because calves weaned for 45 d before shipping consumed, on average, a more energy-dense diet than calves that suckled their dams for all or part of this period. Bolte et al. (2008a) made a similar observation. Calf ADG during the preshipping period was similar ($P = 0.90$; Table 5) between calves vaccinated before 15 d before maternal separation and calves not vaccinated until arrival at the feedlot.

Calf ADG during the 60-d feedlot receiving period was similar ($P = 0.48$; Table 4) between calves weaned for 45 or 15 d prior to feedlot placement; however, both groups of calves had greater ($P < 0.03$) ADG during the first 30 d of the receiving period than those shipped directly to the feedlot after maternal separation (i.e., the 0-d weaning treatment). Bolte et al. (2008a and 2009a) reported that calves weaned for 15, 30, 45, or 60 d before feedlot placement had similar ADG during receiving; however, calves weaned for any length of time prior to feedlot placement had greater ADG than calves placed in a feedlot immediately after maternal separation.

Calf ADG during the 60-d feedlot receiving period was similar ($P = 0.86$; Table 6) between calves vaccinated on their ranch of origin and calves not vaccinated until feedlot arrival. Richeson et al. (2009) reported similar results for calves vaccinated at feedlot arrival and calves vaccinated 14 d after feedlot arrival.

Intake. Dry matter intake by calves weaned for 45 d was greater ($P < 0.01$; Table 3) during the pre-shipment period than that by calves weaned for 15 d. Similarly, DMI during receiving increased ($P < 0.01$; Table 4) successively with length of the weaning period; however, G:F was not affected ($P = 0.23$) by length of the weaning period. Experience consuming dry diets from a feed bunk prior to shipping translated to greater feed intake and greater ADG during the receiving period. Furthermore, the timing of vaccination against BRD-causing organisms did not affect ($P \geq 0.20$) DMI or feed efficiency during the receiving period (Table 6).

Conclusions

Ranch-of-origin weaning periods that were at least 15 d in length improved receiving DMI and growth performance during receiving of cattle that were moved from their ranch of origin to a feedlot within 16 h and were minimally commingled with market-sourced cattle. Receiving performance was similar during receiving for calves weaned 15 d or 45 d before shipping. This study raised the possibility that pre-shipment BRD vaccination may not improve health or performance of ranch-direct cattle relative to BRD vaccination that is deferred until feedlot receiving. Further research will be necessary to verify this finding.

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Table 1. Composition of the weaning diet (Exp. 1)

Ingredient composition[*]	% of DM
Alfalfa extender pellets	41.82
Corn gluten feed	18.22
Wheat middlings	14.68
Cracked corn	10.78
Cottonseed hulls	7.68
Dried distiller's grains	3.01
Molasses	1.67
Limestone	1.85
Nutrient composition[†]	
CP, % of DM	15.31
NE_m, Mcal/kg	1.44
NE_g, Mcal/kg	0.85

[*] Diet also contained Salt, Zinc Sulfate, and Rumensin® 80

[†] Calculated using the values of NRC (2000).

Table 2. Composition of the receiving diet (Exp. 1)

Ingredient composition	% of DM
Ground sorghum grain	59.43
Sorghum silage	25.47
Soybean meal	11.04
Supplement[*]	2.64
Nutrient composition[†]	
CP, % of DM	15.90
NE_m, Mcal/kg	1.75
NE_g, Mcal/kg	1.13

[*] Supplement contained Rumensin® 80, Tylan® 40, limestone, ammonium sulfate, urea, salt, and trace minerals

[†] Calculated using the values of NRC (2000).

Table 3. Performance of beef calves during ranch-of-origin weaning periods lasting 0, 15, or 45 d

	Length of weaning period, d				
Item	0	15	45	SEM	*P*-value
Initial BW (pre-vaccination[1]), kg	209	205	208	2.9	0.32
Weaning BW[2], kg	242^{a}	235^{b}	216^{c}	3.1	< 0.01
Shipping BW, kg	242^{a}	233^{b}	260^{c}	3.2	< 0.01
ADG (pre-vaccination to shipping), kg	0.58^{a}	0.50^{b}	0.95^{c}	0.023	< 0.01
ADG (weaning to shipping), kg	-	-0.12^{a}	1.03^{b}	0.069	< 0.01
DMI (weaning to shipping), kg/d	-	3.92^{a}	5.36^{b}	0.168	< 0.01
Incidence of undifferentiated fever (d 0 to d 15), %	-	0.00	3.47	2.169	0.12
Incidence of undifferentiated fever (d 16 to d 45), %	-	-	1.42	-	-

$^{a, b}$ Means within rows without common superscripts are different ($P < 0.05$)

$^{c, d}$ Means within rows without common superscripts tend to differ ($P < 0.10$)

[1] Pre-vaccination occurred 15 d before maternal separation of calves weaned for 45 d

[2] Calves were weaned on 3 separate dates to vary the length of the weaning period.

Table 4. Performance of beef calves weaned for 0, 15, or 45 d before shipping during a 60-d receiving period

	Length of weaning period, d				
Item	0	15	45	SEM	*P*-value
Arrival BW, kg	220	220	239	2.9	< 0.01
Shrink (shipping to feedlot arrival), % BW	8.95^{a}	5.83^{b}	8.24^{a}	0.549	< 0.01
End BW, kg	295^{a}	299^{a}	317^{b}	4.6	< 0.01
ADG, kg					
Arrival to d 30	1.17^{a}	1.32^{b}	1.32^{b}	0.063	0.04
Arrival to d 60	1.26	1.31	1.30	0.047	0.50
DMI, kg/d	7.21^{a}	7.86^{b}	8.09^{c}	0.076	< 0.01
G:F	0.170	0.167	0.160	0.0057	0.23
Incidence of undifferentiated fever, %	1.37	0.00	1.40	1.123	0.37

[a, b,c] Means within rows without common superscripts are different (P < 0.05)

Table 5. Performance of beef calves vaccinated against respiratory-disease pathogens prior to shipping or at feedlot arrival during a ranch-of-origin weaning period

	Vaccination timing*			
Item	Pre-shipment	Feedlot arrival	SEM	*P*-value
Initial BW (pre-vaccination[1]), kg	208	208	2.4	0.87
Weaning BW[2], kg	230	232	2.5	0.60
Shipping BW, kg	244	246	3.2	0.59
ADG (pre-vaccination to shipping), kg	0.68	0.66	0.019	0.17
ADG (weaning to shipping), kg	0.48	0.44	0.073	0.59
DMI (weaning to shipping), kg/d	4.66	4.62	0.168	0.84
Incidence of undifferentiated fever (weaning to d 15), %	2.19	1.30	2.17	0.69
Incidence of undifferentiated fever (d 16 to d 45), %	0.00	1.41	0.97	0.16

[a, b] Means within rows without common superscripts are different ($P < 0.05$)

*Pre-shipment = Initial vaccination occurred 15 d prior to maternal separation; Feedlot arrival = Initial vaccination occurred upon arrival at the feedlot

[1] Pre-vaccination occurred 15 d before maternal separation of calves weaned for 45 d

[2] Calves were weaned on 3 separate dates to vary the length of the weaning period.

Table 6. Performance of beef calves vaccinated against respiratory-disease pathogens prior to shipping or at feedlot arrival during a 60-d receiving period

	Vaccination timing*			
Item	Pre-shipment	Feedlot arrival	SEM	*P*-value
Arrival BW, kg	227	226	2.4	0.74
Shrink (shipping to feedlot arrival), % BW	7.28	8.08	0.447	0.09
End BW, kg	304	304	3.7	0.99
ADG, kg				
Receiving to d 30	1.25	1.30	0.051	0.37
Receiving to d 60	1.28	1.29	0.040	0.84
DMI, kg/d	7.68	7.76	0.062	0.20
G:F	0.166	0.166	0.0034	0.91
Incidence of undifferentiated fever, %	0.93	0.90	0.651	0.97

[a, b] Treatment means with row that share common superscript are similar.

*Pre-shipment = Initial vaccination occurred 15 d prior to maternal separation; Feedlot arrival = Initial vaccination occurred upon arrival at the feedlot

Chapter 3 - The Importance of Weaning Management and Vaccination History on Finishing Performance and Carcass Characteristics of Beef Steers

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Abstract

Angus × Hereford steers (n = 437; average initial BW = 208 ± 25 kg) were stratified by BW, sex, and age and assigned randomly to be weaned on 1 of 3 dates to vary the length of a ranch-of-origin preconditioning period (45, 15, or 0 d) before shipment to the feedlot. Within each weaning-period length, steers were assigned randomly to 1 of 2 bovine respiratory disease on (BRD)-vaccination treatments: vaccinated 14 d prior to maternal separation and again at weaning (PRE) or vaccinated on the d of arrival at the feedlot and again 14 d later (POST). On a common shipping date, steers were transported 3 h to an auction market and held for 12 h. Steers were then transported 1 h to a feedlot. All steers were fed the same diets for *ad libitum* intake during the weaning, receiving, and finishing phases of the experiment. Steers were fed to a harvest endpoint of 11.5 mm of subcutaneous fat over the 12th rib and harvested in 3 groups. Steers weaned 45 d before shipping required fewer ($P = 0.02$) days on feed than steers weaned 15 or 0 d before shipping. Finishing ADG was greater ($P < 0.01$) for steers weaned 45 and 15 d before shipping than for steers weaned 0 d before shipping, whereas ADG was similar ($P = 0.26$) between PRE and POST. Consequently, 45-d steers had greater ($P < 0.01$) harvest BW than 15- or 0-d steers. Hot carcass weight was greater ($P < 0.01$) for steers weaned 45 and 15 d before shipping than for steers weaned 0 d before shipping. Marbling score, USDA yield grade, 12th-rib fat thickness, REA, and KPH were similar ($P \geq 0.07$) between weaning and vaccination treatments. Likewise, incidence of liver abscesses was similar ($P > 0.39$) between weaning and vaccination treatments. Incidence of lung lesions was not affected ($P > 0.81$) by weaning treatment; however, POST had a numerically greater incidence ($P = 0.11$) of lung lesions than PRE. Carcass weight, carcass merit, and growth performance during finishing were similar between steers weaned for 45 d or 15 d before shipping. Pre-shipping BRD vaccination did not improve growth performance or carcass merit of ranch-direct cattle relative to BRD vaccination deferred until feedlot arrival.

Keywords: carcass merit, preconditioning, weaning.

Introduction

Incidence of bovine respiratory disease (BRD) in the feedlot decreases the profitability of cattle feeding (Gardner et al., 1999). The cost of BRD includes death loss, expense associated with BRD treatment, and reduced growth performance (Perino, 1992). Respiratory disease also decreased carcass weights, USDA quality grade, and longissimus area of feedlot cattle (Roeber al., 2001). Treatment for apparent BRD was associated with decreased carcass weight, fat thickness, and REA compared to animals not treated, whereas reduced incidence of BRD resulted in greater carcass merit (Montgomery et al., 2009). Pre-shipment weaning and vaccination reduced the incidence and severity of BRD in feedlot steers (Cole, 1985; Pritchard and Mendez, 1990; Galyean et al., 1999).

Bolte et al. (2009a, 2009b) reported that length of the pre-shipment weaning period influenced carcass characteristics and time on feed during finishing. Therefore, we hypothesized that vaccination strategy and the length of the pre-shipment weaning period interact to influence steer performance during finishing and subsequent carcass characteristics. The objective of our experiment was to compare the effects of BRD vaccination administered prior to weaning on the ranch of origin or after arrival at a feedlot for calves weaned 45, 15, or 0 days prior to feedlot arrival.

Materials and Methods

Animal care practices used in this study were approved by the Kansas State University Animal Care and Use Committee (protocol no. 2978.1).

Angus × Hereford steers (n = 256; average initial BW = 208 ± 25 kg) were used for this experiment. Steers originated from Kansas State University commercial cow-calf herds at

Manhattan, KS and Hays, KS. Approximately 60 d prior to maternal separation, animals were stratified by BW, sex, and date of birth, and assigned randomly to a pre-shipment weaning period (i.e., 45, 15, or 0 d). Within each weaning treatment steers were assigned randomly to 1 of 2 BRD-vaccination treatments. One vaccination treatment group was vaccinated 14 d prior to maternal separation and again at weaning; the second vaccination treatment group was vaccinated on the d of arrival at the feedlot and again 14 d later.

Initial and booster vaccinations against IBR, BVD, PI3, and BRSV were administered using a modified live product (Bovi-Shield Gold FP®, Pfizer Animal Health Exton, PA). All steers were treated for internal and external parasites using Dectomax® (Pfizer Animal Health Exton, PA) and were vaccinated against clostridial diseases (Vision 7 with SPUR®, Intervet Inc., Millsboro, DE) at the time of weaning. Steers were transported a short distance (< 48 km) to a home-ranch weaning facility.

Steers were weaned in earth-floor pens (minimum area = 18.6 m^2/calf; bunk space = 0.46 m/calf; n = 4 pens / treatment combination at each location) and fed a common weaning diet during the preconditioning period. Bunks were read at 0600 each morning. Steers were fed once daily at 0700 and intake was recorded on a pen basis. An additional 0.1 to 0.2 kg/hd was provided when feed was consumed by 0600 until the calves were consuming the weaning diet at a rate of 2.5 % of BW daily.

Calves were monitored for symptoms of respiratory disease at 0700 and 1400 daily during the ranch-of-origin weaning period. Calves with clinical signs of BRD, as judged by trained animal caretakers, were removed from home pens, restrained using a hydraulic squeeze chute, and evaluated. Upon evaluation, calves were weighed, rectal temperature was determined using a digital thermometer, and assigned a clinical illness score (scale: 1 to 4; 1 = normal, 4 =

moribund). Calves with a clinical illness score > 1 and a rectal temperature > 40.0 ºC were considered morbid and treated. Antibiotic therapy was administered per label directions following a predetermined treatment protocol (1st incidence = Baytril®, Bayer Animal Health, Shawnee Mission, KS; 2nd incidence = Nuflor®, Merck Animal Health, Summit, NJ). Cattle were evaluated 72 h post-treatment and re-treated based on observed clinical signs.

After a 28-d ranch of origin weaning period, all steers were individually weighed and transported 4 h from their respective ranch-of-origin weaning facilities to an auction market on a common shipping date. Steers from both origins were commingled with respect to treatment and were maintained on the premises of the auction market for 12 h. This commingling was employed to simulate the pathogen exposure typically encountered by market-ready steers. The following day, steers were shipped a short distance (< 8 km) to the feedlot.

At arrival, steers were weighed and assigned to a receiving pen (n = 4 pens/treatment combination; minimum area = 57.1 m^2/calf; bunk space = 0.40 m/calf) based upon their weaning and vaccination treatments. Animals were fed a common diet (Table 2) once daily at 0700 h and bunks were evaluated each morning at 0630 h. If the previous days feed was consumed, total feed delivered was increased by approximately 2% of the previous days feed delivery. Bunks were managed using a slick-bunk management method to minimize feed refusals (Pritchard and Bruns, 2003). Steers were monitored for symptoms of respiratory disease at 0700 and 1400 daily during the receiving period using the same protocol as during the weaning period.

Steer body weights were measured 60 d after arrival at the feedlot. Following the receiving phase, steers were adapted to a common finishing ration (Table 7) over a 14-d period. Steers were implanted with Synovex Plus® (Pfizer Animal Health) on d 1 of finishing. Steers remained in their respective receiving pens during finishing. Feeding management was similar to the receiving period. After 165 d on feed, steers were scanned ultrasonically to determine subcutaneous fat thickness over the 12th rib. Steers were assigned to 1 of 3 harvest dates based on this scan to meet an average carcass endpoint of 11.5 mm of fat depth over the 12th rib.

Steers were transported approximately 3 h to a commercial abattoir on their respective harvest date. At the abattoir, lungs were examined for lesions as described by Bryant et al. (1996) and livers were examined for presence of abscesses according to procedures described by Brink et al. (1990). After carcasses were chilled for 48 h, carcass characteristics were measured electronically and included 12th-rib fat thickness, 12th-rib longissimus muscle area, kidney-pelvic-heart fat, USDA maturity grade, USDA yield grade, USDA quality grade, and marbling score (USDA, 1997).

Finishing performance and carcass characteristics were analyzed as a completely randomized design with pen as the experimental unit (PROC MIXED; SAS Inst. Inc., Cary, NC). Incidence of liver abscesses and lung lesions were analyzed using PROC GLIMMIX (SAS Inst. Inc., Cary, NC). All models included terms for treatment, sex, and location. All models included terms for treatment and location. No interactions between weaning and vaccination treatments or locations were detected ($P \geq 0.10$); therefore, main effects of treatments were reported. When protected by a significant *F*-test ($P < 0.05$), least squares treatment means were separated using the method of Least Significant Difference. Treatment differences were discussed when $P \leq 0.05$; trends and tendencies were discussed when $0.05 < P \leq 0.10$.

Results and Discussion

Growth Performance. Steer ADG during finishing was greater ($P < 0.01$; Table 8) for steers weaned for 45 or 15 d before shipping than steers weaned for 0 d before shipping, whereas

ADG was similar ($P = 0.26$; Table 10) between steers vaccinated for BRD-causing organisms before shipping and those vaccinated for BRD-causing organisms at feedlot arrival. This differed from a previous study where preconditioned calves had greater receiving ADG, but finishing gains were similar to non-preconditioned animals (Pritchard and Mendez 1990). Steers weaned 45 d before shipping required fewer ($P = 0.02$; Table 8) days on feed than those steers weaned 15 or 0 d before shipping, which is in agreement with the results reported by Bolte et al. (2009a, 2009b). They also found that longer pre-shipment weaning periods were associated with fewer days on feed. Steers weaned 45 d before shipping had greater ($P < 0.01$) harvest BW than steers weaned 15 or 0 d before shipping. Timing of BRD vaccination did not affect finishing ADG in this experiment.

Carcass Merit. Hot carcass weights were greater ($P < 0.01$; Table 9) for steers weaned 45 and 15 d prior to shipping than for steers weaned 0 d before shipping. This increase was attributed to increased performance in the feedlot. Marbling score, USDA yield grade, 12th-rib fat thickness, REA, and KPH were similar ($P \geq 0.07$; Tables 9 and 11) between weaning and vaccination treatments. This is contrary to the findings of Bolte et al. (2009a, 2009b) in which yield grade, KPH and fat thickness increased with longer weaning periods. Deposition of internal or external fat by our ranch-direct steers was not influenced by pre-shipment weaning length or timing of BRD vaccination. Likewise, incidence of liver abscesses was similar ($P < 0.47$) between weaning (Table 9) and vaccination (Table 11) treatments. Incidence of lung lesions was not affected ($P > 0.81$) by weaning treatment (Table 9); however, cattle vaccinated for respiratory disease at feedlot arrival had a numerically greater incidence ($P = 0.11$) of lung lesions than cattle vaccinated for respiratory disease before shipping. Deferring BRD vaccination until feedlot arrival, may allow sub-clinical BRD incidence to occur in such animals, however more investigation is needed.

Conclusions

A pre-shipment preconditioning period of 15 d or longer was found to increase steer ADG and harvest weights. This increase in growth reduced the length of time on feed needed to reach a predetermined harvest endpoint; however effects on carcass traits were minimal. Carcass weight, carcass merit, and growth performance during finishing were similar between steers weaned for 45 d or 15 d before shipping. Pre-shipment BRD vaccination did not improve growth performance or carcass merit of ranch-direct cattle relative to BRD vaccination deferred until feedlot arrival. Under the conditions of our study, length of pre-shipment weaning period had greater influence on performance and carcass merit than did the timing of BRD vaccination; however, deferred BRD vaccination numerically increased incidence of lung lesions at harvest.

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Table 7. Composition of the finishing diet (Exp. 2)

Ingredient composition	% of DM
Ground sorghum grain	80.9
Sorghum silage	14.8
Soybean meal	3.2
Supplement*	1.1
Nutrient composition[†]	
CP, % of DM	13.43
NE_m, Mcal/kg	1.89
NE_g, Mcal/kg	1.25

*Supplement contained limestone, Rumensin® 80, ammonium sulfate, salt, and Tylan® 40

[†] Calculated using the values of the NRC (2000).

Table 8. Finishing performance of beef steers weaned for 0, 15, or 45 days before shipping

	Length of weaning period, d			
Item	0	15	45	SEM
Initial BW, kg	295^{a}	299^{a}	317^{b}	4.6
Harvest BW, kg	566^{a}	576^{b}	592^{c}	6.1
ADG, kg	1.58^{a}	1.65^{b}	1.68^{b}	0.022
Days on feed	220^{a}	216^{b}	209^{c}	2.9

$^{a, b, c}$ Means within rows without common superscripts differ ($P < 0.05$)

Table 9. Carcass characteristics of beef steers following ranch-of-origin weaning periods lasting 0, 15, or 45 d

	Length of weaning period, d				
Item	0	15	45	SEM	*P*-value
Hot carcass weight, kg	339[a]	347[b]	355[c]	3.8	0.02
Marbling score[a]	49.1	47.4	49.6	1.10	0.33
USDA yield grade	3.3	3.2	3.4	0.07	0.25
12th rib fat thickness, mm	13.9	13.0	14.3	0.41	0.07
Longissimus muscle area, cm^2	79.0	79.5	80.1	1.01	0.68
KPH, %	2.68	2.61	2.67	0.077	0.75
Livers observed with ≥ 1 abscess, %	18.97	23.22	25.32	0.069	0.62
Lungs observed with ≥ 1 lesion, %	33.86	32.38	29.86	0.075	0.86

[a] Marbling score: 30 = Slight^{00}, 40 = Small^{00}, 50 = Modest^{00}; 55 = Modest^{50}

[a, b, c] Means within rows without common superscripts differ ($P < 0.05$)

Table 10. Finishing performance of beef steers vaccinated against respiratory-disease pathogens prior to shipping or at feedlot arrival

	Vaccination timing			
Item	Pre-shipment	Feedlot arrival	SEM	*P*-value
Initial BW, kg	304	304	3.7	0.99
Harvest BW, kg	578	578	4.8	0.87
ADG, kg	1.62	1.65	0.018	0.22
Days on feed	156	155	2.8	0.66

Table 11. Carcass characteristics of beef steers vaccinated against respiratory disease pathogens prior to shipping or at feedlot arrival

	Vaccination timing			
Item	Pre-shipment	Feedlot arrival	SEM	*P*-value
Hot carcass weight, kg	347	347	3.8	0.87
Marbling score[a]	48.3	49.0	1.10	0.57
USDA yield grade	3.3	3.4	0.07	0.52
12th rib fat thickness, mm	13.4	14.0	0.41	0.22
Longissimus area, cm^2	79.5	79.6	1.01	0.95
KPH, %	2.62	2.69	0.077	0.38
Livers observed with $\geq$ 1 abscess, %	24.88	20.13	0.054	0.39
Lungs observed with $\geq$ 1 lesion, %	27.11	36.96	0.059	0.10

[a] Marbling score: 30 = $Slight^{00}$, 40 = $Small^{00}$, 50 = $Modest^{00}$, 55 = $Modest^{50}$

Chapter 4 - Effects of Degree of Respiratory Disease Vaccination During Preconditioning on Health, Performance, and Carcass Merit of Ranch-Direct Beef Calves

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Abstract

Angus × Hereford calves (n = 430; initial BW = 230 ± 31.8 kg) were stratified by sex, age, and BW and assigned randomly to 1 of 4 treatments: 0, 1, 2, or 3 BRD vaccinations prior to feedlot placement (NOVACC, VACC1, VACC2, or VACC3, respectively). Calves were removed from their dams 29 d prior to feedlot placement, weighed, vaccinated for clostridial diseases, treated for internal and external parasites, and placed in a ranch-of-origin weaning facility. Calves on VACC1, VACC2, and VACC3 treatments were given an initial BRD-vaccination at that time. Calves were revaccinated according to their respective treatments at 14-d intervals during the ranch-of-origin weaning phase of the experiment (PRESHIP). On a common shipping date, calves were transported 3 h to an auction market and held for 12 h. Calves were then transported 1 h to a feedlot. During the PRESHIP period, there were no differences ($P \geq 0.39$) in the incidence of undifferentiated fever or drug-therapy costs among treatments, but there was a numerically greater incidence of fever and drug-therapy costs for NOVACC calves. Calf ADG, DMI, and G:F during the PRESHIP period were similar ($P \geq 0.44$) among treatments. Upon arrival at the feedlot, calves were weighed and assigned to a receiving pen based on treatment. Calf BW was similar ($P \geq 0.54$) among treatments at feedlot placement, 27 d post-receiving, and 55 d post-receiving; moreover, calf ADG during receiving was similar ($P = 0.95$) among treatments. Degree of BRD vaccination had no effect ($P \geq 0.59$) on DMI or G:F during the receiving period; furthermore, incidence of undifferentiated fever was not different ($P = 0.66$) among treatments during the receiving period. Finishing ADG, DMI, G:F, DOF, and final BW were similar ($P \geq 0.62$) among treatments. Likewise, marbling score, yield grade, longissimus area, and KPH were not different ($P \geq 0.36$) among treatments at harvest. Vaccination regimens during preconditioning did not affect ($P \geq 0.70$) incidence of liver abscesses or lung lesions. Vaccination for BRD, regardless of degree, may improve health during preconditioning, but did not improve receiving performance, finishing performance, or carcass characteristics of preconditioned calves under the conditions of our study.

Keywords: beef calves, health, preconditioning

Introduction

Reducing incidence of bovine respiratory disease (BRD) is one of the primary goals of preconditioning prior to feedlot placement. In a survey of U.S. feedlots, Woolums et al. (2005) found BRD to be the leading cause of calf morbidity and mortality. Ranch-of-origin weaning has been associated with improved growth performance and health of beef calves during the feedlot receiving period (Bolte et al., 2008a, 2008b). Vaccination, dehorning, castration, adaptation to bunk feeding, and acclimation to automatic watering devices during ranch-of-origin weaning can improve receiving performance, as well (Galyean et al., 1999). Cow-calf producers use a variety of strategies when administering BRD vaccinations. Vaccination at weaning, followed by a revaccination prior to feedlot placement is recommended (Duff and Galyean, 2007), because stress and exposure to BRD pathogens may decrease vaccine efficacy if given immediately upon arrival at the feedlot (Loerch and Fluharty, 1999). Our objective was to evaluate the effects of 0, 1, 2, or 3 vaccinations for respiratory disease given 14 d apart on the ranch of origin on health and growth performance of ranch-preconditioned beef steers.

Materials and Methods

Animal care practices used in this study were approved by the Kansas State University Animal Care and Use Committee (protocol no. 2978.1).

Angus × Hereford calves (n = 430; initial BW = 230 ± 31.8 kg) were used in this experiment. Calves originated from the Kansas State University commercial cow-calf herds in Manhattan, KS and Hays, KS. Steer calves were castrated prior to 60 d of age and if necessary, calves were dehorned at the time of castration. Dehorning was administered to less than 25% of the calves.

Before weaning, calves were stratified by body weight, sex, and birth date, and assigned randomly to a BRD vaccination treatment of 0, 1, 2, or 3 vaccinations (NOVACC, VACC1, VACC2, or VACC3, respectively). Calves were 183 ± 16 d of age at weaning. Calves were removed from their dams and immediately transported (< 48 km) to a home ranch weaning facility. Calves were individually weighed, tagged, treated for internal and external parasites using Dectomax® (Pfizer Animal Health Exton, PA) and vaccinated against clostridial diseases (Vision 7 with SPUR®, Intervet Inc., Millsboro, DE) and *Haemophilus somnus* (Somubac®, Pfizer Animal Health Exton, PA).

Initial and booster vaccinations against IBR, BVD, PI3, and BRSV were administered using a modified-live product (Bovi-Shield Gold FP®, Pfizer Animal Health Exton, PA). Vaccines were acquired in one purchase as a single lot to limit potential variation in the vaccine. Vaccine from the single lot was used at both locations. Vaccination against respiratory disease pathogens was administered to VACC1, VACC2, and VACC3 on d 0. On d 14, all calves were revaccinated against *Haemophilius somnus*, individual BW was recorded, and VACC2, VACC3 received booster BRD vaccine. At 28 d following maternal separation, all calves were revaccinated against clostridial diseases and VACC3 received their final BRD vaccination. At each vaccination event, all calves were processed through a restraining chute, whether they were to receive vaccination or not to control potential variance in stress among treatments.

Calves were stratified by sex and treatment and maintained in earth-floor pens (minimum area = 18.6 m^2/calf; bunk space = 0.46 m/calf; n = 4 pens/ treatment/ location) and fed a common weaning diet formulated to achieve 0.91 kg/d ADG of 0.91 kg at a DMI of 2.5% of BW daily (Table 1). Feed intake was recorded daily on a pen basis. We transitioned calves onto the weaning diet over a 6 day period. Hay was provided at a constant rate of 0.5 % of BW (DM basis) per animal daily for 6 d, and the amount of the weaning diet provided increased from 0.5 % of BW (DM basis) on d 1 to 2.5 % of BW (DM basis) on d 6. Hay was not provided to the cattle after d 6. Bunks were read daily at 0600. After the initial 6-d transition period, an additional 0.1 to 0.2 kg/hd was provided when feed was consumed by 0600 until the calves were consuming the weaning diet at a rate of 2.5 % of BW daily.

Calves were monitored for symptoms of respiratory disease at 0700 and 1400 daily during the ranch-of-origin weaning period. Calves with clinical signs of BRD, as judged by trained animal caretakers, were removed from home pens, restrained using a hydraulic squeeze chute, and evaluated. Upon evaluation, calves were weighed, rectal temperature was determined using a digital thermometer, and assigned a clinical illness score (scale: 1 to 4; 1 = normal, 4 = moribund). Calves with a clinical illness score > 1 and a rectal temperature > 40.0 ºC were considered morbid and treated. Antibiotic therapy was administered per label directions following a predetermined treatment protocol (1st incidence = Baytril®, Bayer Animal Health, Shawnee Mission, KS; 2nd incidence = Nuflor®, Merck Animal Health, Summit, NJ). Cattle were evaluated 72 h post-treatment and re-treated based on observed clinical signs. Drug therapy costs per animal were calculated as: (cost per treatment × number of treatments) ÷ number of animals.

Following the 28-d weaning period, calf BW was recorded and animals were transported 4 h from their respective ranch-of-origin weaning facilities to an auction market. Calves from both origins were commingled and held on the premises of the auction barn for 16 h. This commingling was employed to simulate the pathogen exposure typically encountered by market-ready calves originating from the Great Plains. Calves were then transported 1.5 h to a feedlot. Upon arrival, calves were weighed and assigned to a receiving pen according to sex and vaccination treatment (minimum area = 33.2 m^2/calf; bunk space = 0.40 m/calf; n = 4 pens/ treatment). Animals were fed a common diet (Table 2) once daily at 0700 h and bunks were evaluated each morning at 0630 h. If the previous days feed was consumed, total feed delivered was increased by approximately 2% of the previous days feed delivery. Bunks were managed using a slick-bunk management method to minimize feed refusals (Pritchard and Bruns, 2003). Calves were monitored for BRD symptoms daily at 0700 and 1400. Clinical illnesses were treated in the same manner as during the ranch-of-origin weaning period. Individual BW was recorded after 27 and 55 d on feed.

After receiving, heifers (n = 195) were removed from the trial for use as herd replacements. Steers (n = 235) were then adapted to a finishing ration (Table 14) over a period of 14 days. Steers remained in the same pens as receiving. Feed delivery during finishing was managed similarly to the receiving period. Steers were implanted with Synovex Choice® (Pfizer Animal Health Exton, PA) on d 1 of finishing and remiplanted with Synovex Choice® after 90 d on feed. After 168 d on feed, steers were scanned ultrasonically to determine subcutaneous fat thickness over the 12th rib. Steers were assigned to 1 of 3 harvest dates based on this scan to meet an average carcass endpoint of 11.5 mm of fat depth over the 12th rib.

Steers were transported approximately 3 h to a commercial abattoir on their respective harvest date. At the abattoir, lungs were examined for lesions as described by Bryant et al. (1996), and livers were examined for presence of abscesses according to procedures described by Brink et al. (1990). After carcasses were chilled for 48 h, carcass characteristics were measured electronically and included 12th-rib fat thickness, 12th-rib longissimus muscle area, USDA yield grade, and marbling score (USDA, 1997).

Preconditioning performance, receiving intake, receiving performance, finishing performance, and carcass characteristics were analyzed as a completely randomized design with pen as the experimental unit (PROC MIXED; SAS Inst. Inc., Cary, NC). Incidences of undifferentiated fever during preconditioning and receiving, incidence of liver abscesses and lung lesions were analyzed using PROC GLIMMIX (SAS Inst. Inc., Cary, NC). All models included terms for treatment and location. Because calves were stratified by sex during preconditioning and receiving, sex was initially included in the model, but no significant treatment by sex interactions were detected ($P \geq 0.05$), and sex was removed from the statistical model. No interactions between vaccination treatments and locations were detected ($P \geq 0.10$). When protected by a significant F-test ($P < 0.05$), least squares treatment means were separated using the method of Least Significant Difference. Treatment differences were discussed when $P \leq 0.05$; trends and tendencies were discussed when $0.05 < P \leq 0.10$.

Results and Discussion

Preconditioning and Receiving Performance. Calf BW was not affected by treatment during the weaning period ($P \geq 0.56$; Table 15) or during the feedlot receiving phase ($P \geq 0.54$; Table 16). Calf ADG during PRESHIP was similar ($P = 0.57$) between vaccination groups. Similarly, Step et al. (2008) found no difference in receiving ADG between vaccinated and unvaccinated calves that were preconditioned for 45-d. Furthermore, DMI and G:F during the PRESHIP period were similar ($P \geq 0.56$) between treatments (Table 15).

Loss of BW during transit to the auction market and feedlot was similar ($P = 0.44$; Table 16) between all BRD treatment groups. Daily gains during receiving were not affected ($P \geq 0.95$) by vaccination treatment at d 27 and d 55. Degree of BRD vaccination had no effect ($P \geq 0.59$)

on DMI or G:F during the receiving period. Richeson et al., (2009) reported similar results with growth traits being similar between vaccination treatment groups. Additional studies are needed to elucidate relationships between vaccination timing and frequency and calf growth performance.

Health. During the PRESHIP period, there were no differences ($P \geq 0.39$) in the incidence of undifferentiated fever or drug-therapy costs among treatments, but numerically greater incidence of fever and drug-therapy costs in NOVACC calves (Table 17). The numeric trend in clinical BRD among vaccinated calves is consistent with previous research (Cole, 1985; Galyean et al., 1999); however, BRD incidence is variable (Prichard and Mendez, 1990) and ranch-direct calves could be considered at lesser risk for BRD than is typical for market-sourced cattle.

Finishing Performance and Carcass Characteristics. Average daily gain over the finishing period was not different (P = 0.77; Table 18) among vaccination treatments. Gain efficiency and harvest BW were also similar ($P \geq 0.62$) among treatments and no differences ($P = 0.87$) in DOF were detected among treatments. Ranch direct calves are at low risk for BRD during receiving, but a thorough vaccination schedule (initial vaccination plus at least 1 booster) is common among value-added preconditioning programs (Thrift and Thrift, 2011), because BRD at the feedlot reduces net returns due to therapeutic costs (Brooks et al., 2011) and reduced performance (Waggoner et al., 2007). Under the conditions of this experiment, finishing performance was not impacted by vaccination program during the preconditioning phase.

Hot carcass weight, dressing percent, and longissimus muscle area were not different ($P \geq 0.07$; Table 19) among treatments. Likewise, marbling score, USDA yield grade, 12th rib fat thickness, and KPH were similar ($P \geq 0.54$) among treatments. Incidence of BRD during the feedlot period impacts carcass characteristics (Holland et al., 2010) and reduces overall carcass value (Waggoner et al., 2007). Preconditioning vaccination protocols designed to reduce BRD during the feedlot period did not influence carcass characteristics, under the conditions of this experiment.

Conclusions

Vaccination for BRD, regardless of degree, improved health of calves during the ranch-of-origin preconditioning period. However, feed intake, ADG, or feed efficiency during preconditioning, receiving, or finishing was not affected by level of vaccination when compared with non-treated herd mates. However, due to the variation in outcomes from similar experiments, vaccination effects on growth performance should be evaluated further. Improved animal health was observed with a single BRD pathogen vaccination; however added benefits with subsequent treatment will need to be further investigated.

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Table 12 Composition of the weaning diet (Exp. 3)

Ingredient composition*	% of DM
Alfalfa extender pellets	33.0
Corn gluten feed	18.2
Wheat middlings	14.6
Dried distillers grains	11.5
Cracked corn	10.9
Cottonseed hulls	7.8
Supplement*	4.0
Nutrient Composition[†]	
CP, % of DM	17.7
NE_m, Mcal/kg	1.51
NE_g, Mcal/kg	0.92

*Supplement included molasses, limestone, salt, Bovatec 91, Vitamin A 650, and Zinc Sulfate

[†] Calculated using the values of the NRC (2000)

Table 13. Composition of the receiving diet (Exp. 3)

Ingredient composition	% of DM
Ground sorghum grain	49.0
Sorghum hay	33.5
Wet distillers grains	15.1
Supplement	2.4
Nutrient Composition[†]	
CP, % of DM	14.9
NE_m, Mcal/kg	1.53
NE_g, Mcal/kg	0.93

[*] Supplement contained Rumensin® 80, Tylan® 40, limestone, ammonium sulfate, urea, salt, and trace minerals

[†] Calculated using the values of the NRC (2000)

Table 14. Composition of the finishing diet (Exp. 3)

Ingredient composition*	% of DM
Ground sorghum grain	70.4
Sorghum hay	13.2
Wet distillers grains	15.0
Supplement*	1.4
Nutrient Composition[†]	
CP, % of DM	14.8
NE_m, Mcal/kg	1.91
NE_g, Mcal/kg	1.26

[*] Supplement contained Rumensin® 80, Tylan® 40, Ca carbonate, ammonium sulfate, salt, and trace minerals

[†] Calculated using the values of the NRC (2000).

Table 15. Preconditioning performance of beef calves vaccinated 0, 1, 2, or 3 times during a 28-d ranch-of-origin weaning period

	Vaccination treatment*					
Item	NOVACC	VACC1	VACC2	VACC3	SEM	*P*-value
Weaning weight, kg	232	224	228	230	5.6	0.56
End of preconditioning weight, kg	249	241	243	248	6.6	0.59
Preconditioning ADG, kg	0.60	0.60	0.55	0.65	0.072	0.57
DMI, kg/d	4.41	4.37	4.36	4.51	0.262	0.56
G:F	0.133	0.137	0.124	0.143	0.0138	0.56

*NOVACC = Received no respiratory vaccination during preconditioning; VACC1 = Received one respiratory vaccination during preconditioning; VACC2 = Received 2 respiratory vaccinations during preconditioning; VACC3 = Received 3 respiratory vaccinations during preconditioning

Table 16. Receiving performance of beef calves vaccinated 0, 1, 2, or 3 times during a 28-d ranch-of-origin weaning period

	Vaccination treatment					
Item	NOVACC	VACC1	VACC2	VACC3	SEM	*P*-value
Arrival BW, kg	233	229	229	237	6.2	0.54
Transport shrink, % BW	6.32	4.96	6.38	4.70	1.277	0.44
End BW, kg	297	296	294	303	9.4	0.82
ADG, kg/d						
Arrival to d 27	1.17	1.22	1.25	1.19	0.144	0.95
Arrival to d 55	1.17	1.21	1.20	1.19	0.087	0.97
DMI, kg/d	7.07	7.05	7.07	7.05	0.025	0.59
G:F	0.165	0.171	0.169	0.169	0.0119	0.96

*NOVACC = Received no respiratory vaccination during preconditioning; VACC1 = Received one respiratory vaccination during preconditioning; VACC2 = Received 2 respiratory vaccinations during preconditioning; VACC3 = Received 3 respiratory vaccinations during preconditioning

Table 17. Incidence of fever and cost of treatment during weaning and receiving for beef calves vaccinated 0, 1, 2, or 3 times during a 28-d ranch-of-origin weaning period

	Vaccination treatment					
Item	NOVACC	VACC1	VACC2	VACC3	SEM	*P*-value
Incidence of fever, %						
Weaning period	11.6	5.2	7.4	5.3	4.25	0.48
Receiving period	0.90	0.00	3.70	0.00	0.901	0.66
Treatment cost, $/animal						
Weaning period	3.05	1.21	1.79	1.19	1.244	0.39
Receiving period	0.22	0.00	1.02	0.00	0.521	0.22
Overall	3.45	1.15	2.73	1.21	1.431	0.29

*NOVACC = Received no respiratory vaccination during preconditioning; VACC1 = Received one respiratory vaccination during preconditioning; VACC2 = Received 2 respiratory vaccinations during preconditioning; VACC3 = Received 3 respiratory vaccinations during preconditioning

Table 18. Finishing performance of beef calves vaccinated 0, 1, 2, or 3 times during a ranch-of-origin weaning period

	Vaccination treatment					
Item	NOVACC	VACC1	VACC2	VACC3	SEM	*P*-value
Initial BW, kg	297	296	294	303	9.4	0.82
Final BW, kg	602	568	585	583	24.8	0.62
ADG, kg/d	1.76	1.72	1.80	1.74	0.087	0.77
DMI, kg/d	12.00	11.95	11.94	11.98	0.102	0.92
G:F	0.145	0.144	0.150	0.139	0.0075	0.64
Days on feed	221	209	209	215	16.8	0.87

*NOVACC = Received no respiratory vaccination during preconditioning; VACC1 = Received one respiratory vaccination during preconditioning; VACC2 = Received 2 respiratory vaccinations during preconditioning; VACC3 = Received 3 respiratory vaccinations during preconditioning

Table 19. Carcass characteristics of beef calves vaccinated 0, 1, 2, or 3 times during a ranch-of-origin weaning period

	Vaccination treatment					
Item	NOVACC	VACC1	VACC2	VACC3	SEM	*P*-value
Hot carcass weight, kg	364	344	355	353	12.4	0.54
Dressing percent	60.8	60.7	60.8	60.6	0.74	0.99
Marbling score	44.6	45.4	43.9	47.0	1.59	0.36
USDA yield grade	3.1	3.1	3.2	3.2	0.26	0.92
12th rib fat thickness, mm	9.22	9.19	9.79	9.69	1.228	0.93
Longissimus area, cm^2	85.4	80.2	81.3	80.1	1.40	0.07
KPH, %	3.49	3.25	3.26	3.25	0.708	0.98
Livers observed with ≥ 1 abscess, %	24.1	36.2	24.2	30.4	9.79	0.72
Lungs observed with ≥ 1 lesion, %	29.3	32.7	35.1	42.6	8.88	0.70

*NOVACC = Received no respiratory vaccination during preconditioning; VACC1 = Received one respiratory vaccination during preconditioning; VACC2 = Received 2 respiratory vaccinations during preconditioning; VACC3 = Received 3 respiratory vaccinations during preconditioning

Chapter 5 - Effects of Degree of Transport Following Ranch-of-Origin Preconditioning on Health, Performance, and Carcass Merit of Beef Cattle

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Abstract

Angus × Hereford calves from 2 locations (n = 428) were blocked by sex, stratified by age and BW, and assigned randomly to 1 of 3 transport durations [4 h (**4H**), 8 h (**8H**), or 12 h (**12H**)] following commingling at an auction market and before feedlot placement. Calves were weaned at 183 ± 17 d of age, penned according to treatment (n = 5 pens/treatment at each location), and fed a common diet (16.7% CP, 1.07 Mcal NE_g/kg) during a 28-d preconditioning period. At weaning, calves were weighed, vaccinated against respiratory and clostridial pathogens, and treated for internal and external parasites. Booster vaccinations were administered 14 d later. Preconditioning ADG, final BW, and incidence of undifferentiated fever were not different ($P \geq 0.21$) among treatments. After preconditioning, calves were transported 4 h to an auction market where they were commingled for 12 h before being loaded onto a motor carrier and subjected to assigned transport durations to the feedlot. Calves were weighed upon arrival at the feedlot and penned according to sex and treatment (n = 3 pens/treatment for each sex) and fed a common receiving diet (16.8% CP, 1.07 Mcal NE_g/kg) for 57 d. Feedlot arrival BW were similar ($P = 0.44$) among treatments, but transport shrink was greater ($P < 0.01$) for 8H and 12H calves than 4H calves. Receiving ADG and G:F for 8H and 12H calves were better ($P \leq 0.05$) than for 4H calves. Conversely, DMI was not different ($P = 0.85$) among treatments. Overall incidence of undifferentiated fever during receiving was modest (< 5 %) and was not different ($P = 0.67$) among treatments. Subsequently, a subset of heifers (n = 152) were removed for use as herd replacements. The remaining calves (n = 276) were transitioned gradually to a finishing diet (13.8% CP, 1.26 Mcal NE_g/kg). Final BW, finishing ADG, and DOF were not different ($P \geq 0.34$) among treatments. Similarly, carcass weight, carcass traits, lung condition, and liver condition were also not different ($P \geq 0.10$) between treatments. Under the conditions of our study, performance of preconditioned beef calves during receiving and finishing was not influenced negatively by transport durations between 4 and 12 h immediately following exposure to auction market conditions and prior to feedlot placement.

Keywords: health, preconditioning, transport

Introduction

Transport stress is indicated as a predisposing factor for BRD upon feedlot arrival (Grandin, 1997; Taylor et al., 2010). Moreover, BW lost during transport may be recovered slowly during receiving because of poor DMI (Coffey et al., 2001). Previous research evaluating the effects of transport stress compared performance of preconditioned and non-preconditioned calves subject to a single transport duration (Pritchard and Mendez, 1990). Additionally, research focused on effects of transport duration on calf performance dealt with non-preconditioned calves hauled for > 20 h (Cole et al., 1988). Thus, our goal was to evaluate the ability of preconditioned calves to perform in the feedlot after being transported for time periods typical for cattle that originate from and are fed in the Great Plains. Our specific objective was to measure performance during receiving and finishing of preconditioned beef calves subject to transport lengths of 4 to 12 h from an auction market to a feedlot.

Materials and Methods

Animal care practices used in this study were approved by the Kansas State University Animal Care and Use Committee (protocol no. 2978.1).

Angus × Hereford calves (n = 428; initial BW = 210 ± 33 kg) originating from the Kansas State University commercial cow-calf herds in Manhattan, KS and Hays, KS were used in this experiment. Calves were weaned at 183 ± 17 d of age. Steer calves were castrated prior to 60 d of age and if necessary, calves were dehorned at the time of castration. Dehorning was administered to less than 25% of the calves.

At the time of maternal separation, calves were individually weighed and given initial vaccinations against respiratory pathogens (Bovi-Shield Gold® 5, Pfizer Animal Health, Exton, PA), clostridial pathogens (Ultrabac® 7, Pfizer Animal Health), and *Haemophilus somnus* (Somubac®, Pfizer Animal Health). In addition, all calves were treated for internal and external parasites (Ivomec®, Merial Limited, Atlanta, GA). Booster vaccinations were administered 14 d later.

Following initial processing, calves were confined to 1 of 15 pens within each location (minimum area = 18.6 m^2/calf; bunk space = 0.46 m/calf). We transitioned calves onto the weaning diet over a 6 day period. Hay was provided at a constant rate of 0.5 % of BW (DM basis) per animal daily for 6 d, and the amount of the weaning diet provided increased from 0.5 % of BW (DM basis) on d 1 to 2.5 % of BW (DM basis) on d 6. Hay was not provided to the cattle after d 6. Bunks were read daily at 0600. After the initial 6-d transition period, an additional 0.1 to 0.2 kg/hd was provided when feed was consumed by 0600 until the calves were consuming the weaning diet at a rate of 2.5 % of BW daily.

Calves were monitored for symptoms of respiratory disease at 0700 and 1400 daily during the ranch-of-origin weaning period. Calves with clinical signs of BRD, as judged by trained animal caretakers, were removed from home pens, restrained using a hydraulic squeeze chute, and evaluated. Upon evaluation, calves were weighed, rectal temperature was determined using a digital thermometer, and assigned a clinical illness score (scale: 1 to 4; 1 = normal, 4 = moribund). Calves with a clinical illness score > 1 and a rectal temperature > 40.0 ºC were considered morbid and treated. Antibiotic therapy was administered per label directions following a predetermined treatment protocol (1st incidence = Baytril®, Bayer Animal Health, Shawnee Mission, KS; 2nd incidence = Nuflor®, Merck Animal Health, Summit, NJ). Cattle were evaluated 72 h post-treatment and re-treated based on observed clinical signs.

After 28 d of preconditioning on respective ranches of origin, calves from each location were transported 4 h to a commercial auction market and commingled for 12 h on the premises. Following commingling, calves were loaded by treatment aboard 3 separate motor carriers and subjected to a transport duration of either 4 (4H), 8 (8H), or 12 (12H) h from the auction market to the Western Kansas Agricultural Research Center Feedlot in Hays, KS.

Upon arrival at the feedlot, calves were individually weighed, stratified by sex and penned according to treatment (3 pens/treatment for each sex). Calves were fed a single diet during a 57-d receiving phase and daily DMI was recorded (Table 21). Animals were fed once daily at 0700 h and bunks were evaluated each morning at 0630 h. If the feed allowance from the previous day was consumed, the subsequent feeding was increased by approximately 2% of the previous feed delivery. Bunks were managed using a slick-bunk management method to minimize feed refusals (Pritchard and Bruns, 2003). Calf health was monitored as during the weaning phase of the study and clinical illnesses were treated in the same manner as during the ranch-of-origin weaning period. Individual BW was recorded after 29 and 57 d on feed.

Following receiving, a subset of heifers (n = 152) was removed from the trial to keep as herd replacements. The remaining heifers and all steers (n = 276) were adapted to a finishing diet over a period of 14 d (Table 22). Steers were implanted with Component TE-IS® (Elanco Animal Health) on d 1 of finishing and reimplanted with Component TE-S® (Elanco Animal Health) 90 d later. After 177 d on feed, steers were scanned ultrasonically to determine subcutaneous fat thickness over the 12th rib. Steers were assigned to 1 of 3 harvest dates based on this scan to meet an average carcass endpoint of 11.5 mm of fat depth over the 12th rib. Final BW was collected within 36 h of transport to the abattoir.

Calves were transported approximately 3 h to a commercial abattoir on their respective harvest date. At the abattoir, lungs were examined for lesions as described by Bryant et al. (1996) and livers were examined for presence of abscesses according to procedures described by Brink et al. (1990). After carcasses were chilled for 48 h, carcass characteristics were measured electronically and included 12th-rib fat thickness, 12th-rib longissimus muscle area, kidney-pelvic-heart fat, USDA maturity grade, USDA yield grade, and marbling score (USDA, 1997).

Preconditioning performance, receiving intake, receiving performance, finishing performance, and carcass characteristics were analyzed as a completely randomized design with pen as the experimental unit (PROC MIXED; SAS Inst. Inc., Cary, NC). Incidence of sickness during preconditioning and receiving was analyzed using PROC GLIMMIX (SAS Inst. Inc., Cary, NC). All models included terms for treatment, sex, and location. Because calves were stratified by sex during preconditioning and receiving, sex was initially included in the model, but no significant treatment by sex interactions were detected ($P \geq 0.05$), and sex was removed from the statistical model. No interactions between treatments, locations, and sex were detected ($P \geq 0.10$). When protected by a significant F-test ($P \leq 0.05$), least squares treatment means were separated using the method of Least Significant Difference. Treatment differences were discussed when $P \leq 0.05$; trends and tendencies were discussed when $0.05 < P \leq 0.10$.

Results and Discussion

There were no treatment differences in BW ($P = 0.97$; Table 23) or ADG ($P = 0.21$) at the end of the preconditioning period. This was expected, as all calves were managed in the same manner before application of the transportation treatments. Incidence of undifferentiated fever during preconditioning was not different among treatments (*P* = 0.67) and modest overall (< 7% across all treatments).

We calculated transport shrink as the difference between BW measured upon arrival at the feedlot and BW measured 24 h before transport to the auction facility. The calves transported for 4 h lost less (*P* < 0.01) BW than calves transported 8 or 12 h (Table 24). There was no difference (*P* = 0.27) in BW loss between calves transported 8 h or 12 h.

In beef cattle, shrink increases as the length of transport increases (Knowles, 1999), with the majority of BW losses occurring within the first 4 h (Coffey, et al., 2001). Calves of similar BW to those used in our study (< 271 kg) had greater feedlot morbidity after transport-induced shrink exceeded 2.6% of pre-transport BW (Cernicchiaro et al., 2012a and 2012b). By that standard, calves assigned to all treatments in our study were at relatively high risk for BRD (BW shrink = 2.9 to 5.2%) during receiving and for relatively poor growth performance during receiving.

Data describing the effects of preconditioning on transport shrink is equivocal. Pritchard and Mendez (1990) noted differences in shrink between preconditioned calves and non-preconditioned calves transported for the same length of time; however, treatment effects were inconsistent between experiments. Conversely, Barnes et al. (1990) reported that calves preconditioned for 22 d before auction market commingling and transport had less BW loss than calves weaned and transported to the auction market the same day. During receiving, ADG by 8H and 12H calves was greater (*P* < 0.01) than that by 4H calves (Table 24). There were no treatment differences (*P* = 0.85) in DMI, perhaps because we limited receiving DMI to 2.5% of BW/d. Conversely, G:F by 8H and 12H calves was improved (*P* ≤ 0.05) compared to 4H calves. Favorable ADG and improved G:F by calves transported 8 or 12 h during feedlot receiving can be explained by the replenishment of gut fill lost during transport. Self and Gay (1972) reported that calves transported ~1000 km lost 8.3% of pre-transport BW during transit and needed 12 d to recover lost BW. In our study, there were no treatment differences (*P* = 0.88) in BW at the end of receiving. Consequently, we concluded that increased shrink in the 8H and 12H calves had little or no long-term effects on calf value.

We subjected calves to transport conditions that, according to previous reports, could have increased susceptibility to BRD and other diseases. Cattle from the central region of the US that were transported > 250 km had greater risk for BRD morbidity and mortality upon arrival at the feedlot than cattle transported < 250 km (Cernicchiaro et al., 2012a). In contrast, we observed no treatment differences (*P* = 0.67) in incidence of undifferentiated fever during receiving, possibly because overall incidence of fever during receiving was small. Arguably, the major benefit of preconditioning is temporally separating the occurrence of stressors such as castration, dehorning, weaning, vaccination, transport, and marketing (Cole, 1985). Calves in our study did not seem to manifest any lasting effects of transport on health and performance during receiving, possibly because stressful events were separated in time.

Finishing ADG did not differ (*P* = 0.92; Table 25) among treatments. We noted no treatment differences (*P* = 0.88) in pre-harvest BW among treatments. Cole et al. (1985) summarized 8 trials where ADG of preconditioned and non-preconditioned calves were compared during finishing; they reported no differences between groups. Similarly, we noted no differences (*P* = 0.34) in days on feed, despite feeding to a common physiological end-point (Table 26). Hot carcass weights were not different (*P* = 0.50) among treatments. Measures of carcass fat content, such as KPH, 12th-rib fat thickness, marbling score, and USDA yield grade, were also not different ($P \geq 0.25$) among treatments. We also evaluated lungs and livers at the packing plant, as they can provide valuable evidence about subclinical disease incidence during finishing; however, frequency of lung lesions and liver abscesses were not different ($P \geq 0.10$; Table 26) among treatments.

Conclusions

We interpreted these data to suggest that feedlot performance and health of beef calves preconditioned as described in our study were not impacted negatively by auction-market commingling or a transport length of 4 to 12 h prior to feedlot placement.

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Table 20. Composition of the weaning diet (Exp. 4)

Ingredient composition	% of DM
Alfalfa extender pellets	33.9
Corn gluten feed	18.7
Wheat middlings	14.8
Cracked corn	10.9
Cottonseed hulls	8.1
Dried distillers grain	11.9
Supplement*	3.7
Nutrient composition†	
Crude protein, % of DM	16.7
NE_m, Mcal/kg	1.69
NE_g, Mcal/kg	1.07

*Supplement contained Vitamin A, limestone, molasses, salt, Zn sulfate and Rumensin® 90

†Calculated using the values of the NRC (2000).

Table 21. Composition of the receiving diet (Exp. 4)

Ingredient composition	% of DM
Ground sorghum grain	50.4
Wet distillers grains	11.6
Ground sorghum hay	35.9
Supplement*	2.1
Nutrient composition†	
Crude protein, % of DM	16.8
NE_m, Mcal/kg	1.69
NE_g, Mcal/kg	1.08

*Supplement also contained Rumensin®90, Tylan®, ammonium sulfate, Ca, and Na

†Calculated using the values of the NRC (2000).

Table 22. Composition of the finishing diet (Exp. 5)

Ingredient composition	% of DM
Ground sorghum grain	73.2
Wet distillers grains	11.7
Sorghum silage	12.1
Supplement*	3.0

Nutrient composition†	
CP, % of DM	13.8
NEm, Mcal/kg	1.88
NEg, Mcal/kg	1.26

* Supplement contained Rumensin® 80, Tylan® 40, limestone, salt, and trace minerals.

† Calculated using the values of the NRC (2000).

Table 23. Pre-shipment performance of market-comingled beef calves transported for 4, 8, or 12 h from the ranch of origin to a feedlot

	Length of transport, h				
	4	8	12	SEM	*P*-value
Initial BW, kg	211	210	210	4.0	0.91
Final BW[1], kg	223	224	224	3.8	0.97
ADG, kg/d	0.41	0.50	0.49	0.052	0.21
Incidence of undifferentiated fever, %	4.27	6.84	4.63	3.136	0.68

[1] Weight taken 24 h prior to application of transport treatments.

Table 24. Receiving performance[1] of market-commingled beef calves transported 4, 8, or 12 h from the ranch of origin to a feedlot

	Length of transport, h				
	4	8	12	SEM	*P*-value
Arrival BW, kg	216	213	212	3.6	0.44
Shrink[2], %	2.91^{a}	4.81^{b}	5.15^{b}	0.301	< 0.01
BW at end of 29 d, kg	253	252	252	4.7	0.95
BW at end of 57 d, kg	284	286	284	4.2	0.88
ADG, kg/d					
Arrival to d 29	1.28	1.36	1.37	0.086	0.50
Arrival to d 57	1.18^{a}	1.28^{b}	1.26^{b}	0.029	0.01
DMI, kg/d	6.94	6.94	6.94	0.008	0.81
G:F	0.181^{a}	0.170^{b}	0.184^{b}	0.0050	0.05
Incidence of undifferentiated fever, %	2.05	3.08	1.43	1.818	0.66

[1] Receiving period was 57 d in length.

[2] Calculated as the difference between the end weight from the final preshipment BW and the feedlot arrival weight. Between the aforementioned weights, calves were subjected to transport treatments.

[a, b] Means within rows without common superscripts differ ($P \leq 0.05$)

Table 25. Finishing performance of market-commingled beef calves transported 4, 8, or 12 h from the ranch of origin to a feedlot

	Length of transport, h				
Item	4	8	12	SEM	*P*-value
Initial BW[*], kg	284	286	284	4.2	0.88
Final BW[†], kg	563	559	558	10.7	0.89
ADG, kg	1.78	1.79	1.79	0.038	0.93
Days on feed	224	218	218	4.4	0.34

[*] BW at the end of a 57-d receiving period.

[†] BW measured 24 h before harvest.

Table 26. Carcass characteristics of market-commingled beef calves transported 4, 8, or 12 h from the ranch of origin to a feedlot

	Length of transport, hours				
Item	4	8	12	SEM	*P*-value
Hot carcass weight, kg	342	341	335	6.2	0.50
Marbling score	44.1	44.5	45.7	1.47	0.52
USDA yield grade	3.13	3.29	3.02	0.153	0.25
12th rib fat thickness, mm	11.1	11.4	10.1	0.81	0.27
Longissimus area, cm^2	27.7	26.9	27.3	0.50	0.31
KPH, %	2.69	2.74	2.69	0.099	0.84
Livers observed with ≥ 1 abscess, %	15.3	34.6	25.4	8.13	0.10
Lungs observed with ≥ 1 lesion, %	44.4	38.5	37.3	8.99	0.68

[a] Marbling score: 30 = Slight^{00}, 40 = Small^{00}, 50 = Modest^{00}; ex. 55 = Modest^{50}.

Chapter 6 - Effect of Weaning Method on the Welfare and Performance of Beef Calves during Receiving

E. A. Bailey, J. R. Jaeger, J. W. Waggoner,
G. W. Preedy, L. A. Pacheco, and K. C. Olson

Abstract

We evaluated the welfare and performance of beef calves during receiving that had previously been subject to 1 of 3 ranch-of-origin weaning methods 28 d in duration: drylot weaning + dam separation (**D**), pasture weaning + fence-line contact with dams (**PF**), and pasture weaning + fence-line contact with dams + supplemental feed delivered in a bunk (**PF+S**). Calves assigned to D were fed a diet formulated to promote an ADG of 1 kg at a DMI of 2.5% of BW daily (17.7% CP and 0.93 Mcal NE_g/kg); PF calves had access to native forage only; and PF+S calves had access to native forage and supplemented 3× weekly at a rate of 1% of BW per feeding. Weaning diet fed to D was used as the supplement for PF+S calves. Weaning-phase ADG was greater ($P = 0.01$) for D than for PF or PF+S; however, incidence of undifferentiated fever during weaning tended to be greater ($P = 0.09$) in D calves. Calves assigned to D were heavier ($P < 0.01$) at the end of the weaning period than PF and PF+S calves. At the end of the weaning phase, all calves were transported 4 h to a feedlot, penned according to treatment (n = 6 pens/treatment), and fed a receiving diet (14.9% CP and 0.93 Mcal NE_g/kg) for *ad libitum* intake. Feed intake, growth, and health were monitored during a 60-d receiving period. Observations of calf behavior were made 3× daily for the first 7 d of receiving; the proportion of calves in each pen that were eating, resting, or pacing was recorded by 2 trained observers and reported as a pen average. During the first 30 d of receiving, ADG was less ($P < 0.01$) for PF than for D and PF+S; also, ADG of D was greater ($P < 0.01$) than that of PF and PF+S during the entire 60-d receiving phase. Diet DMI and G:F were also greater ($P \leq 0.01$) for D than for PF calves during receiving. Calves assigned to D continued to be heavier ($P < 0.01$) at the end of the receiving period than PF and PF+S calves. Fewer PF calves were observed at the bunk during the first 4 d of receiving (treatment × day; $P < 0.01$) than D or PF+S calves; however, the numbers of calves observed at the bunk were similar (treatment × day; *P* = 0.64) across treatments by d 6. We interpret these data to suggest that animal performance and welfare during the receiving period were not improved by pasture weaning + fence-line contact with dams compared to drylot weaning + dam separation. Best-management practices for animal welfare may involve initiating diet transitions from forage to grain prior to feedlot placement.

Keywords: animal welfare, health, preconditioning

Introduction

Ranch-of-origin preconditioning has been advocated as a means of improving the welfare and performance of beef calves by easing the stresses associated with weaning, transport, diet change, and commingling (Cole, 1985). Preconditioning methods that involve pasture weaning coupled with maternal contact (i.e., fence-line weaning) have been promoted as possible best-management practices for minimizing stress (Smith et al., 2003). Fence-line weaning reduced morbidity compared to drylot weaning (Boyles et al., 2007; Mathis et al., 2008). Additionally, Price et al. (2003) found that maintaining fence-line contact with dams after weaning reduced behavioral distress (vocalizing, pacing, etc.) when compared with abrupt separation from dams. These studies focused on performance and behavior during weaning on the ranch of origin. Little information has been published relating to carryover effects of fence-line weaning compared to conventional drylot weaning on performance and behavior during feedlot receiving. Therefore, our objectives were to measure growth and health during a 28-d ranch-of-origin weaning phase and during a 60-d feedlot receiving phase among beef calves subjected to 1 of 3 ranch-of-origin preconditioning programs: drylot weaning + dam separation, pasture weaning + fence-line contact with dams, and pasture weaning + fence-line contact with dams + supplemental feed delivered in a bunk. In addition, we observed the behavior among treatments during first 7 d of feedlot receiving.

Materials and Methods

Animal care practices used in our study were approved by the Kansas State University Animal Care and Use Committee (protocol no. 2978.1).

Angus × Hereford calves (n = 460; initial BW = 225 ± 35 kg) originating from the Kansas State University commercial cow-calf herds in Manhattan, KS and Hays, KS were used in this experiment. Calves were 180 ± 19 d of age at weaning. Steer calves were castrated prior to 60 d of age and if necessary, calves were dehorned at the time of castration. Dehorning was administered to less than 25% of the calves.

At weaning, calves were weighed individually and assigned randomly to 1 of 3 ranch-of-origin weaning methods: drylot weaning + dam separation (**D**), pasture weaning + fence-line contact with dams (**PF**), and pasture weaning + fence-line contact with dams + supplemental feed delivered in a bunk (**PF+S**). All calves were individually weighed at the time of maternal separation and were given initial vaccinations against respiratory pathogens (Bovi-Shield Gold® 5, Pfizer Animal Health, Exton, PA), clostridial pathogens (Ultrabac® 7, Pfizer Animal Health), and *Haemophilus somnus* (Somubac®, Pfizer Animal Health). In addition, all calves were treated for internal and external parasites (Ivomec®, Merial Limited, Atlanta, GA). Booster vaccinations were administered 14 d later.

Within location, calves assigned to PF and PF+S were maintained for 28 d in a single native forage pasture (minimum area = 48 ha). Dams were maintained for the first 7 d of this period in adjacent native pastures that afforded fence-line contact with calves (minimum frontage = 200 m; 4-strand, barbed-wire fence with the bottom 2 wires electrified). Fresh water, salt, and mineral supplements were available continually. Calves assigned to D were transported (< 48 km) immediately after separation from dams and confined within location to a single earth-surfaced pen (minimum area = 18.6 m^2/calf; bunk space = 0.46 m/calf).

Calves assigned to D were fed a diet formulated to promote 1 kg ADG at a DMI of 2.5% of BW daily during the weaning phase of the study (Table 27). We transitioned calves onto the weaning diet over a 6 day period. Hay was provided at a constant rate of 0.5 % of BW (DM basis) per animal daily for 6 d, and the amount of the weaning diet provided increased from 0.5

% of BW (DM basis) on d 1 to 2.5 % of BW (DM basis) on d 6. Hay was not provided to the cattle after d 6. Bunks were read daily at 0600. After the initial 6-d transition period, an additional 0.1 to 0.2 kg/hd was provided when feed was consumed by 0600 until the calves were consuming the weaning diet at a rate of 2.5 % of BW daily.

Calves assigned to PF had access to native forage only (Table 28), whereas calves assigned to PF+S had access to native forage and received the diet fed to D but fed 3 x weekly in amounts equal to 1% of BW at each feeding. No adjustments were made to feed delivery rate during the weaning phase of the study. All calves were gathered into a working facility located adjacent to the fence line shared with dams at 0900 on Mondays, Wednesdays, and Fridays during the weaning phase. Calves were sorted in an alley according to ear tags colored by treatment and penned. The pen where PF+S were sorted into contained portable bunks (bunk space = 0.46 m/calf), into which the supplement was placed. Pens afforded drinking water in open-topped tanks and consumption of the ration was complete by 1100 at each feeding episode.

All calves were monitored for symptoms of respiratory disease at 0700 and 1400 daily during the weaning phase of our study. Calves with clinical signs of BRD, as judged by animal caretakers, were removed from pens or pastures and evaluated. Calves were assigned a clinical score (scale: 1 to 4; 1 = normal, 4 = moribund), weighed, and assessed for fever. Calves with a clinical illness score > 1 and a rectal temperature > 40.0°C were treated with therapeutic antibiotics according to label directions (1st incidence = Baytril®, Bayer Animal Health, Shawnee Mission, KS; 2nd incidence = Nuflor®, Merck Animal Health, Summit, NJ). Cattle were evaluated 72 h post-treatment and re-treated based on observed clinical signs.

At the end of the 28-d weaning period, all calves were transported 4 h from their respective ranches of origin to the Western Kansas Agricultural Research Center in Hays, KS and individually weighed upon arrival. At that time, calves were stratified by sex and assigned to 1 of 18 pens by treatment (6 pens / treatment). Animals were fed a common receiving diet (Table 29) once daily at 0700 h and bunks were evaluated each morning at 0630 h. If the previous days feed was consumed, total feed delivered was increased by approximately 2% of the previous days feed delivery. Bunks were managed using a slick-bunk management method to minimize feed refusals (Pritchard and Bruns, 2003). Dry matter intake was estimated based on feed delivered to the pen. Calf health was monitored as during the weaning phase of the study. In addition, calves were weighed individually on d 30 and d 60 of the receiving phase of the experiment.

Beginning on the morning after feedlot arrival, attendance at the feed bunk immediately following feed delivery was recorded by 2 trained observers. Our method were adapted from the work of Walker et al. (2007), who used attendance at the feed bunk as a measure of learned feeding behavior in cattle newly received at the feedlot.

Weaning period performance, receiving intake, and receiving performance were analyzed as a completely randomized design (PROC MIXED; SAS Inst. Inc., Cary, NC). Animal was used as the experimental unit during preconditioning. Pen was the experimental unit during receiving. Incidence of weaning and receiving period sickness were analyzed using PROC GLIMMIX (SAS Inst. Inc., Cary, NC). All models included terms for treatment and location. All models included terms for treatment, sex, and location; no 2-way or 3-way interactions were detected ($P \geq 0.10$). When protected by a significant *F*-test ($P < 0.05$), least squares treatment means were separated using the method of Least Significant Difference. Receiving-period behavioral observations were analyzed using PROC GLIMMIX (SAS Inst. Inc., Cary, NC). Models included terms for treatment, day, time, and all appropriate interactions. Treatment differences in performance were discussed when $P \leq 0.05$; tendencies were discussed when $0.05 < P \leq 0.10$.

Results and Discussion

Weaning period. Calf ADG during the 28-d weaning period was greater ($P = 0.01$; Table 30) for drylot-weaned calves (D) than for pasture-weaned calves receiving no supplement (PF). Based on the chemical analyses of our pasture forage, these results were expected. In previous research, fence-line weaned calves gained 95% more weight than abruptly-weaned calves during the first 2 wk of preconditioning and maintained that difference for 10 wk post-weaning (Price et al., 2003); however, calves in that study were fed a single diet across treatments.

Our treatments were designed such that calves assigned to D were on a greater plane of nutrition than calves assigned to PF or PF+S. This condition is typical of drylot- vs. pasture-weaning programs executed during the fall in Kansas. Supplement provided to PF+S in our study was designed to train pasture-weaned calves how to eat out of a bunk rather than to promote BW gains that were competitive with D. One causative feature of poor initial feedlot performance is stress associated with learning to eat from a bunk (Hutcheson and Cole, 1986). Walker et al. (2007) weaned calves either in a drylot or on pasture without supplement for 21 d. All calves were subsequently moved into a feedlot. Drylot-weaned calves in that study exhibited more vigorous feeding behavior during the first 4 d in the feedlot than pasture-weaned calves, and BW gain was greater for drylot-weaned calves than for pasture-weaned calves during a 30-d feedlot receiving period.

Incidence of undifferentiated fever tended to be greater ($P = 0.08$) in drylot-weaned calves during the weaning phase of our study. Step et al. (2008) indicated that preconditioned calves were less susceptible to disease during weaning and receiving than calves sold through auction markets immediately after separation from dams. Preconditioning was applied to both drylot- and pasture-weaned calves in our study. Supporting results were reported by Krebs et al. (2010) who noted that serum acute phase protein concentrations were not different in calves weaned either abruptly or in 2 stages. Conversely, Walker et al. (2007) reported increased morbidity in drylot-weaned calves compared with pasture-weaned calves.

Receiving period. We observed calves at the time of feeding as an indicator of their desire to eat from a bunk during the first 7 d of receiving. A greater (treatment × day; $P < 0.05$) proportion of D than PF came to the bunk at time of feeding during the first 5 d of receiving (Figure 1). Similarly, a greater proportion (treatment × day; $P < 0.05$) of D than P+S came to the bunk at time of feeding during the first 4 d of receiving. Walker et al. (2007) also reported that drylot-weaned calves had more favorable feeding activity during the first 4 d in the feedlot than unsupplemented, pasture-weaned calves.

Buhman et al. (2000) recorded feeding behavior of recently-received calves purchased through an auction market in an attempt to determine the number of observations needed for appropriate statistical analyses of behavior in feedlot environments. During the first 10 d of the receiving period, these researchers indicated that the CV for feeding behaviors were large and would have required 50 animals/treatment to detect a 20% change in feeding behavior with 95% confidence coefficient. We were able to detect treatment differences with similar sensitivity by averaging feeding behaviors by pen within treatment (6 pens/treatment with 25 to 28 calves per pen) in our study.

During the receiving period, D calves had greater ($P < 0.01$) ADG from arrival to d 60 and greater BW ($P < 0.01$) on d 60 than either pasture-weaned treatment (Table 31). This increase in performance was driven by greater ($P < 0.01$) DMI by D than by PF or PF+S. In addition, G:F was greater ($P = 0.01$) for D than for PF calves; G:F of PF+S calves was intermediate and similar to D and PF. Significantly, providing calves with supplement in a bunk on pasture did not improve receiving ADG ($P > 0.05$) or DMI ($P > 0.05$) compared with pasture-weaned calves receiving no supplement.

Pasture-weaned calves in our study were supplemented infrequently (3× weekly for 4 wk) and ate less feed during receiving that drylot-weaned calves. Conversely, Boyles et al. (2007) reported no difference in feed consumption between drylot-weaned calves and pasture-weaned calves that were provided supplement daily. It may be possible to achieve greater performance and feed intake with pasture-weaned calves during receiving when supplementation is provided more frequently than in our study.

Incidence of undifferentiated fever during the receiving period was not different ($P = 0.28$) among treatments. Step et al. (2008) found calves preconditioned before sale were less likely to be treated for BRD and had lesser serum-acute phase protein concentrations than calves sold through common marketing channels without preconditioning. Previous work (Boyles et al., 2007; Mathis et al, 2008) reported greater incidence of disease during receiving in drylot-weaned calves compared with pasture-weaned calves. In our study, the health of drylot-weaned calves was not different from that of pasture-weaned calves.

Preconditioning is thought to add value to all segments of beef industry through decreased calf morbidity, decreased costs associated with morbidity, reduced drug use, increased feed efficiency, greater BW gain, and greater beef quality. In spite of this, adoption of preconditioning management practices by the cow-calf segment of the beef industry has been relatively slow (49.8% of cow-calf producers sold their calves immediately after weaning, NAHMS, 2007). Calf performance during preconditioning on the ranch of origin is variable (Pritchard and Mendez, 1990; Step et al., 2008; Thrift and Thrift, 2011). As a result, economic returns associated with preconditioning are difficult to predict. A majority of the reluctance to adopt preconditioning is related to inconsistent financial rewards (King et al., 2006). Pasture-weaning systems may be a lower-cost alternative to conventional drylot-weaning systems; however, decreased growth performance during pre-shipment weaning and receiving may result.

Conclusions

We interpret these data to suggest that animal performance and behavior during the receiving period were not improved by pasture weaning + fence-line contact with dams compared to drylot weaning + dam separation. Optimal growth during feedlot receiving was achieved when calves were weaned in a drylot and fed a concentrate-based diet during a 28-d ranch-of-origin preconditioning period. The drylot weaned calves in our study were approximately 20 kg heavier at the end of the receiving period than calves weaned in pastures. Weary et al. (2008) indicated that the most significant stressors associated with weaning were maternal separation and dietary transition from forages to concentrates. To our knowledge, no previous study has attempted to elucidate which of these 2 factors has greater relative influence calf performance during receiving. Based on receiving behavior, ADG, and DMI, previous experience consuming a concentrate-based diet from a bunk paid greater dividends during receiving than reducing stress associated with maternal separation through fence-line contact with dams.

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Table 27. Composition of the weaning diet (Exp. 5)

Ingredient composition[*]	% of DM
Alfalfa extender pellets	33.0
Corn gluten feed	18.2
Wheat middlings	14.6
Cracked corn	11.5
Cottonseed hulls	10.9
Dried distillers grain	7.8
Supplement	4.0

Nutrient composition[†]	
CP, % of DM	14.3
NE_m, Mcal/kg	1.50
NE_g, Mcal/kg	0.93

[*] Diet also contained salt, Zn sulfate, and Rumensin® 80

[†] Calculated using the values of the NRC (2000)

Table 28. Nutrient composition of native pasture forage available to pasture-weaned beef calves (DM basis)

Nutrient	Manhattan	Hays
CP, %	3.2	4.1
NDF, %	74.4	74.8
ADF, %	51.8	48.6

Table 29. Composition of the receiving diet (Exp. 5)

Ingredient composition	% of DM
Ground sorghum grain	47.8
Wet distillers grains	11.0
Ground sorghum hay	33.9
Supplement*	7.3
Nutrient composition [†]	
CP, % of DM	16.8
NE_m, Mcal/kg	1.50
NE_g, Mcal/kg	0.93

* Supplement contained Rumensin® 80, Tylan® 40, limestone, salt, and trace minerals.

[†] Calculated using the values of the NRC (2000)

Table 30. Preconditioning performance of beef calves subjected to 1 of 3 ranch-of-origin preconditioning regimens

	Preconditioning regimen*				
	Drylot	Pasture	Pasture + Supplement	SEM	*P*-value
Weaning BW, kg	224^{a}	226^{a}	226^{a}	4.0	0.83
Final BW[1], kg	233^{a}	217^{b}	220^{b}	3.6	< 0.01
ADG (weaning to feedlot arrival), kg/d	0.31^{a}	-0.31^{b}	-0.22^{b}	0.055	< 0.01
Incidence of undifferentiated fever (28 d), %	5.16^{c}	1.97^{d}	0.65^{cd}	1.825	0.08

[1] Weight taken immediately upon arrival at feedlot

$^{a, b}$ Means within rows without common superscripts differ ($P < 0.01$)

$^{c, d}$ Means within rows without common superscripts tend to differ ($P = 0.08$)

*Drylot = Calves preconditioned for 28 d in a drylot; Pasture = Calves preconditioned on pasture for 28 d; Pasture + Supplement = Calves preconditioned on pasture for 28 d and provided supplement 3x weekly at a rate of 1% of BW per feeding.

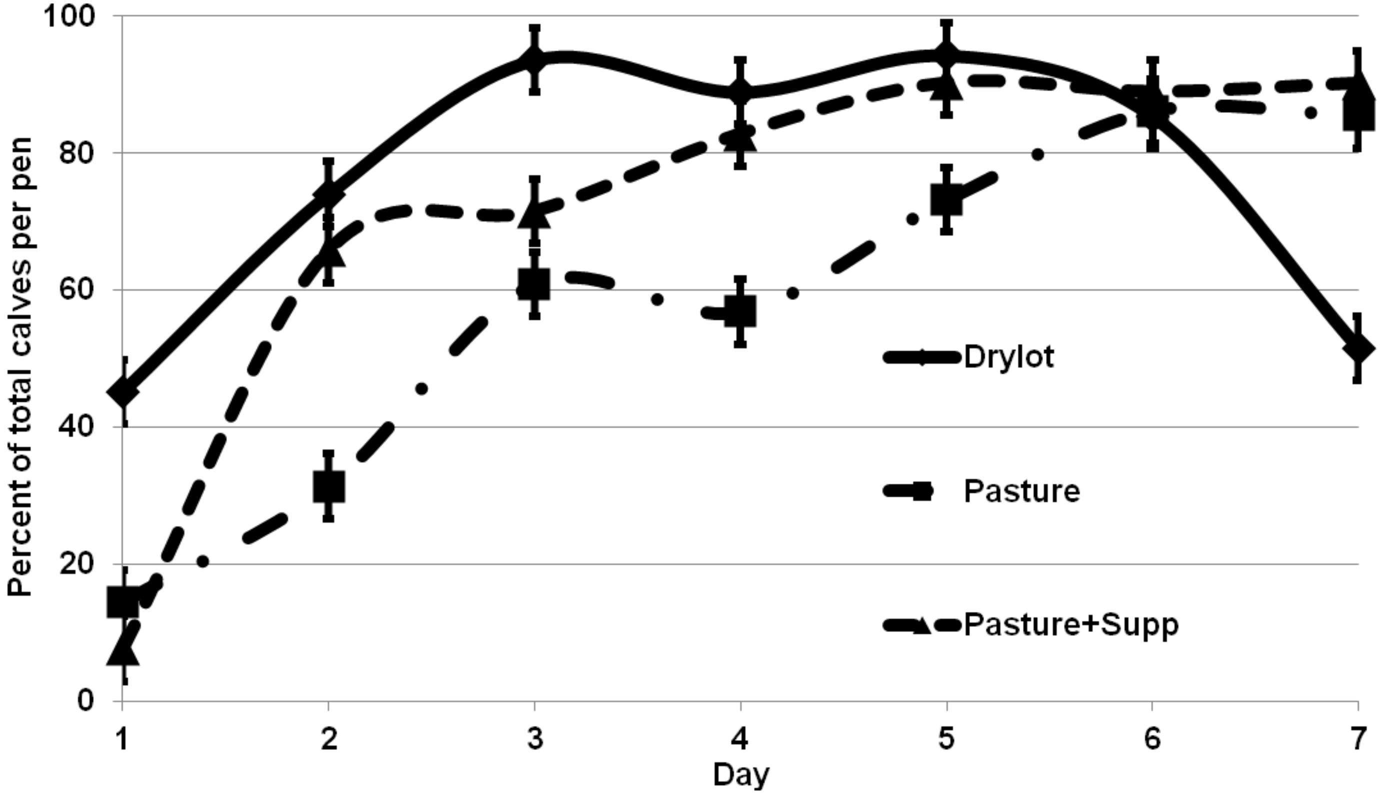
Table 31. Performance of beef calves subjected to 1 of 3 ranch-of-origin preconditioning regimens during a 60-d receiving period

	Preconditioning regimen*				
Item	Drylot	Pasture	Pasture + Supplement	SEM	*P*-value
Arrival weight, kg	235^{a}	218^{b}	220^{b}	3.6	< 0.01
Weight at end of 30 d, kg	263^{a}	241^{b}	248^{b}	3.9	< 0.01
Weight at end of 60 d, kg	315^{a}	291^{b}	296^{b}	4.4	< 0.01
ADG, kg/d					
Arrival to d 30	1.12^{a}	0.89^{b}	1.06^{a}	0.059	< 0.01
Arrival to d 60	1.42^{a}	1.28^{b}	1.32^{b}	0.040	0.01
DMI, kg/d	7.80^{a}	7.72^{b}	7.70^{b}	0.011	< 0.01
G:F	0.182^{a}	0.166^{b}	0.173^{ab}	0.0038	0.03
Incidence of undifferentiated fever, %	0.00	1.97	0.65	0.085	0.28

[a, b] Means within rows having common superscripts do not differ ($P < 0.05$)

*Drylot = Calves preconditioned for 28 d in a drylot; Pasture = Calves preconditioned on pasture for 28 d; Pasture + Supplement = Calves preconditioned on pasture for 28 d and provided supplement 3x weekly at a rate of 1% of BW per feeding.

Figure 1. Proportion of calves observed at feed bunks immediately after feed delivery during receiving (Treatment × time; $P < 0.05$; Maximum SEM = 4.7).



Chapter 7 - Effect of Weaning Method on Finishing Performance and Carcass Characteristics of Beef Calves

E. A Bailey, J. R. Jaeger, J. W. Waggoner,
L. A. Pacheco, G. W. Preedy, and K. C. Olson

Abstract

We evaluated finishing performance of beef steers (n = 234) that had previously been subjected to 1 of 3 ranch-of-origin weaning programs 28 d in duration: drylot weaning + dam separation (**D**), pasture weaning + fence-line contact with dams (**PF**), and pasture weaning + fence-line contact with dams + supplemental feed delivered in a bunk (**PF+S**). Steers assigned to D were fed a preconditioning diet designed to promote an ADG of 1 kg at a DMI of 2.5% of BW daily (17.7% CP and 0.93 Mcal NE_g/kg); PF steers had access to native forage only; and PF+S steers had access to native forage and received a ration of the diet fed to D in amounts equal to 1% of BW 3× weekly. After preconditioning, steers were transported to a finishing facility, penned by treatment (n = 3 pens/treatment) and fed a common receiving diet for 57 d. Steers were transitioned to a finishing diet over 21 d and fed to a common endpoint (12.7 mm 12th-rib fat thickness). At the beginning of the finishing period, steers assigned to D were heavier ($P <$ 0.01) than steers assigned to PF or PF+S. Steers assigned to PF had greater finishing ADG ($P <$ 0.01) than D or PF+S. There were no differences in DOF among treatments ($P = 0.14$), despite PF steers weighing 24 kg less ($P < 0.01$) at the start of the finishing phase. No differences were detected ($P = 0.40$) in finishing period DMI. Gain:feed was greater ($P < 0.01$) in PF steers than either D or PF+S steers. Body weight at harvest did not differ ($P = 0.56$) among treatments. We noted no differences ($P = 0.49$) in hot carcass weight among treatments; moreover, 12th-rib fat thickness, KPH, marbling score, USDA yield grade, and longissimus muscle area were unaffected ($P \geq 0.36$) by treatments. We interpreted these data to suggest that, under the conditions of our study, steers preconditioned on pasture without supplementation were able to compensate for previous nutrient restriction during finishing.

Keywords: beef cattle, finishing, preconditioning

Introduction

Calf weight gains during preconditioning are variable and can be affected by weaning method (Mathis et al., 2008). Decreased weight gain during preconditioning may carry over into the finishing phase and impact performance and carcass characteristics. Previous research demonstrated that modest weight gains during preconditioning resulted in reduced calf body weights for the first 10 wk of finishing relative to calves fed more aggressively during preconditioning (Price et al., 2003). In contrast, Mathis et al. (2008) found that calves preconditioned on native range weighed less at the end of preconditioning and gained more weight during the first 75 d of finishing than calves preconditioned in a drylot. Mathis et al. (2009) compared low- and high-input pasture preconditioning methods where calves had access to self-fed pellets (high-input) or were hand fed range cubes (low-input) 3x weekly and found no difference in finishing performance or profitability of the calves from weaning through harvest. Thus, a producer who retains ownership of calves through finishing may be able to employ a low-cost preconditioning program to minimize costs, while expecting similar finishing performance relative to a high-cost preconditioning program. Therefore, our objective was to measure growth and health during finishing among beef steers that had previously been subjected to 1 of 3 ranch-of-origin preconditioning programs: 1) drylot preconditioning + dam separation, 2) pasture preconditioning + fence-line contact with dams, and 3) pasture preconditioning + fence-line contact with dams + supplemental feed delivered in a bunk.

Materials and Methods

Animal care practices used in our study were approved by the Kansas State University Animal Care and Use Committee (protocol no. 2978.1).

Angus × Hereford steers (n = 234; initial BW = 228 ± 34 kg) originating from the Kansas State University commercial cow-calf herds in Manhattan, KS and Hays, KS were used in this experiment. Steers were 180 ± 19 d of age at weaning. All steers were de-horned and castrated before 60 d of age. At weaning, steers were weighed individually and assigned randomly to 1 of 3 ranch-of-origin weaning methods: drylot weaning + dam separation (**D**), pasture weaning + fence-line contact with dams (**PF**), and pasture weaning + fence-line contact with dams + supplemental feed delivered in a bunk (**PF+S**).

All steers were individually weighed at the time of maternal separation and were given initial vaccinations against respiratory pathogens (Bovi-Shield Gold® 5, Pfizer Animal Health, Exton, PA), clostridial pathogens (Ultrabac® 7, Pfizer Animal Health, Exton, PA), and *H. somnus* (Somubac®, Pfizer Animal Health). In addition, all steers were treated for internal and external parasites (Ivomec®, Merial Limited, Atlanta, GA). Booster vaccinations were administered 14 d later.

Within location, steers assigned to PF and PF+S were maintained for 28 d in a single native pasture (minimum area = 48 ha). Dams were maintained for the first 7 d of this period in adjacent native pastures that afforded fence-line contact with their calves (minimum frontage = 200 m; 4-strand, barbed-wire fence with the bottom 2 wires electrified). Fresh water, salt, and mineral supplements were available continually. Steers assigned to D were transported (< 48 km) immediately after separation from dams and confined within location to a single earth-surfaced pen (minimum area = 18.6 m^2/calf; bunk space = 0.46 m/calf).

Steers assigned to D were fed a diet formulated to promote 1 kg ADG at a DMI of 2.5% of BW daily during the weaning phase of the study. Steers assigned to PF had access to native forage only, whereas steers assigned to PF+S steers had access to native forage and received a ration of the diet fed to D in amounts equal to 1% of BW 3× weekly. No adjustments were made to feed delivery rates during the weaning phase. Steers assigned to PF+S were sorted into a single pen located adjacent to the fence line shared with dams at 0900 on Mondays, Wednesdays, and Fridays during the weaning phase. The ration was offered in portable bunks (bunk space = 0.46 m/calf). Pens afforded drinking water in open-topped tanks and consumption of the ration was complete by 1100 at each feeding episode.

All steers were monitored for symptoms of respiratory disease at 0700 and 1400 daily during the weaning phase of our study. Steers with clinical signs of BRD, as judged by animal caretakers, were removed from pens or pastures and evaluated. Steers were assigned a clinical score (scale: 1 to 4; 1 = normal, 4 = moribund), they were weighed, and assessed for fever. Steers with a clinical illness score > 1 and a rectal temperature > 40.0°C were treated with therapeutic antibiotics according to label directions (1st incidence = Baytril®, Bayer Animal Health, Shawnee Mission, KS; 2nd incidence = Nuflor®, Merck Animal Health, Summit, NJ). Cattle were evaluated 72 h post-treatment and re-treated based on observed clinical signs.

At the end of the 28-d weaning period, all steers were transported 4 h from their respective ranch of origin to the Western Kansas Agricultural Research Center in Hays, KS and weighed individually upon arrival. At that time, steers assigned to 1 of 9 pens (n = 6 pens / treatment). Animals were fed once daily at 0700 h and bunks were evaluated each morning at 0630 h. If the previous days feed was consumed, total feed delivered was increased by approximately 2% of the previous days feed delivery. Bunks were managed using a slick-bunk management method to minimize feed refusals (Pritchard and Bruns, 2003). Dry matter intake was estimated based on feed delivered to the pen. Calf health was monitored as during the weaning phase of the study.

Following a 56-d receiving period, steers were adapted to a finishing ration over a period of 21 d (Table 32). Steers were implanted with Component TE-IS (Elanco Animal Health) on d 1 of finishing. Feeding management during finishing was identical to that previously described for the receiving period.

After 176 d on feed, steers were scanned ultrasonically to determine subcutaneous fat thickness over the 12th rib. Steers were assigned to 1 of 2 harvest dates based on this scan to meet an average carcass endpoint of 11.5 mm of fat depth over the 12th rib.

Steers were transported approximately 3 h to a commercial abattoir on their respective harvest dates. At the abattoir, lungs were examined for lesions as described by Bryant et al. (1996) and livers were examined for presence of abscesses according to procedures described by Brink et al. (1990). Once carcasses were chilled for 48 h, carcass characteristics were evaluated electronically and included 12th-rib fat thickness, 12th-rib longissimus muscle area, USDA yield grade, and marbling score (USDA, 1997).

Finishing performance and carcass characteristics were analyzed as a completely randomized design with pen as the experimental unit (PROC MIXED; SAS Inst. Inc., Cary, NC). All models included terms for treatment and pen. When protected by a significant F-test ($P < 0.05$), least squares treatment means were separated using the method of Least Significant Difference. Treatment differences were discussed when $P \leq 0.05$; tendencies were discussed when $0.05 < P \leq 0.10$.

Results and Discussion

Finishing Performance. The BW difference ($P < 0.01$; Table 33) between D steers and PF+S steers was 24 kg at the beginning of the finishing period. PF+S steers gained BW at a greater rate ($P = 0.01$) and had greater G:F ($P < 0.01$) during finishing than D steers or PF+S steers. Kumar etl al. (2012) noted no differences in finishing ADG or G:F of calves that had been subject to 1 of 3 forage-based backgrounding programs that induced initial feedlot BW differences similar to ours. Mathis et al. (2008) reported that pasture-weaned calves had greater finishing ADG than drylot-weaned calves through the first 75 d on feed but, over the entire finishing period, there were no differences in ADG.

The key difference between our study and others heretofore cited is that our PF steers lost BW during preconditioning (-0.3 kg/d; Bailey et al., 2012); moreover, BW differences persisted through a 57-d receiving period. D calves were observed at the feed bunk more often during the first 6 d of receiving than pasture-preconditioned calves and D calves had greater ADG during receiving. Thus, there were compensatory gains to be captured in finishing. We observed no differences ($P = 0.40$) in finishing-phase DMI among treatments. Under the conditions of our experiment, the unsupplemented pasture-weaned steers compensated for previous nutritional restriction during the finishing period.

The number of days on feed was not different ($P = 0.14$) among treatments. Similarly, BW at harvest was not different ($P = 0.56$) among treatments, likely because we employed a predetermined finishing-phase end point based on backfat thickness. Mathis et al. (2009) also did not note differences in final BW among calves preconditioned at either high or low rates of gain.

Carcass Characteristics. HCW (P = 0.49; Table 34) was not different among treatments. Yield grade ($P = 0.38$), marbling score ($P = 0.92$), and 12^{th}-rib fat thickness ($P = 0.42$) did not differ among treatments. Based on HCW and harvest determination methodology (common backfat thickness end point), it appeared that the nutritional restriction that unsupplemented pasture-weaned steers were subject to during preconditioning did not alter carcass quality. Other research (Hersom et al., 2004; Sharman et al., 2010) reported that the growing diet prior to finishing had minimal effects on marbling score at harvest when calves were fed to a common BF-thickness endpoint. In the aforementioned studies, BW differences at the end of the growing period were ~100 kg; our BW difference at the beginning of finishing was only 24 kg and may not have been large enough to affect carcass characteristics.

Conclusions

Unsupplemented pasture-weaned steers weighed less at the beginning of the finishing period than drylot-weaned steers but gained BW at a greater rate during finishing without increased DMI. We interpret this to suggest that that preconditioned steers compensated fully during the finishing period for previous nutritional restriction. There were no differences in days on feed when fed to a common-backfat end point. Low-input preconditioning programs that involve pasture weaning may not have negative impacts on finishing performance or carcass characteristics of beef cattle and may be a means of reducing the cost of preconditioning. Mathis et al. (2008) noted an increase in the net income at harvest of calves preconditioned on pasture compared to calves preconditioned in a drylot.

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Table 32. Composition of the finishing diet (Exp. 6)

Ingredient composition	% of DM
Ground sorghum grain	74.3
Wet distillers grains	11.8
Sorghum silage	12.3
Supplement*	1.5

Nutrient composition	
CP, % of DM	12.7
NE_m, Mcal/kg	1.87
NE_g, Mcal/kg	1.21

* Supplement contained Rumensin® 80, Tylan® 40, limestone, salt, and trace minerals.

Table 33. Finishing performance of beef steers subject to 1 of 3 ranch-of-origin preconditioning regimens

	Preconditioning regimen*			
Item	Drylot	Pasture	Pasture+Supp	SEM
Initial BW, kg	316^{a}	292^{b}	297^{b}	4.3
Harvest BW, kg	561	570	559	7.9
ADG, kg	1.60^{a}	1.79^{b}	1.65^{a}	0.038
DMI, kg/d	10.72	10.72	10.73	0.012
G:F	0.150^{a}	0.167^{b}	0.153^{a}	0.0034
Days on feed	163	169	164	2.7

$^{a, b}$ Means within rows without common superscripts differ ($P < 0.05$).

*Drylot = Calves preconditioned for 28 d in a drylot; Pasture = Calves preconditioned on pasture for 28 d; Pasture + Supplement = Calves preconditioned on pasture for 28 d and provided supplement 3x weekly at a rate of 1% of BW per feeding

Table 34. Carcass characteristics of beef steers subject to 1 of 3 ranch-of-origin preconditioning regimens

	Preconditioning regimen*				
Item	Drylot	Pasture	Pasture+Supp	SEM	*P* value
Hot carcass weight, kg	349	343	346	4.9	0.49
Marbling score	49.4	50.6	50.7	3.54	0.92
USDA yield grade	3.5	3.3	3.3	0.16	0.38
12th rib fat thickness, mm	12.8	11.6	12.3	0.93	0.42
Longissimus area, cm^2	79.0	78.4	80.2	1.19	0.36
KPH, %	2.65	2.43	2.57	0.148	0.37

[a] Marbling score: 30 = Slight^{00}, 40 = Small^{00}, 50 = Modest^{00}; ex. 55 = Modest^{50}

*Drylot = Calves preconditioned for 28 d in a drylot; Pasture = Calves preconditioned on pasture for 28 d; Pasture + Supplement = Calves preconditioned on pasture for 28 d and provided supplement 3x weekly at a rate of 1% of BW per feeding.

Chapter 8 - Effect of Restricting Feed Intake During an 84-d Growing Period on Performance and Efficiency of Early-Weaned Beef Calves

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Abstract

Harvested forages become scarce and expensive during times of drought; moreover, grains typically have lesser unit cost of energy than forages. Our objective was to evaluate the performance and efficiency of light-weight, early-weaned beef calves program-fed a dry-rolled sorghum-based diet (15.6% CP, 1.20 Mcal NE_g/kg) with intake levels adjusted to achieve 1 of 3 rates of gain during an 84-d post-weaning growing period: 1) 0.45 kg ADG (**LOGAIN**; 1.5% of BW daily DMI), 2) 0.91 kg ADG (**MIDGAIN**; 2.0% of BW daily DMI), and 3) 1.36 kg ADG (**HIGAIN**; 2.5% of BW daily DMI). Angus × Hereford calves (n = 243; initial BW = 156 ± 31 kg; initial age = 113 ± 17 d) were stratified by sex and assigned randomly to treatment (n = 3 pens/treatment for each sex). Daily feed allowances were estimated based on initial BW; feed deliveries were adjusted to meet targeted gains every 28 d based on BW at the end of the preceding period. Carcass characteristics (i.e., 12th rib fat thickness, longissimus muscle depth, and marbling score) were evaluated ultrasonically at the end of the 84-d growing period. Incidence of undifferentiated fever was not different ($P = 0.95$) among treatments. Average daily gain increased ($P < 0.01$) as feed allowance increased; HIGAIN calves were heavier ($P < 0.01$) than either MIDGAIN or LOGAIN calves at the end of the 84-d experiment. Targeted ADG were not achieved (0.55, 0.69, and 0.88 kg for LOGAIN, MIDGAIN, and HIGAIN, respectively). Per design of our study, DMI was greater ($P < 0.01$) for HIGAIN (4.32 kg/d) calves than for MIDGAIN (3.48 kg/d) calves; moreover, DMI of MIDGAIN calves was greater ($P < 0.01$) than that of LOGAIN (2.65 kg/d) calves. Growth efficiency did not differ ($P = 0.83$) among treatments. Fat thickness over the 12th rib was greater ($P \leq 0.02$) for HIGAIN than either LOGAIN or MIDGAIN calves, but there were no differences ($P = 0.14$) in marbling among treatments. Longissimus-muscle depth was less ($P \leq 0.04$) in LOGAIN calves than in MIDGAIN or HIGAIN calves. Under the conditions of this experiment, feed efficiency of early-weaned beef calves was not improved by restricting DMI of a concentrate-based diet during an 84-d growing phase.

Keywords: beef calves, early weaning, intake restriction

Introduction

Early weaning can be used by cow-calf producers to reduce rangeland stocking rates by 20 to 30% during periods of drought (Rasby, 2007). Early-weaned calves can weigh less per day of age than calves weaned at conventional ages; therefore, calf value may be less, even with a positive price slide for lighter calves (Story et al., 2000). To avoid revenue shortfalls, calves can be retained and grown before selling; however, grain prices are currently at unprecedented levels. Feeding grain-based diets to calves less than 125 d of age has been associated with excessive fat accumulation early in the feeding period and decreased carcass weights compared with calves that enter the feedlot after 200 d of age (Schoonmaker et al., 2002). Conversely, growth of early-weaned calves can be highly efficient when compared with calves weaned at conventional ages (Peterson et al., 1987). Marked improvements in feed efficiency have been noted when grain-based finishing diets were limit-fed (Zinn, 1986; Murphy and Loerch, 1994; Schmidt et al., 2005) to early-weaned calves. Thus, high feed costs and early fat deposition may be attenuated greater feed efficiency by limit-feeding a grain-based diet to early-weaned calves. Our goal was to measure performance and efficiency of light-weight, early-weaned, beef calves during an 84-d post-weaning growing period when feed intakes were varied to achieve targeted ADG of 0.45, 0.90, or 1.35 kg / day.

Materials and Methods

Animal care practices used in this study were approved by the Kansas State University Animal Care and Use Committee (protocol no. 3175).

Angus × Hereford calves (n = 243; initial BW = 156 ± 31 kg) originating from the Kansas State University commercial cow-calf herd in Hays, KS were used in this experiment.

Calves were weaned at 113 ± 17 d of age. Steer calves were castrated prior to 60 d of age and if necessary, calves were dehorned at the time of castration. Dehorning was administered to less than 25% of the calves. At weaning, calves were weighed individually and assigned randomly to a common diet (Table 35) fed at amounts to achieve 1 of 3 rates of gain: 1) 0.45 kg ADG (LOGAIN), 2) 0.90 kg ADG (MIDGAIN), and 3) 1.35 kg ADG (HIGAIN). Growth and health performance were evaluated during an 84-day growing period.

At weaning, calves were stratified by sex and assigned to 1 of 18 pens (3 pens/treatment for each sex; minimum area = 18.6 m^2/calf, bunk space = 0.46 m/calf). Animals were fed a common diet once daily at 0800. Diet formulation software (BRaNDS; Iowa State University) predicted calves to gain ~1.35 kg/d at maximal intake; we restricted the intake of the LOGAIN and MIDGAIN calves to a level that decreased their software-predicted ADG to 0.45 kg/d and 0.90 kg/d, respectively.

Calves were weighed individually and given initial vaccinations against respiratory pathogens (Bovi-Shield Gold® 5, Pfizer Animal Health, Exton, PA), clostridial pathogens (Ultrabac® 7, Pfizer Animal Health), and *Haemophilus somnus* (Somubac®, Pfizer Animal Health) at the time of maternal separation. In addition, all calves were treated for internal and external parasites (Ivomec®, Merial Limited, Atlanta, GA). Booster vaccinations were administered 14 d later. Calves were not implanted during the study.

Calf BW was measured at weaning and every 28 d thereafter until the end of the study. Initial feed allowances were determined based on weaning BW and targeted rates of gain. Feed deliveries were adjusted every 28 d observed BW. Carcass characteristics (12th-rib fat thickness, LM depth, and marbling) were determined via ultrasound using an Aloka 500V (Aloka Co., Ltd, Wallingford, CT) B-mode instrument equipped with a 3.5-MHz general purpose transducer array (UST 5021-125 mm window) at the end of the 84-d growing period.

All calves were monitored for symptoms of respiratory disease twice daily during the study. Calves with clinical signs of BRD were removed from pens and evaluated. Calves were assigned a clinical morbidity score (scale: 1 to 4; 1 = normal, 4 = moribund), weighed, and assessed for fever. Calves with a clinical illness score > 1 and a rectal temperature > 40.0 °C were treated with therapeutic antibiotics according to label directions (1st incidence = Baytril®, Bayer Animal Health, Shawnee Mission, KS; 2nd incidence = Nuflor®, Merck Animal Health, Summit, NJ). Cattle were evaluated 72 h post-treatment and re-treated based on observed clinical signs.

Animal performance, intake, and ultrasound data were analyzed as a completely randomized design with pen as the experimental unit (PROC MIXED; SAS Inst. Inc., Cary, NC). Incidence of undifferentiated fever was analyzed using PROC GLIMMIX (SAS Inst. Inc., Cary, NC). All models included terms for treatment and sex. When protected by a significant F-test ($P < 0.05$), least squares treatment means were separated using the method of Least Significant Difference. Treatment differences were discussed when $P \leq 0.05$; tendencies were discussed when $0.05 < P \leq 0.10$.

Results and Discussion

Calf BW increased as feed allowance increased ($P < 0.01$; Table 36). Feed intake was greater ($P < 0.01$) for the HIGAIN treatment than for the MIDGAIN treatment; moreover, feed intake of the MIDGAIN treatment was greater ($P < 0.01$) than for the LOGAIN treatment (Table 2). In addition, ADG increased ($P < 0.01$) as feed allowance increased.

Gain efficiency did not differ (*P* = 0.77) among treatments. Among instances where G:F improved when intake was restricted (e.g., Schmidt et al., 2005), diet NE and MP concentrations were held constant across treatments. Other research showed no difference in G:F (Murphy and Loerch, 1994) or a reduction in G:F (Murphy et al., 1994) when intakes of high-concentrate diets were restricted. We fed a common diet at varied intakes, thus a greater proportion of energy intake was used to meet maintenance requirements in cattle fed for lesser rates of gain.

We back-calculated the NE content of diets based on the calculations of Zinn and Shen (1998). Calves fed to gain 0.45 kg/d had greater (*P* < 0.01) apparent dietary NEm and NEg concentrations than either calves fed to gain 0.90 or 1.35 kg/d. Murphy and Loerch (1994) also noted no differences in gain efficiency but a difference in performance-based NE concentrations of calves that were limit-fed compared with counterparts that were fed more aggressively. They attributed differences in performance-based NE concentrations to potential differences in diet digestibility, as intake and digestibility are inversely related (Tyrrell and Moe, 1975). Another potential explanation is that calves with greater DMI may have had increased visceral organ weights compared with limit-fed calves, a condition which has been associated with elevated maintenance energy requirements per unit of metabolic body weight (Hersom et al., 2004).

Backfat over the 12th rib was greater in the HIGAIN calves than either the LOGAIN (*P* < 0.01; Table 37) or the MIDGAIN (*P* = 0.02) calves. In contrast, there were no differences (*P* = 0.14) in marbling among treatments. Longissimus muscle depth was lesser in the LOGAIN calves than either the MIDGAIN (*P* = 0.04) or HIGAIN (*P* < 0.01) calves. Early-weaned calves offered ad libitum access to a high-concentrate diet after weaning had poorer performance during finishing and achieved a predetermined backfat end point at BW than calves weaned at conventional ages (Schoonmaker et al., 2004). These authors reported that early-weaned cattle reached physiological maturity at a lighter-than-expected BW. Other work noted increased marbling scores in early-weaned calves limit-fed concentrates during the growing phase (Meyer et al., 2005) but calves were fed to a common-age end point in that study. Thus, the criteria used to determine harvest date may strongly influence carcass measurements.

If the harvest decision is based on ultrasonic measurement of carcass composition, early-weaned cattle can be smaller potentially and can produce less kg of beef per carcass than contemporaries weaned at conventional ages. This may reduce beef production potential of early-weaned calves. One of the goals of this trial was to utilize restricted feeding to overcome this phenomenon, while also minimizing the amount of forage fed to early-weaned calves. Meyer et al. (2005) noted increased HCW and marbling score in calves weaned 112 d before conventional weaning age and subsequently finished in a calf-fed system.

Incidence of undifferentiated fever was not different among treatments ($P = 0.95$) and was relatively mild overall (< 6 %). Previous research found no differences in the health of early-weaned calves compared to calves weaned at conventional ages (Myers et al., 1999; Arthington et al., 2005; Arthington et al., 2008). Calves in the aforementioned studies were kept on pasture for a period of time after early weaning. Studies in which early-weaned calves were placed in a feedlot after weaning did not report health data (Schoonmaker et al., 2002; Schoonmaker et al., 2004). Other studies involving limit-fed, early-weaned calves also did not report health data (Murphy and Loerch, 1994; Schoonmaker et al., 2003). Based on our results, it appeared that limit-feeding early-weaned calves in a feedlot did not affect health performance.

Conclusions

Light-weight, early-weaned calves that were fed a grain-based diet at restricted rates did not exhibit improved efficiency relative to full-fed counterparts.   In addition, there appeared to be limitations associated with predicting feed intake and performance of light-weight, early-weaned calves fed a grain-based diet. Our treatments influenced body composition, which may have ramifications for finishing performance.

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Table 35. Composition of the growing diet (Exp. 7)

Ingredient composition	% of DM
Ground sorghum grain	52.9
Dried distillers grains	23.8
Sorghum silage	18.0
Supplement*	5.3
Nutrient composition[†]	
CP, % of DM	15.6
NE_m, Mcal/kg	1.81
NE_g, Mcal/kg	1.20

*Supplement contained Ca, urea, ammonium sulfate, Na, Rumensin® 80, and Tylan® 40

[†] Calculated using the values of the NRC (2000)

Table 36. Growth performance of of early-weaned beef calves fed a common diet to achieve 1 of 3 targeted weight gains during an 84-d growing period

	Targeted ADG			
Item,	0.45 kg/d	0.90 kg/d	1.35 kg/d	SEM
Weaning weight, kg	155	155	157	7.7
Weight at end of 84 d, kg	201[a]	213[a]	231[b]	5.8
ADG, kg/d	0.55[a]	0.69[b]	0.88[c]	0.043
DMI, kg/d	2.65[a]	3.48[b]	4.32[c]	0.001
Gain:feed	0.208	0.199	0.205	0.0138
Performance-based NE calculations[1]				
NE_m	1.93[a]	1.65[b]	1.59[b]	0.052
NE_g	1.28[a]	1.03[b]	0.98[b]	0.044

[a, b] Means within rows without common superscripts differ ($P \leq 0.05$).

[1] Calculations based on the equations of Zinn and Shen (1998).

Table 37. Carcass and health characteristics of early-weaned beef calves fed a common diet to achieve 1 of 3 targeted weight gains during an 84-d growing period

	Targeted ADG			
Item,	0.45 kg/d	0.90 kg/d	1.35 kg/d	SEM
Backfat over the 12th rib, mm	3.36^a	3.55^a	4.13^b	0.218
Marbling, % of LM area	4.75	4.68	4.56	0.092
Muscle depth over the 12th rib, mm	38.71^a	40.24^b	41.45^b	0.527
Incidence of undifferentiated fever, %	4.89	6.05	5.85	3.046

[a, b] Means within rows without common superscripts differ ($P < 0.05$).