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Effects of commingling beef calves from different sources and weaning protocols during a forty-two-day receiving period on performance and bovine respiratory disease[1,2]

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ABSTRACT: The study objective was to determine health and performance of ranch calves from different preconditioning strategies during a 42-d receiving period when commingled with calves of unknown health histories from multiple sources. Steer calves from a single source ranch (RANCH) were weaned and immediately shipped to a feedlot (WEAN, initial BW = 247 ± 29 kg); weaned on the ranch for 45 d before shipping, but did not receive any vaccinations (WEAN45, initial BW = 231 ± 26 kg); or weaned, vaccinated with modified live viral vaccine, and held on the ranch for 45 d before shipping (WEANVAC45, initial BW = 274 ± 21 kg). Multiple-source steers were purchased through auction markets (MARKET, initial BW = 238 ± 13 kg), and upon receiving, a portion of ranch-origin steers from each weaning group was commingled with a portion of MARKET cattle (COMM). The experimental design was completely randomized with a 2 × 3 +1 factorial arrangement of treatments. Factors were RANCH vs. COMM and weaning management (WEAN vs. WEAN45 vs. WEANVAC45) as the factors; MARKET cattle served as the control. Calves of WEAN, WEAN45, and MARKET were vaccinated on arrival at the feedlot. Ranch-origin calves tended ($P = 0.06$) to have greater ADG than COMM or MARKET calves, although ADG was not affected ($P = 0.46$) by weaning management. Across the 42-d receiving period, DMI was not affected ($P = 0.85$) by cattle origin. However, MARKET, WEAN45, and WEANVAC45 calves consumed more ($P < 0.001$) DM than WEAN calves. Gain efficiency was not affected ($P \geq 0.11$) by treatment. Ranch-origin calves were less ($P < 0.001$) likely to be treated for bovine respiratory disease than MARKET calves; COMM calves were intermediate. Calves that were retained on the ranch after weaning (WEAN45 and WEANVAC45) were also less likely to be treated ($P = 0.001$) than MARKET or WEAN calves. As expected, differences in morbidity related to differences in health costs. Calves of WEAN45 and WEANVAC45 had less ($P < 0.001$) health costs than MARKET and WEAN calves. On arrival, serum haptoglobin concentrations were greater ($P < 0.001$) in MARKET and WEAN compared with WEAN45 and WEANVAC45 calves. Calves from a single source that are retained on the ranch for 45 d after weaning exhibit less morbidity and less health costs during the receiving period at the feedyard than when cattle are commingled or trucked to the feedyard immediately after weaning.

Key words: bovine respiratory disease, calf, commingling, performance, stress

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INTRODUCTION

Bovine respiratory disease (**BRD**) involves the complex interaction between infectious agents, the environment, and stress (Galyean et al., 1999). Fulton et al. (2002) reported that calves treated for BRD once returned $40.64 less, calves treated twice returned $58.35 less, and calves treated 3 or more times returned $291.93 less than calves that were not treated. Therefore, management strategies to decrease the incidence of BRD would likely increase economic returns.

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Table 1. Background information regarding calves received at Willard Sparks Beef Research Center

Origin/Weaning management[1]	Transported from	Date received	No. of calves	Initial BW, kg
RANCH/WEAN	South central Missouri	November 2, 2002	86	247 ± 29
Multiple-source/MARKET	Mississippi	November 2, 2002	101	229 ± 26
RANCH/WEANVAC45	South central Missouri	December 18, 2002	75	273 ± 24
RANCH/WEAN45	South central Missouri	December 18, 2002	88	231 ± 27
Multiple-source/MARKET	Mississippi	December 19 and 21, 2002	159	234 ± 15

[1]Calves from a single-source ranch (RANCH) were weaned and immediately transported to the Willard Sparks Beef Research Center (WEAN); weaned, vaccinated with modified live viral vaccine, and held on the ranch for 45 d before transporting (WEANVAC45); or weaned on the ranch for 45 d before transporting, but did not receive any vaccinations (WEAN45). Multiple-source steers were purchased through several auction markets (MARKET), assembled at a central facility in Mississippi, and then transported.

Marketing practices in the US beef cattle industry can result in varying periods of stress, nutritional deficiencies, and exposure to infectious agents when calves are commingled from various sources, transported to distant sites, and changes in diet, feed intake, or both are abrupt. Limited data and practical experience have provided evidence that the effects of BRD on beef cattle morbidity and mortality can be decreased through pretransport preventive health programs commonly referred to as preconditioning, which may include vaccination for various infectious agents, anthelmintic treatments, exposure to feed bunks and troughs, and delayed shipment for 3 to 6 wk after weaning (Duff and Galyean, 2007). Due to the large population of cattle at risk of developing BRD in postweaning production, data evaluating the efficacy of various weaning management protocols are warranted.

Previous studies have shown that serum concentrations of haptoglobin on arrival was increased in steers that required more than one antimicrobial treatment (Carter et al., 2002; Berry et al., 2004). Serum haptoglobin measured on arrival may have potential as a predictor of clinical BRD. A diagnostic tool to identify infection would be useful to producers and veterinarians by providing objectivity to diagnosis. The first objective of this experiment was to determine the effects of commingling calves of unknown backgrounds and sources with calves obtained directly from their ranch of origin but differing in management before shipping. The second objective was to evaluate serum haptoglobin concentrations as a prognostic indicator of health, treatment outcome, and performance in these cattle.

MATERIALS AND METHODS

The experimental protocol was approved by the Oklahoma State University Institutional Animal Care and Use Committee.

Animals

A total of 509 crossbred beef steers (Table 1) were used to study the effects of calf origin and weaning management on animal health and performance. The experiment was conducted at the Willard Sparks Beef Research Center (**WSBRC**), Stillwater, OK. The steers were from multiple sources (auction market; **MARKET**) or a single ranch (**RANCH**). Auction market origin steers (n = 260) were purchased through a private order buyer who acquired the steers through regular auction-market channels in the southeastern United States. Steers were assembled at a facility in Mississippi before transporting to the WSBRC, approximately 1,086 km (approximately 11 h transport time). The MARKET cattle did not have known health histories, and thus were considered to be high-risk, exposed cattle (i.e., likely exposure to different respiratory pathogen isolates not indigenous to herds of origin due to commingling that occurred at various facilities before shipment to the WSBRC). To minimize possible sources of variation due to animal management and genetics, RANCH calves (n = 249) were selected from a single ranch in south-central Missouri located approximately 563 km (approximately 6 h transport time) from the WSBRC.

Due to the objectives and subsequent design of the experiment (see below), groups of calves arrived at the WSBRC on dates separated by approximately 46 d (Table 1). Average daily temperature, humidity, wind speed, and precipitation in Stillwater, OK from November 2 through December 16, 2002 were 5.57 ± 5.10°C, 75.4 ± 16.1%, 11.6 ± 9.4 km/h, and 0.81 ± 4.38 mm, respectively. Average daily temperature, humidity, wind speed, and precipitation in Stillwater, OK from December 18, 2002 through January 31, 2003 were −0.01 ± 5.28°C, 74.1 ± 15.3%, 15.6 ± 9.0 km/h, and 0.34 ± 2.06 mm, respectively.

Experimental Design

Calves from the ranch were weaned and immediately shipped to the WSBRC (**WEAN**); weaned on the ranch for 45 d before shipping, but did not receive any vaccinations (**WEAN45**); or weaned, vaccinated with modified live viral vaccine, and held on the ranch for 45 d before shipping (**WEANVAC45**). At approximately 2 mo of age (approximately 115 kg), RANCH calves had been castrated, dehorned, and vaccinated with a 7-way Clostridial bacterin/toxoid (brand unknown). The MARKET cattle used in this experiment arrived at the WSBRC on November 2 or December 19 and 21, 2002. As indicated, prearrival health management and processing was unknown for MARKET cattle. Although we requested predominantly black *Bos taurus* crossbred castrated males with similar BW as RANCH steers for this experiment, the shipment of purchased cattle included intact males (n = 3 in November arrival cattle) with some variation in phenotype. After initial processing, a portion of MARKET cattle was commingled with a portion of steers from each weaning management group (**COMM**). Treatments were arranged in a 2 × 3 + 1 factorial with RANCH vs. COMM and weaning management (WEAN vs. WEAN45 vs. WEANVAC 45) as the factors; MARKET cattle served as the control.

The WEAN steers were simultaneously weaned and shipped to the WSBRC when they were approximately 8 mo of age (November 2, 2002). No other preventive health procedures for BRD were performed on these steers before arrival; hence, these calves were considered high-risk and nonexposed cattle. The WEAN calves were kept isolated from MARKET cattle on arrival. After arrival, all steers were allowed to rest in clean dry pens at least 1 h before being weighed and individually identified with a bangle tag. After weighing and tagging, steers were allowed to acclimate for approximately 24 h in 12.2 m × 30.5 m pens. Long-stemmed prairie hay and water were provided ad libitum. Approximately 24 h after arrival, initial processing procedures included administration of a modified live viral respiratory vaccine (IBRV-BVDV type 1 and 2-PI3V-BRSV, Titanium 5, AgriLabs, St. Joseph, MO), a 7-way Clostridial bacterin/toxoid (Vision 7 with SPUR, Intervet Inc., Millsboro, DE), a *Mannheimia* (*Pasteurella*) *hemolytica*/toxoid (Presponse SQ, Fort Dodge Laboratories Inc., Fort Dodge, IA), and an endectocide (Ivomec Plus, Merial Ltd., Iselin, NJ) to all WEAN and MARKET steers. In addition, all steers were re-weighed and palpated for testicles. Fourteen days after initial processing, WEAN and MARKET steers were revaccinated with a modified live viral respiratory vaccine in combination with a *Leptospira* bacterin component (Titanium 5 L5, AgriLabs).

As indicated, WEAN45, and WEANVAC45 steers originated from the same ranch and were weaned November 2, 2002 like the WEAN steers, but were held on the ranch for 45 d before being transported to the WSBRC. At weaning, WEANVAC45 calves were vaccinated with 1 dose each of a modified live viral respiratory vaccine (Titanium 5, AgriLabs), a 7-way Clostridial bacterin/toxoid (Vision 7 with SPUR, Intervet), and a *Mannheimia* (*Pasteurella*) *hemolytica*/toxoid (Presponse SQ, Fort Dodge Laboratories). Two weeks after weaning, WEANVAC45 calves were re-vaccinated with a modified live viral vaccine in combination with a *Leptospira* bacterin component (Titanium 5 L5, AgriLabs) and categorized as low-risk cattle. The WEAN45 calves were weaned on the ranch for 45 d but were not vaccinated at weaning. These calves were considered to be of unknown risk. At weaning, calves were randomly assigned to the 3 weaning management groups on the ranch. The WEAN45 and WEANVAC45 steers were weaned in separate tall fescue grass pastures at similar stocking rates. The WEAN45 and WEANVAC45 steers were shipped to the WSBRC in separate trucks on December 18, 2002. Separate truckloads of MARKET calves arrived on December 19 and 21, 2002. The protocol for handling cattle on arrival was the same as for calves arriving in November. Approximately 24 h after arrival, WEAN45 and MARKET cattle were processed using procedures described previously. The WEANVAC45 steers were processed through the chute; however, only the endectocide was given and no vaccinations were administered. Fourteen days after initial processing, WEAN45 and MARKET steers were revaccinated with a modified live viral respiratory vaccine in combination with a *Leptospira* bacterin component (Titanium 5 L5, AgriLabs).

For cattle arriving in both November and December, experimental treatments were randomly assigned to 4 adjacent pens (n = 4) within the feedyard, and calves within treatment group were randomly assigned to 1 of the 4 pens. Each treatment group of 4 pens was separated with an empty pen or alley to prevent animal-to-animal exposure among treatments. Pens were 12.2 m × 30.5 m with 12.2 m of concrete fence-line bunk. For steers arriving in November, 58 ranch-origin steers (WEAN) were randomly allocated to 4 pens (14 or 15 steers/pen), and 28 ranch-origin steers were randomly allocated to 4 different pens for commingling with MARKET cattle (7 WEAN steers/COMM pen). Sixty-eight MARKET steers were randomly allocated to 4 pens (17 steers/pen), whereas 33 MARKET steers were commingled with WEAN calves in the 4 COMM pens (8 or 9 MARKET calves/pen; 15 or 16 total calves/COMM pen). For steers arriving in December, 52 WEANVAC45 steers were randomly allocated to 4 pens (13 calves/pen), whereas 59 WEAN45 steers were randomly allocated to 4 pens (14 or 15 calves/pen). There were 16 MARKET calves allocated to each of 4 pens (64 total MARKET steers). For the commingling treatments, 29 WEAN45 (7 or 8 calves/pen) and 35 MARKET (8 or 9 calves/pen) steers were commingled into 4 pens (16 total calves/pen). In addition, 23 WEANVAC45 (5 or 6 calves/pen) and 41 MARKET (10 or 11 calves/pen) steers were commingled into 4 pens (16 total calves/pen). For all COMM treatment pens, RANCH steers were placed in the pens first followed by MARKET steers.

The order for the initial and all subsequent processing of calves through the chute remained consistent during both receiving periods (i.e., November and December). The order was implemented to minimize the potential for accidental mixing of treatment groups. Steers received in November were processed on arrival and throughout the experiment in the order of WEAN; MARKET; and commingled WEAN and MARKET. Steers received in December were processed as in the order: WEANVAC45; WEAN45; MARKET; commingled WEANVAC45 and MARKET; and commingled WEAN45 and MARKET.

Diet and Weighing

After d-0 processing, calves were moved to assigned pens and offered 1% of BW of a diet consisting of (DM basis) 34.7% dry-rolled corn, 25.0% ground alfalfa hay, 27.0% cottonseed hulls, 3.0% cane molasses, and 10.3% pelleted supplement [58.4% soybean meal, 29.2% cottonseed meal; 9.7% limestone; 2.3% salt; 0.16% Rumensin 80 (Elanco Animal Health, Greenfield, IN); 0.18% vitamin A 30,000; 0.04% vitamin E; and 0.01% selenium]. Feed was delivered into the feed bunks (12.2 m). Cattle were fed the diet twice daily (approximately 0700 and 1400 h) to ensure ad libitum intake; one-half of the calculated ration was fed at each feeding. Prairie hay (1.8 kg/steer on the day of processing) was supplied for the first 7 d of receiving only and was decreased by 0.23 kg/d as intake of the mixed diet increased. Feed bunks were evaluated at approximately 0630 h for remaining feed and feed delivery was adjusted before the 0700 h feeding. Inclement weather was the only factor involved in a change in the above-described feeding schedule. Feed refused was weighed at 14-d intervals and as needed (e.g., after inclement weather). Dry matter content of pen orts samples was determined in a forced-air oven by drying for 12 h at 100°C. In addition, diets were composited in 14-d increments and DM determinations used to calculate DMI and G:F per pen after correcting for orts. Steers had ad libitum access to water via automatic waterers positioned to supply water to 2 adjacent pens/basin.

Calves were weighed on d −1, 0, 14, 28, and 42 (0700 h) of the experiment. All BW with the exception of initial (average of d −1 and 0) and d 42 were shrunk by 4% to calculate ADG and gain efficiency. On d 41, calves received morning feed only and the water was turned off the previous evening (1700 h) before weighing.

Clinical Evaluation for BRD

All calves were monitored by 2 experienced evaluators (1 doctor of veterinary medicine with 25 yr of experience and 1 herdsman with 35 yr of experience identifying morbid cattle) daily throughout the study for clinical signs consistent with BRD. The evaluators used criteria based on the DART system (Pharmacia Upjohn Animal Health, Kalamazoo, MI) with some modifications. Specifically, the subjective criteria used to indicate further evaluation for clinical BRD were depression, abnormal appetite, and respiratory signs. Signs of depression included depressed attitude, hanging head, glazed or sunken eyes, slow movement, arched back, difficulty getting up from lying down, knuckling or dragging toes when walking, and stumbling when moving (not including being bumped by another animal). Signs of abnormal appetite included completely off feed, eating less than expected, slow eating (when considered different from the normal behavior of an animal), lack of fill (gaunt), and obvious BW loss. Respiratory signs included obvious labored breathing, extended head and neck, and noise when breathing. The evaluators also assigned a severity score of 1 to 4, where 1 was assigned for mild, 2 for moderate, 3 for severe, and 4 for moribund (steer would not rise from recumbency; assistance was needed) during their evaluation. The fourth objective criteria used to determine if antimicrobial therapy was needed on an individual animal basis was rectal temperature. Any animal with a rectal temperature of 40°C or greater received an antimicrobial according to label directions. Before antimicrobial administration, an accurate BW was obtained to calculate the appropriate dosage. In situations where the evaluators assigned a severity score of 3 or 4 to a steer, antimicrobial therapy was administered regardless of the rectal temperature of the animal. If a steer did not meet the subjective severity score and temperature criteria, no antimicrobial therapy was administered. All steers were returned to their home pen after evaluation. Temperature readings, BW, and treatments (or no therapy administered) were recorded for every steer that was examined for clinical signs consistent with BRD. Information was recorded for any animal that required examination for any medical condition, such as digestive disorders, lameness, neurological diseases, etc.

The first treatment administered to steers suffering from clinical BRD was tilmicosin (Micotil 300, Elanco Animal Health) at a dosage rate of 10 mg/kg of BW. If steers required a second treatment after 48 h from receiving their first treatment, the antimicrobial used was enrofloxacin (Baytril 100, Bayer Corp, Shawnee Mission, KS) at a dosage rate of 10 mg/kg of BW. If a steer required a third antimicrobial treatment after 48 h from receiving their second treatment, the antimicrobial used was ceftiofur HCl (Excenel RTU, Pharmacia Upjohn) at a dosage rate of 2.2 mg/kg of BW. The dose of ceftiofur HCl was repeated in 48 h. Any steer that exhibited clinical signs consistent with BRD and meeting criteria for a fourth treatment was deemed to be suffering from a chronic disease process and was removed from the experiment. In addition, any steer that exhibited severe clinical signs was moved to an isolated hospital pen for the remainder of the experiment. Any steer that died or required euthanasia was submitted for a complete postmortem examination at the Oklahoma Animal Disease Diagnostic Laboratory. Beef Quality Assurance Guidelines as recommended by the National Cattlemen's Beef Association (NCBA, 2001) were followed throughout this study.

Haptoglobin and Serology

Blood samples were collected via jugular venipuncture (10-mL Vacutainer tube with no additive; Becton Dickinson, Rutherford, NJ) from all calves on arrival and from steers that were treated for BRD. Blood was allowed to equilibrate to ambient temperature before overnight storage at 4°C. Serum was separated the next day (by centrifugation of blood at 3,000 × *g* for

20 min) and stored at −10°C until laboratory analysis could be conducted. Serum haptoglobin concentrations were determined using Bovine Serum Haptoglobin radial immunodiffusion kits (Code No. P0105–1, Cardiotech Svcs. Inc., Louisville, KY) as described by Berry et al. (2004). The CV for the kit was less than 4% for repeated, identical measurements of the same specimen.

Serum antibody concentrations to formalin killed *Mannheimia hemolytica* whole cells (**MhWC**), *Mannheimia hemolytica* leukotoxin (**MhLKT**), and *Pasteurella multocida* outer-membrane proteins (**PmOMP**) were determined by ELISA (Confer et al., 1998). The ELISA wells were coated with 100 μL of antigen at a concentration of 1 ng/μL of coating buffer for PmOMP. For the MhWC preparation, *M. hemolytica* A1 obtained from a washed 18-h culture was suspended in 0.4% formalinized saline at a concentration determined spectrophotometrically to be 1.350 OD_{600}. Leukotoxin was prepared from the supernatant of *M. hemolytica* A1 culture in log phase growth. The MhLKT was partially purified by ammonium sulfate precipitation (Clinkenbeard et al., 1994), confirmed by SDS-PAGE and immunoblotting with an anti-MhLKT antibody, and MhLKT activity of the preparation calculated at 10^4 MhLKT U/mL (Confer et al., 1998). As a measure of lipopolysaccharide contamination of the MhLKT preparation, the 2-keto-deoxyoctonate concentration was 7.5 μg/mg of protein.

Ninety-six-well microtiter plates were coated with MhWC at an optical density reading equivalent to 10^8 CFU of a 24-h culture and MhLKT at 50 ng per well. Sera was tested at 1:400 for PmOMP, 1:800 for MhWC or 1:1,600 for MhLKT dilutions in PBS-Tween 20 containing 1% BSA. Antibody binding was detected using a 1:400 dilution of horseradish peroxidase-conjugated, affinity purified rabbit anti-bovine immunoglobulin (**Ig**) G (Kirkegaard & Perry Laboratories, Gaithersburg, MD). Antibody responses were reported as nanogram of Ig binding based upon comparison with a set of IgG standards on each plate.

Carcass Data

After completion of the 42-d receiving period, cattle were transported to a commercial feedlot for finishing. The feedlot was selected by the cooperating producer/owner with retained ownership of the cattle through slaughter. All cattle were fed a commercial high-concentrate finishing diet for approximately 200 d. Cattle were slaughtered at a commercial facility when 60% appeared to grade USDA Choice based upon subjective evaluation of body composition. Carcass data (HCW, USDA Quality grade, and USDA Yield grade) were collected at slaughter.

Calculations and Statistics

Individual health costs per steer were calculated using: $1.00 each time a steer went through the chute; $0.35 per antimicrobial treatment for syringe and needle; $0.97/mL for 1st treatment antimicrobial; $0.46/mL for 2nd treatment antimicrobial; $0.49/mL for 3rd treatment antimicrobial; and $7.63 for vaccines and dewormer for all groups except WEANVAC45, which was $8.02 (administered an additional 1 mL of dewormer due to increased arrival BW). Costs assigned per steer for the calculation of total cost of production per steer included the individual health cost plus a yardage charge of $0.25/steer daily and the feed cost per pen/number steers per pen. The cost of gain was calculated using the total cost of production divided by ADG over the 42-d period of the experiment.

Receiving performance and health data were analyzed as a 2 × 3 + 1 factorial arrangement of treatments in a completely randomized design using the MIXED procedure (SAS Inst. Inc., Cary, NC). Pen was used as the experimental unit. Fixed effects included RANCH vs. COMM, 3 weaning management treatments (WEAN, WEAN45, and WEANVAC45), and MARKET served as the control. When no interaction (commingling × weaning management; $P > 0.10$) occurred, least-squares means for main effects are reported. For comparing treatment differences among MARKET and RANCH calves in COMM pens, individual animal was used as the experimental unit. The model included the fixed effects of calf origin, weaning management, and the calf origin × weaning management interaction. Calf origin × weaning management nested within pen was included as a random effect. Due to arrival BW being greater ($P = 0.01$) for WEANVAC45 calves compared with MARKET, WEAN, and WEAN45 calves, arrival BW was included in the model as a covariate for all performance, health cost, and carcass data. Analysis was conducted to determine if differences in haptoglobin concentrations could be detected in calves that would never be treated for BRD, calves that would be treated only once for BRD, or calves that would require multiple antimicrobial treatments for BRD. For this analysis, individual animal was used as the experimental unit. The model included fixed effects of number of antimicrobial treatments, weaning management, and the antimicrobial treatments × weaning management interaction. Antimicrobial treatments × weaning management nested within pen was included as a random effect. Least-squares means were compared using LSD when protected by an ($P < 0.05$) F-test. Regression analysis was conducted using the REG procedure (SAS) with number of times treated (0, 1, >1) as the independent variable and haptoglobin concentration as a dependent variable. Results are discussed as significant if $P \leq 0.05$ and as tendencies if $P > 0.05$ to $P \leq 0.10$.

RESULTS

Criteria for removing data from a steer used in the experiment included severe respiratory distress, lameness, neurological abnormalities, or death (dead animals were used in the calculation of mortality rates). Fourteen steers were removed from the entire study

Table 2. Effects of calf origin/commingling on receiving performance by calves fed for 42 d[1]

Item	RANCH	MARKET	COMM	SEM[2]	$P > F$
BW, kg					
d 1	242	226	234	7.83	0.28
d 14	252	253	250	1.48	0.38
d 28	269	265	265	1.89	0.15
d 42	291	287	288	1.38	0.06
ADG, kg					
d 1 to 14	1.19	1.29	1.10	0.11	0.38
d 15 to 28	1.22[a]	0.81[b]	1.04[ab]	0.11	0.03
d 29 to 42	1.62	1.63	1.66	0.12	0.97
d 1 to 42	1.34	1.25	1.27	0.03	0.06
DMI, kg					
d 1 to 14	5.48	4.99	5.11	0.21	0.16
d 15 to 28	7.83	7.75	7.94	0.14	0.58
d 29 to 42	8.46	8.67	8.46	0.20	0.66
d 1 to 42	7.30	7.19	7.27	0.15	0.85
DMI, % of BW					
d 1 to 14	2.33	2.11	2.18	0.09	0.13
d 15 to 28	3.13	3.06	3.18	0.06	0.33
d 29 to 42	3.16	3.28	3.26	0.08	0.42
d 1 to 42	2.51	2.50	2.53	0.05	0.91
G:F, kg/kg					
d 1 to 14	0.227	0.265	0.217	0.023	0.26
d 15 to 28	0.157[a]	0.105[b]	0.131[ab]	0.014	0.03
d 29 to 42	0.190	0.189	0.191	0.012	0.99
d 1 to 42	0.186	0.174	0.174	0.005	0.11

[a,b]Means within a row with different superscripts are different ($P < 0.05$).

[1]Origins of the steers were either from a single ranch (RANCH) or multiple sources (MARKET). After initial processing a portion of RANCH steers were commingled with a portion of MARKET steers (COMM).

[2]Standard error of the least squares means.

due to respiratory distress, and all were of MARKET origin (2 from November and 12 from December); 8 of the 14 died (1 from November and 7 from December), and the clinical diagnosis of BRD was confirmed on postmortem examination. Fifteen steers were removed from the study due to lameness (5 WEAN, 7 MARKET from November, and 3 MARKET from December); all 15 recovered with appropriate therapy. One WEAN steer was removed from the study for treatment of neurological disease; the condition of the steer deteriorated despite treatment and was euthanized. The postmortem diagnosis for the steer was severe bronchopneumonia, and a cerebral infarct was observed in the brain.

Animal Performance

There were no commingling × weaning management interactions ($P > 0.10$) for BW, ADG, or DMI across the 42-d receiving period. Therefore, main effects means for commingling (Table 2) and weaning management (Table 3) are reported. Commingling RANCH- and MARKET-origin calves did not affect ($P \geq 0.15$) BW on d 1, 14, or 28 of the receiving period (Table 2). However, BW on d 42 tended ($P = 0.06$) to be greater for RANCH compared with MARKET and COMM calves. On d 15 through 28, ADG was greatest ($P = 0.03$) for RANCH calves, intermediate for COMM calves, and least for MARKET calves. In addition, from d 1 through 42, ADG tended ($P = 0.06$) to be greater for RANCH compared with MARKET and COMM calves. Dry matter intake did not differ ($P \geq 0.16$) among calf origins. Similarly, DMI expressed as a percentage of BW did not differ ($P \geq 0.13$) among calf origins, averaging 2.51 ± 0.05% of BW across the 42-d receiving period. From d 1 through 14 there was a commingling × weaning management interaction ($P = 0.03$) for G:F (data not shown). Calves weaned on the ranch for 45 d (WEAN45 and WEANVAC45) had lesser G:F than WEAN calves when calves were not commingled. However, when commingled, WEAN45 and WEANVAC45 calves had similar G:F compared with WEAN calves. A similar interaction ($P = 0.03$) occurred from d 1 through 42 (data not shown). From d 15 through 28, G:F was greatest ($P = 0.03$) for RANCH calves, intermediate for COMM calves, and least for MARKET calves (Table 2). However, across the receiving period (d 1 through 42), G:F did not differ ($P = 0.11$) among calf origins.

Effects of weaning management are shown in Table 3. On arrival, calves in the WEANVAC45 treatment had greater ($P = 0.01$) BW than MARKET, WEAN, and WEAN45 calves; therefore, arrival BW was used as a covariate in the statistical analysis. On d 28, BW was greater ($P = 0.02$) for WEAN compared with MARKET, WEAN45, and WEANVAC45 calves. No other differences ($P \geq 0.24$) in BW were observed. From d 1 through 14 ($P = 0.24$) and d 1 through 42 ($P = 0.46$), ADG did not differ among weaning management treatments. However, ADG was greater ($P = 0.005$) for

WEAN and WEANVAC45 than MARKET calves from d 15 through 28; WEAN45 had lesser ADG than WEAN calves, and similar ADG compared with WEANVAC45 calves during the same period. From d 29 through 42, MARKET, WEAN45, and WEANVAC45 calves had greater ($P < 0.001$) ADG than WEAN calves. Calves on the WEAN45 and WEANVAC45 treatments had similar ADG, but WEAN45 calves had greater ADG than MARKET calves. From d 1 through 14, DMI expressed as kilograms per day or as a percentage of BW was greater ($P \leq 0.002$) for WEAN45 and WEANVAC45 than WEAN and MARKET calves. Dry matter intake expressed as kilograms per day or as a percentage of BW was greater ($P \leq 0.003$) for MARKET, WEAN45, and WEANVAC45 than WEAN calves from d 29 to 42. Similarly, DMI expressed as a percentage of BW was greater ($P < 0.001$) for MARKET, WEAN45, and WEANVAC45 than WEAN calves across the 42-d receiving period. Gain efficiency was greater ($P = 0.01$) for MARKET and WEAN than for WEAN45 and WEANVAC45 calves from d 1 through 14. From d 15 through 28, G:F was greatest ($P = 0.003$) for WEAN, followed by WEANVAC45, WEAN45, and MARKET. From d 29 through 42, WEAN calves had lesser ($P = 0.001$) G:F than calves on the remaining treatments. However, G:F did not differ ($P = 0.17$) among weaning protocols across the 42-d receiving period.

We determined the effects of calf-origin and weaning management on ADG of steers in commingled pens (data not shown). There were no calf-origin × weaning management interactions ($P > 0.10$) for ADG. Calf origin did not affect ($P > 0.10$) ADG in commingled pens. Interestingly, similar to calves that were not commingled, weaning management did not affect ADG from d 1 through 14 ($P = 0.89$), d 15 through 28 ($P = 0.30$) or d 1 through 42 ($P = 0.45$). However, from d 29 through 42, WEAN45 (1.91 kg/d) and WEANVAC45 (1.76 kg/d) had greater ($P = 0.03$) ADG than WEAN (1.22 kg/d) calves.

Animal Health

Serum haptoglobin concentrations and antibody titers to *M. hemolytica* and *P. multocida* in steers on arrival are shown in Table 4. On arrival, serum haptoglobin concentrations were greater ($P < 0.001$) in MARKET and WEAN calves compared with WEAN45 and WEANVAC45 calves. Whole cells of *M. hemolytica* were different ($P < 0.001$) among treatments (WEAN < MARKET < WEAN45 < WEANVAC45). *Mannheimia*

Table 3. Effects of weaning management on receiving performance by calves fed for 42 d[1]

Item	MARKET	RANCH: WEAN	RANCH: WEAN45	RANCH: WEANVAC45	SEM[2]	$P > F$
BW, kg						
d 1	226[a]	231[a]	226[a]	257[b]	6.83	0.01
d 14	253	253	251	249	1.65	0.24
d 28	265[a]	271[b]	264[a]	266[a]	1.97	0.02
d 42	288	289	291	289	1.70	0.46
ADG, kg						
d 1 to 14	1.31	1.27	1.15	1.00	0.12	0.24
d 15 to 28	0.81[a]	1.31[c]	0.90[ab]	1.19[bc]	0.11	0.005
d 29 to 42	1.64[a]	1.29[b]	1.95[c]	1.68[ac]	0.09	<0.001
d 1 to 42	1.25	1.29	1.29	1.33	0.04	0.46
DMI, kg						
d 1 to 14	4.97[a]	4.71[a]	5.59[b]	5.61[b]	0.20	0.002
d 15 to 28	7.72	7.64	7.94	8.10	0.15	0.12
d 29 to 42	8.67[a]	8.06[b]	8.96[a]	8.61[a]	0.18	0.003
d 1 to 42	7.17[a]	6.85[b]	7.54[c]	7.48[ac]	0.13	<0.001
DMI, % of BW						
d 1 to 14	2.11[a]	2.01[a]	2.39[b]	2.38[b]	0.08	0.001
d 15 to 28	3.05[a]	3.03[a]	3.17[ab]	3.26[b]	0.06	0.03
d 29 to 42	3.28[a]	2.98[b]	3.40[a]	3.25[a]	0.07	<0.001
d 1 to 42	2.50[a]	2.38[b]	2.60[a]	2.59[a]	0.04	<0.001
G:F, kg/kg						
d 1 to 14	0.269[a]	0.271[a]	0.208[b]	0.182[b]	0.023	0.01
d 15 to 28	0.105[a]	0.171[b]	0.115[ac]	0.146[bc]	0.014	0.003
d 29 to 42	0.189[a]	0.159[b]	0.217[c]	0.195[ac]	0.011	0.001
d 1 to 42	0.175	0.188	0.177	0.173	0.006	0.17

[a–c]Means within a row with different superscripts are different ($P < 0.05$).

[1]Calves from a single-source ranch (RANCH) were weaned and immediately transported to the Willard Sparks Beef Research Center (WEAN); weaned on the ranch for 45 d before transporting, but did not receive any vaccinations (WEAN45); or weaned, vaccinated with modified live viral vaccine, and held on the ranch for 45 d before transporting (WEANVAC45). Multiple-source steers were purchased through several auction markets (MARKET), assembled at a central facility in Mississippi, and then transported.

[2]Standard error of the least squares means.

Table 4. Serum haptoglobin and antibody titers to *Mannheimia hemolytica* and *Pasteurella multocida* on arrival[1]

		RANCH				
Item	MARKET	WEAN	WEAN45	WEANVAC45	SEM[2]	P > F
Haptoglobin, µg/mL	255.0[a]	255.4[a]	87.8[b]	108.9[b]	23.1	<0.001
M. hemolytica whole cells[3]	0.63[a]	0.35[b]	1.34[c]	1.70[d]	0.09	<0.001
M. hemolytica leukotoxin[3]	0.18[a]	0.08[a]	0.68[b]	0.61[b]	0.04	<0.001
P. multocida outer membrane protein[3]	0.59[a]	0.48[a]	1.08[b]	0.95[b]	0.05	<0.001

[a–d]Means within a row with different superscripts are different ($P < 0.05$).

[1]Calves from a single-source ranch (RANCH) were weaned and immediately transported to the Willard Sparks Beef Research Center (WEAN); weaned on the ranch for 45 d before transporting, but did not receive any vaccinations (WEAN45); or weaned, vaccinated with modified live viral vaccine, and held on the ranch for 45 d before transporting (WEANVAC45). Multiple-source steers were purchased through several auction markets (MARKET), assembled at a central facility in Mississippi, and then transported.

[2]Standard error of the least squares means.

[3]Measured as nanograms of secondary antibody that bound to sample.

hemolytica leukotoxin and PmOMP were greater ($P < 0.001$) in WEAN45 and WEANVAC45 calves than MARKET and WEAN calves.

There were no commingling × weaning management interactions ($P > 0.10$) for animal health response variables across the 42-d receiving period (data not shown); therefore, main effects means for calf origin and commingling (Table 5) and weaning management (Table 6) are reported. Percent morbidity differed ($P < 0.001$) among calf origins (Table 5). A greater ($P < 0.04$) percentage of MARKET calves required 3 antimicrobial treatments compared with RANCH or COMM calves. Calves receiving MARKET and COMM treatments received their first antimicrobial treatment earlier ($P < 0.001$; d 7 and 11, respectively) than RANCH calves (d 18). However, during the first antimicrobial treatment, serum haptoglobin, MhWC, MhLKT, and PmOMP did not differ ($P > 0.10$) among calf origins.

Calves on the MARKET treatment received their second antimicrobial treatment on approximately d

Table 5. Effects of calf origin/commingling on morbidity, mortality, and health costs[1]

Item	RANCH	MARKET	COMM	SEM[2]	P > F
Morbidity, %	11.1[a]	41.9[b]	22.6[c]	5.6	<0.001
Treated once, %	7.4[a]	31.9[b]	15.9[a]	4.2	<0.001
Treated twice, %	1.9	4.0	6.1	2.4	0.32
Treated thrice, %	1.8[a]	6.0[b]	0.6[a]	1.6	0.04
First treatment					
Day	17.9[a]	7.2[b]	10.6[b]	2.0	0.001
Haptoglobin, µg/mL	538.3	574.7	626.7	90.3	0.63
Mannheimia hemolytica whole cells[3]	1.01	0.81	1.02	0.29	0.61
M. hemolytica leukotoxin[3]	0.10	0.29	0.30	0.13	0.35
Pasteurella multocida outer membrane protein[3]	0.38	0.57	0.74	0.17	0.17
Second treatment					
Day	21.7[a]	9.4[b]	22.5[a]	4.0	0.007
Haptoglobin, µg/mL	310.0	768.8	657.5	171.5	0.09
M. hemolytica whole cells[3]	1.36	0.71	0.88	0.35	0.33
M. hemolytica leukotoxin[3]	0.09[a]	0.13[a]	0.43[b]	0.11	0.04
P. multocida outer membrane protein[3]	0.35	0.29	0.60	0.15	0.17
Third treatment					
Day	34.7	24.7	16.0	12.2	0.37
Haptoglobin, µg/mL	—	583.0	440.0	331.3	0.71
M. hemolytica whole cells[3]	—	1.74	3.74	1.40	0.26
M. hemolytica leukotoxin[3]	—	1.07	0.59	1.54	0.79
P. multocida outer membrane protein[3]	—	0.64	0.22	0.62	0.57
Mortality, % respiratory	0.0[a]	3.1[b]	2.1[b]	0.8	0.03
Mortality, % total	0.6	3.1	2.1	1.0	0.15
Health costs, $/steer	9.67[a]	13.48[b]	10.70[b]	0.99	0.02
Total costs, $/steer	57.89[a]	61.05[b]	58.73[a]	0.66	0.004
Cost of BW gain, $/kg	1.41	1.68	1.52	0.11	0.22

[a–c]Means within a row with different superscripts are different ($P < 0.05$).

[1]Origins of the steers were from a single ranch (RANCH) or multiple sources (MARKET). After initial processing a portion of RANCH steers were commingled with a portion of MARKET steers (COMM).

[2]Standard error of the least squares means.

[3]Measured as nanograms of secondary antibody that bound to sample.

Table 6. Effects of weaning management on morbidity, mortality, and health costs[1]

Item	MARKET	RANCH WEAN	RANCH WEAN45	RANCH WEANVAC45	SEM[2]	P > F
Morbidity, %	41.9[a]	35.1[a]	5.9[b]	9.5[b]	4.2	<0.001
Treated once, %	31.9[a]	22.2[a]	5.0[b]	7.7[b]	3.8	<0.001
Treated twice, %	4.0[ab]	9.2[a]	0.9[b]	1.8[b]	2.2	0.05
Treated thrice, %	6.0[a]	3.7[ab]	0.0[b]	0.0[b]	1.5	0.02
First treatment						
Day	7.2[a]	12.5[b]	18.0[b]	11.6[ab]	3.4	0.004
Haptoglobin, µg/mL	574.7	591.3	678.3	599.5	128.6	0.90
Mannheimia hemolytica whole cells[3]	0.81	0.99	1.24	0.97	0.42	0.72
M. hemolytica leukotoxin[3]	0.29	0.16	0.50	0.43	0.18	0.18
Pasteurella multocida outer membrane protein[3]	0.57[ab]	0.46[a]	1.19[c]	0.95[bc]	0.23	0.01
Second treatment						
Day	9.4[a]	22.7[b]	29.0[b]	15.0[ab]	9.7	0.01
Haptoglobin, µg/mL	768.8	439.3	900.0	900.0	297.0	0.13
M. hemolytica whole cells[3]	0.71	1.12	1.38	0.35	0.80	0.55
M. hemolytica leukotoxin[3]	0.13[a]	0.24[a]	0.96[b]	0.12[a]	0.23	0.02
P. multocida outer membrane protein[3]	0.29[a]	0.41[a]	1.37[b]	0.54[ab]	0.29	0.02
Third treatment						
Day	24.7	30.0	—	—	6.3	0.52
Haptoglobin, µg/mL	583.0	440.0	—	—	331.3	0.71
M. hemolytica whole cells[3]	1.74	3.74	—	—	1.40	0.26
M. hemolytica leukotoxin[3]	1.07	0.59	—	—	1.54	0.79
P. multocida outer membrane protein[3]	0.64	0.22	—	—	0.62	0.57
Mortality, % respiratory	3.1	0.0	0.0	0.0	0.9	0.16
Mortality, % total	3.1	0.9	0.0	0.0	1.0	0.50
Health costs, $/steer	13.54[a]	13.24[a]	8.30[b]	8.93[b]	0.81	<0.001
Total costs, $/steer	61.03[a]	59.00[b]	57.81[b]	58.15[b]	0.75	0.009
Cost of BW gain, $/kg	1.65	1.63	1.32	1.45	0.11	0.07

[a–c]Means within a row with different superscripts are different ($P < 0.05$).

[1]Calves from a single source ranch (RANCH) were weaned and immediately transported to the Willard Sparks Beef Research Center (WEAN); weaned on the ranch for 45 d before transporting, but did not receive any vaccinations (WEAN45); or weaned, vaccinated with modified live viral vaccine, and held on the ranch for 45 d before transporting (WEANVAC45). Multiple-source steers were purchased through several auction markets (MARKET), assembled at a central facility in Mississippi, and then transported.

[2]Standard error of the least squares means.

[3]Measured as nanograms of secondary antibody that bound to sample.

9 compared with d 22 to 23 for RANCH and COMM calves, respectively ($P = 0.007$; Table 5). Serum haptoglobin concentration tended ($P = 0.09$) to be greater for MARKET and COMM compared with RANCH calves during the second antimicrobial treatment. During the second antimicrobial treatments, MhWC and PmOMP did not differ ($P > 0.10$) among treatments. However, MhLKT concentration ($P = 0.04$) was greater in COMM calves compared with RANCH or MARKET calves. Commingling did not affect ($P = 0.37$) the day of the third antimicrobial treatment. In addition, haptoglobin, MhWC, MhLKT, and PmOMP did not differ ($P > 0.10$) among treatments during the third antimicrobial treatment. Mortality due to BRD was greater ($P = 0.03$) in MARKET and COMM than RANCH calves. In addition, health costs and total costs were greater ($P \leq 0.02$) in MARKET and COMM compared with RANCH calves; cost of gain did not differ ($P = 0.22$) among calf-origin treatments.

Effects of weaning management on morbidity, mortality, and health costs are shown in Table 6. Total percent morbidity and percentage of calves treated once was greater ($P < 0.001$) in MARKET and WEAN calves compared with WEAN45 and WEANVAC45 calves. Calves on MARKET treatment were pulled and treated earlier ($P = 0.004$) in the receiving period than WEAN and WEAN45 calves; WEANVAC45 calves were intermediate. The percentage of calves treated twice was greater ($P = 0.05$) for WEAN compared with WEAN45 and WEANVAC45, whereas percentage of calves treated 3 times was greater ($P = 0.02$) for MARKET compared with WEAN45 and WEANVAC45. Weaning management did not affect ($P > 0.10$) haptoglobin, MhWC or MhLKT; however, PmOMP was greater ($P = 0.01$) in WEAN45 and WEANVAC45 compared with WEAN calves, whereas MARKET calves were intermediate.

Similar to the first day of antimicrobial treatment, MARKET calves were pulled and treated earlier ($P = 0.01$) for their second antimicrobial treatment than WEAN and WEAN45 calves, and WEANVAC45 calves were intermediate (Table 6). Concentrations of haptoglobin and MhWC did not differ ($P > 0.10$) among weaning management treatments. However, during the second antimicrobial treatment MhLKT and PmOMP were greater ($P = 0.01$) in WEAN45 calves than MAR-

KET or WEAN calves. There were no differences ($P >$ 0.10) in days, haptoglobin, or antibody concentrations among weaning management treatments during the third antimicrobial treatment. Mortality did not differ ($P = 0.50$) among treatments. Health costs were greater ($P < 0.001$) for MARKET and WEAN steers than WEAN45 or WEANVAC45 steers. Total costs were greater ($P = 0.009$) for MARKET than WEAN, WEAN45, and WEANVAC45 steers. Cost of BW gain tended ($P = 0.07$) to be greater for MARKET and WEAN than for WEAN45 and WEANVAC45 calves.

The effects of calf origin and weaning management on morbidity, mortality, and health costs of steers in commingled pens are shown in Table 7. There were no calf origin × weaning management interactions ($P >$ 0.10; data not shown); therefore, main effects are reported. In commingled pens, there tended ($P = 0.06$) to be more MARKET steers treated once than RANCH steers. In addition, day of first treatment averaged 8.5 for MARKET versus 15.4 for RANCH ($P = 0.02$). No other effects due to calf origin ($P > 0.10$) were observed. Within commingled pens, effects due to weaning management were generally similar to steers that were not commingled. A greater percentage of WEAN calves than WEAN45 or WEANVAC45 calves were treated once ($P < 0.001$) or twice ($P = 0.01$). During the first antimicrobial treatment, antibody titers to *P. multocida* tended ($P = 0.08$) to be greater for WEAN45 and WEANVAC45 compared with WEAN steers. In addition, health costs were greater ($P = 0.05$) for WEAN than for WEAN45 and WEANVAC45 calves.

Arrival serum haptoglobin concentrations for calves that were never treated for BRD were greater ($P <$ 0.001) for MARKET and WEAN than for WEAN45 and WEANVAC45 calves (240.1, 241.6, 82.3, and 93.7 ± 29.6 ug/mL, respectively). In addition, arrival haptoglobin concentration increased ($P = 0.05$) as the number of antimicrobial treatments increased (164.4, 229.1, and 317.3 ± 77.2 μg/mL for calves treated 0, 1, or >1 times, respectively). However, regression analysis showed that the relationship between arrival serum haptoglobin and number of antimicrobial treatments was poor [antimicrobial treatments = 0.197 (±0.032) + 0.0005 (±0.0001) × (Hp, μg/mL)]; ($r^2 = 0.06$; $P < 0.001$).

Carcass Data

Calf origin and commingling did not affect ($P > 0.10$) HCW or USDA Quality grade (data not shown). United States Department of Agriculture Yield grade was greater ($P < 0.001$) for RANCH (2.61) compared with MARKET (1.97) and COMM (2.28) steers. The effects of weaning management on carcass merit are shown in Table 8. Hot carcass weight and USDA Quality grade did not differ ($P \geq 0.18$) among treatments. However, USDA Yield grade was greater ($P < 0.001$) for WEAN steers than for WEAN45 and WEANVAC45 steers, which had greater Yield grades than MARKET steers.

DISCUSSION

Steers weaned, vaccinated, and held on the ranch for 45 d were heavier than other treatment groups on arrival. Steers were handled in a similar fashion and housed similarly on the ranch to minimize processing and facility variations. Although we attempted to minimize variation by including ranch source steers from a single ranch, factors such as genetic variation, forage quality and intake, physical comfort to cattle, among other unknown factors, cannot be ruled out as potential reasons for this difference. In addition, the present data may suggest that including a vaccination program during the 45-d weaning period on the ranch of origin resulted in increased BW. For example, Schunicht et al. (2003) and MacGregor and Wray (2004) have reported an improvement in cattle performance when multiple viral antigen vaccines were used. In the present experiment, due to this difference among WEANVAC45 and WEAN45 calves, arrival BW was included as a covariate in the statistical models in an attempt to remove this source of variation.

The purpose of preconditioning programs is to decrease the incidence of BRD from weaning to slaughter by ensuring that calves have been weaned for 30 to 45 d, vaccinated (clostridial and viral vaccines), treated with anthelmintic, castrated, dehorned, and accustomed to feed bunks and water troughs before being transported to the feedlot (King et al., 2006; Duff and Galyean, 2007). In general, the importance of animal performance in the 45-d preconditioning period might be of secondary importance compared with improving animal health, although improved performance by preconditioned calves might be expected across the entire finishing phase. In the present experiment, RANCH steers that were not commingled with MARKET steers tended to have greater ADG than COMM steers, whereas ADG of MARKET and COMM steers was similar. The tendency toward greater ADG in noncommingled RANCH steers may be attributed to differences in genetic potential, less stress due to social interactions, less transport stress, less subclinical disease caused by potential pathogen exposure or yet to be identified factors (Galyean et al., 1999; Duff and Galyean, 2007). Although differences in ADG were noted among weaning management treatments at various periods within the 42-d receiving period, differences did not carry through the entire trial (d 1 to 42). In addition, in the present experiment ADG within commingled pens generally ranked similarly to ADG in noncommingled pens with the exception of RANCH steers that were weaned and immediately shipped to the WSBRC. Average daily gain of these commingled steers was 1.18 vs. 1.29 kg for weaned, ranch-origin steers immediately shipped to the WSBRC that were not commingled. Although a direct comparison cannot be made from the present experiment, this may imply greater stress for RANCH calves that are weaned, transported, and commingled

Table 7. Effects of calf-origin and weaning management on morbidity, mortality, and health costs of commingled steers

Item	Origin[1]				Weaning management[2]				
	RANCH	MARKET	SEM[3]	$P > F$	WEAN	WEAN45	WEANVAC45	SEM[3]	$P > F$
Treated once, %	6.8	15.3	—	0.06	13.0[a]	3.4[b]	5.7[b]	—	<0.001
Treated twice, %	2.8	3.4	—	0.92	4.5[a]	0.6[b]	1.1[b]	—	0.01
Treated thrice, %	0.0	0.6	—	0.37	0.6	0.0	0.0	—	0.35
First treatment									
Day	15.4	8.5	2.3	0.02	11.1	13.3	8.0	3.5	0.45
Haptoglobin, µg/mL	588.3	640.0	108.1	0.68	624.7	678.3	599.5	134.3	0.90
Mannheimia hemolytica whole cells[4]	1.44	0.96	0.38	0.33	1.31	1.21	0.93	0.60	0.86
M. hemolytica leukotoxin[4]	0.33	0.29	0.12	0.82	0.19	0.50	0.43	0.15	0.12
Pasteurella multocida outer membrane protein[4]	0.73	0.75	0.22	0.94	0.53	1.19	0.96	0.27	0.08
Second treatment									
Day	28.6	17.3	6.0	0.20	23.5	29.0	15.0	15.0	0.71
Haptoglobin, µg/mL	512.5	730.0	241.4	0.54	536.3	900.0	900.0	343.0	0.54
M. hemolytica whole cells[4]	0.46	1.19	0.66	0.47	0.88	1.38	0.35	1.32	0.86
M. hemolytica leukotoxin[4]	0.33	0.50	0.24	0.62	0.38	0.96	0.12	0.37	0.35
P. multocida outer membrane protein[4]	0.89	0.39	0.23	0.20	0.46	1.37	0.54	0.36	0.18
Health costs, $/steer	10.19	10.97	0.92	0.55	13.55[a]	8.53[b]	8.34[b]	0.79	0.05
Total costs, $/steer	57.84	59.17	0.67	0.15	58.97	57.53	56.81	1.39	0.31
Cost of BW gain, $/kg	1.52	1.50	0.15	0.94	1.87	1.41	1.23	0.31	0.40

[a,b]Means within a row with different superscripts are different ($P < 0.05$).

[1]Origins of the steers were either from a single ranch (RANCH) or multiple sources (MARKET).

[2]Calves from a single-source ranch were weaned and immediately transported to the Willard Sparks Beef Research Center (WEAN); weaned on the ranch for 45 d before transporting, but did not receive any vaccinations (WEAN45); or weaned, vaccinated with modified live viral vaccine, and held on the ranch for 45 d before transporting (WEANVAC45).

[3]Standard error of the least squares means.

[4]Measured as nanograms of secondary antibody that bound to sample.

Table 8. Effects of weaning management on carcass merit[1]

		RANCH				
Item	MARKET	WEAN	WEAN45	WEANVAC45	SEM[2]	$P > F$
HCW, kg	352	356	354	347	4.3	0.45
USDA Quality grade[3]	2.46	2.30	2.45	2.35	0.08	0.18
USDA Yield grade	2.10[a]	2.77[b]	2.33[c]	2.44[c]	0.09	<0.001

[a–c]Means within a row with different superscripts are different ($P < 0.05$).

[1]Calves from a single-source ranch (RANCH) were weaned and immediately transported to the Willard Sparks Beef Research Center (WEAN); weaned on the ranch for 45 d before transporting, but did not receive any vaccinations (WEAN45); or weaned, vaccinated with modified live viral vaccine, and held on the ranch for 45 d before transporting (WEANVAC45). Multiple-source steers were purchased through several auction markets (MARKET), assembled at a central facility in Mississippi, and then transported.

[2]Standard error of the least squares means.

[3]1 = Standard; 2 = Select; 3 = Choice.

compared with RANCH calves that are preconditioned, transported, and commingled at a receiving or finishing facility.

Hutcheson and Cole (1986) summarized research which suggested that DMI of newly arrived calves that are healthy should average 1.55% of BW from d 0 to 7 after arrival and approximately 1.90% of BW from d 0 to 14 (NRC, 1996). In the present experiment, DMI as a percentage of arrival BW averaged 2.21% from d 1 to 14 and was not different among calf-origin treatments. Therefore, DMI was greater for calves in the present experiment than DMI suggested by NRC (1996) for stressed calves. Greater DMI (% of BW) for WEAN45 and WEANVAC45 during the first 14 d, and greater DMI (% of BW) for WEAN45 and WEANVAC45 across the receiving period might suggest that previously weaned calves are less influenced by transport and other stressors during shipment to a feedyard. Similarly, Boyles et al. (2007) reported greater DMI for steer calves that were preconditioned for 30 d before shipment to a receiving facility vs. steers that were weaned immediately before shipping. However, in their experiment, preconditioning in a drylot did not improve morbidity compared with calves that were weaned and immediately shipped.

As generally perceived, MARKET steers exhibited greater morbidity rates than ranch-origin steers, and those in commingled pens exhibited intermediate morbidity rates. Within commingled pens, MARKET steers had greater morbidity than RANCH steers. Additionally, days to first treatment for clinical respiratory disease were earlier in MARKET steers in commingled pens than for RANCH steers. Roeber et al. (2001) conducted an experiment to evaluate effects of morbidity on feedlot performance and carcass traits. In their experiment, preconditioned calves had fewer hospital visits than calves that were purchased at auction markets, similar to the present experiment. In the present experiment, steers weaned on the ranch (WEAN45, WEANVAC45) exhibited less morbidity than MARKET and WEAN steers. This difference influenced health care cost per steer (average = $13.39/steer for MARKET and WEAN vs. $8.62/steer for WEAN45 and WEANVAC45). Therefore, there was an economic benefit to weaning on the ranch of origin for 45 d. King et al. (2006) reported that price premiums for calves in intensive certified health programs ranged from $2.74/45.45 kg to $7.91/45.45 kg from 1995 to 2004.

In the present experiment, weaning on the ranch for 45 d had a profound effect on measured serum proteins on arrival. Serum haptoglobin concentrations were greater in MARKET and WEAN steers than for preconditioned steers. In addition, serum antibody titers to bacterial respiratory pathogens were significantly increased in steers weaned on the ranch for 45 d. Lesser serum haptoglobin and greater serum titers to the bacterial pathogens corresponded to lesser morbidity, mortality, and health costs in steers in the present experiment. Similar to previous studies (Carter et al., 2002; Berry et al., 2004), arrival haptoglobin was increased in steers that required more than one antimicrobial treatment. However, the relationship between serum haptoglobin measured on arrival and number of antimicrobial treatments required was poor in the present experiment, leaving its potential as a prediction marker of clinical BRD in question. Nonetheless, weaning cattle for 45 d on the ranch of origin resulted in a lesser morbidity and haptoglobin concentrations compared with weaning and immediately shipping calves, or purchasing MARKET calves, regardless of vaccination protocol on the ranch. Minimizing stress is commonly discussed in dealing with many animal health production diseases (Galyean et al., 1999). One way of minimizing the incidence of BRD is to precondition weaned beef cattle. There are many preconditioning programs, but most will include vaccinations against common respiratory pathogens and weaning for greater than 30 d before shipping to the feedlot. In the present experiment, weaning on the ranch for 45 d resulted in healthier cattle.

Weaning calves on the ranch for 45 d (i.e., preconditioning) before transporting to a receiving facility results in improved health and performance during the subsequent receiving and feeding period compared with weaning and transporting calves immediately, or purchasing calves of high health risk. In the present experiment, weaning alone had similar benefits as weaning and vaccination for calves held on the ranch of origin for 45 d. In addition, commingling preconditioned calves has less potential negative effects than commingling calves that are weaned and immediately transported to a feedyard.

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