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Dietary Management Strategies to Mitigate Decreased Feed Intake Associated with Terminal Implant Administration in Finishing Beef Steers

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Abstract: Re-implanting with a terminal implant often reduces subsequent dry matter intake (DMI). Crossbred steers (n = 27, initial body weight = 385 ± 30.8 kg) were used to assess the effects of locomotion immediately after terminal implantation and increased forage inclusion 7-d post-implantation on feed and water intake, rumination, and activity. Steers were implanted with 100 mg trenbolone acetate and 14 mg estradiol benzoate (Synovex Choice; Zoetis, Parsippany, NJ) and fed a finishing diet (1.43 Mcal NEg/kg DM). Steers were re-implanted on d-87 with 200 mg trenbolone acetate and 28 mg estradiol benzoate (Synovex Plus; Zoetis). Steers were allocated into 3 post-implanting treatments: (1) Moved 0.43 km following re-implanting (CON), (2) Moved 1.05 km (ACT), or (3) Moved 1.05 km with increased forage for 7d (ACT + DIET). Feed and water intake were measured using an Insentec RIC system (Hokofarm, Marknesse, Netherlands) with activity measured using accelerometer tags (Sense Hub Beef; All Flex Livestock Intelligence, Madison, WI). Treatment did not affect cumulative DMI or cattle performance ($p \geq 0.67$). Treatment and day interacted for DMI with CON greater than ACT + DIET on d5-10 ($p \leq 0.05$) and tended ($p = 0.06$) to be greater on d4. Treatment and day interacted for rumination time ($p = 0.02$) with ACT and ACT + DIET greater than CON on d5 and ACT ruminating longer on d14 than either CON or ACT + DIET. Cumulative rumination time increased for ACT and ACT + DIET compared to CON ($p \leq 0.001$). Activity time differed ($p = 0.001$) between all treatments. Treatment affected cumulative water intake ($p = 0.001$) with ACT steers drinking less than CON or ACT + DIET. Increased activity tended to reduce DMI immediately following re-implantation. Increased roughage inclusion after re-implanting did not affect DMI or performance but increased rumination time.

Keywords: Feedlot, Re-Implant, Roughage, Activity, Water

Introduction

The use of implants in US beef production is an important management practice to improve Average Daily Gain (ADG), increase dry matter intake (DMI), and delay fattening (Johnson *et al*., 1996; Smith *et al*., 2020; Smith and Rusche, 2022). Calves are often implanted multiple times from the weaning phase to the finishing phase. In 2013, 4 out of 5 (79.8%) steers placed in the feedlot weighing less than 317 kg received more than one implant (U.S. GPO, 2013). Traditionally, the decision to administer multiple implants between backgrounding and finishing phases is largely based on the frame size of cattle and average daily gain, which predicts how long cattle will be fed before harvesting. Smaller cattle require more time on feed to reach their terminal endpoint because it is desired to allow them to reach their potential for frame size before optimum muscle growth and fattening occur.

Costs associated with reworking cattle are labor, cost to operate the chute, cost of the implant, increased locomotion, and time away from feed (Stanton, 1997; Wallace *et al*., 2008). The physiological effects of locomotion on DMI are unknown in cattle operations, but evidence of decreased DMI post-reimplantation is clear. The effects of replanting on DMI were observed in finishing feedlots (n = 321 pens; 47,000 cattle) across KS, NE, IA, and TX (Wallace *et al*., 2008). In that study, 61% of pens evaluated had decreased DMI following re-implantation for 10 days, whereas 39% of pens did not differ or had increased DMI before and after a reimplant event. A more recent study showed decreased DMI associated with re-implantation in heifers given a greater hormone dosage than single implant heifers; however, despite depressed DMI re-implantation had positive effects on live-basis growth performance (Merck Animal Health, 2020). Helmuth *et al*. (2022) concluded that increased locomotion associated with re-implantation decreased DMI for a 10-day period and for the rest of the feeding period. Restricting access to feed and water in that experiment did not affect subsequent DMI.

Decreased DMI may be caused by fluctuations in feeding due to a disruption in body homeostasis and increased locomotion at re-implantation. Cattle must consume consistent, small meals to maintain volatile fatty acid production and rumen microbial populations. Rumination between meals stimulates saliva production and buffering capacity. Rapid consumption of highly fermentable carbohydrates, commonly found in feedlot finishing diets, can result in acute or sub-acute acidosis with increasing acid accumulation in the rumen. Acidosis is caused by a rapid ruminal pH decrease, which may be affected by feed type, frequency of feeding bouts, weather, and rumination (Owens *et al*., 1998). Forage stimulates saliva production and increases rumination time, thus creating a buffer for the rumen (Beauchemin, 1991). Including additional forage provides physically effective neutral detergent fiber (peNDF), which would decrease the incidence of acidosis (Chibisa *et al*., 2020).

It is unknown which factors related to re-implantation have a negative effect on cattle. Potential causative agents include locomotion distance immediately after re-implantation, time away from the pen, and feeding behavior after re-implantation. Increasing forage in the diet after re-implantation may mitigate the decreased DMI observed following re-implantation and reduce acidosis risk. The objective of this study was to determine the effect of increased locomotion at the time of re-implantation on DMI, water intake, activity, growth performance, and carcass characteristics and to evaluate whether increasing dietary roughage would affect those parameters. Our hypothesis was that increased locomotion would negatively impact DMI and that increasing forage will increase rumination thus mitigating the effects of acidosis.

Materials and Methods

All procedures involving the use of animals in this experiment were approved by the South Dakota State University Institutional Animal Care and Use Committee (IACUC, approval number 2011-054A).

Cattle Management

The experiment utilized Angus and Simmental x Angus steers (n = 27*)* sourced from the South Dakota State University Cow-Calf Education and Research Facility in Brookings, SD. Calves were born on-site and never left the facility, from birth to their terminal shipment. Calves were processed prior to turning out to pasture during spring of 2020 at which time they were vaccinated against clostridial species *Clostridium* chauvoei, septicum, novyi, sordellii, perfringens types C and D and Moraxella bovis (Alpha 7; Boehringer Ingelheim Health Inc., Duluth, GA) and against respiratory diseases caused by Bovine Respiratory Syncytial Virus (BRSV), Infectious Bovine Rhinotracheitis (IBR) virus and Parainfluenza 3 (PI_3) virus (Inforce 3; Zoetis Animal Health, Parsippany, NJ). Calves were treated with a parasiticide to control roundworms, lungworms, grubs, and mites commonly found on cattle on pasture (Long Range; Boehringer Ingelheim Health Inc., Duluth, GA). In August 2020, cattle were processed again before weaning where they were vaccinated against viral papillomas warts (Wart Vaccine; Colorado Serum Company, Denver, CO) and respiratory diseases caused by BRSV, IBR, PI3, Bovine Viral Diarrhea Virus Types 1-2 and Mannheimia haemolytica (Bovi-shield one shot; zoetis animal health).

Steers were weaned in September 2020. At weaning, cattle were re-vaccinated against blackleg-causing clostridial species chauvoei, septicum, novyi, sordellii and perfringens types C and D (Ultrabac 7; zoetis animal health), viral papillomas warts (Wart Vaccine; Colorado Serum Company), bovine respiratory disease (Bovi-shield one shot; zoetis animal health) and vaccinated for Mycoplasma bovis bacteria (Myco-B One Dose, American Animal Health Inc., Grand Prairie, TX). Weaning was conducted using a fence-line weaning method, which provides a less stressful transition for both cows and calves, allowing physical and audible contact between pairs without the ability for the calf to nurse (Price *et al*., 2003). Weaned calves were kept on pasture and provided a pellet comprised of 50% dried distiller's grains with solubles and 50% soybean hulls and supplemental minerals. Calves were processed again on November 12, 2020, weighed, castrated via banding, received a tetanus vaccination (BAR-VAC CD/T, Boehringer Ingelheim Animal Health Inc., Duluth GA) and were assigned electronic identification transponders (Allflex Livestock Intelligence, Dallas, TX). Calves were weighed every 45 days from November 2020 to March 2021. After March 2021, cattle were weighed every 28d.

Steers were moved into a single pen in an open-front mono-slope building which contained 12 Insentec automated feeding units and 2 watering units (Insentec RIC, Hokofarm, Marknesse, Netherlands). Each pen included outdoor space (1647 m^2) and a covered area (106 m^2) where the Insentec feeding and watering systems were located. Steers were allowed a 14-day adaptation period to the feeding bunks on this trial. For 7d they had access to all bunks; then they were assigned to specific bunks based on treatments.

Steers were implanted with 100 mg trenbolone acetate (TBA) and 14 mg estradiol benzoate (EB) on March 26, 2021 (Synovex Choice; Zoetis Animal Health). Calves were affixed with a transponder to continuously monitor rumination and activity data (Sense Hub Beef, Allflex Livestock Intelligence, Madison, WI). We used rumination and activity data collected 7d prior to re-implanting to establish a baseline for each individual steer. All treatments received a uniform diet until the time of reimplant. Calves received their terminal implant containing 200 mg of TBA and 28 mg of EB (Synovex Plus; Zoetis Animal Health) on June 21, 2021, 87d after the initial implant, in accordance with Synovex Choice re-implant interval label instructions (DailyMed, 2024). The observation period began on the day of re-implantation and is considered d1 of this experiment.

Experimental Design

Three treatments were applied in a completely randomized design with animals as the experimental unit. Steers were randomly assigned to one of three treatments (n = 9 steers per treatment): (1) reimplanted on d 1 and then immediately returned to their home pen (CON); (2) reimplanted on d1, walked 1.05 km and held in holding pen without access to food or water for 4 h to simulate common handling procedures in large commercial feedlots (ACT); or (3) reimplanted on d1, walked 1.05 km and held in holding pen without access to food or water for 4 h followed by diet adjustment to increase forage by 19% for 7d after re-implantation (ACT + DIET). Processing began at 0800 h before feeding and cattle from ACT and ACT + DIET were returned to their home pen at 1200 h. Calves assigned to treatments ACT and ACT + DIET traveled from their home pen to and from the processing facility on concrete and a dirt road for a total travel distance of 1.05 km. The CON group traveled from their home pen to the processing area and returned immediately for a total distance of 0.43 km. On the day of processing, calves in the ACT + DIET treatment received an altered diet that increased forage and decreased net energy for gain (NE_g; Table 1). This diet was provided to the ACT + DIET cattle when they returned to their home pen and continued for 7d at which time the cattle were fed their original finishing diet. Steers in CON and ACT remained on their original diet for the duration of the study.

Table 1: Diet composition

	Diet[b]	
Item	Finishing	DIET
Dry rolled corn (%)	61.50	33.85
Dried distillers grain (%)	20.00	20.00
Oat hay (%)		10.00
Corn silage (%)	12.00	29.65
Liquid supplement[c] (%)	6.50	6.50
Dry matter (%)	82.22	72.22
Crude protein (%)	14.52	14.42
Neutral detergent fiber (%)	7.85	17.37
NEm[d] (mcal/kg)	2.11	1.91
NEg[e] (mcal/kg)	1.43	1.38

[a]Treatment: CON; steers implanted and returned to home pen; ACT, steers were implanted, walked 1.05 km; ACT + DIET, steers were implanted, walked 1.05 km, and fed a diet with increased forage inclusion for 7 d after re-implantation
[b]Finishing diet was fed to CON and ACT from d1 – d70; DIET was fed to ACT + DIET treatment steers from d1 – d7 at which time they were fed the finishing diet until trial completion on d70
[c]Liquid supplement formulated to add monensin sodium at 30 g/ton of dry matter and to provide vitamins and minerals to meet N.A.S.E.M. (2016) requirements
[d]Net energy for maintenance
[e]Net energy for gain

All steers on treatments ACT and ACT + DIET were determined to be structurally sound before and after the walking event. One steer in CON was eliminated from the experiment in July because of chronic acidosis. Data from that animal (DMI and final body weight) were not included in the cumulative growth performance analysis. However, the animal did not exhibit signs of acidosis during the 14 days after re-implanting, thus data from d1-14 were included for that period analysis. All ears were palpated 28d after implanting to ensure that implants were intact, and infection had not developed. All implants were intact with no signs of infection.

Dietary Management

Feed bunks were managed to provide ad libitum feed to animals. Bunks were evaluated at 0800 h each day and adjustments to feed deliveries were made based on how much feed remained in each feeder. Feed deliveries were targeted to have 3 kg or less of feed refusals for each of the treatment diets. Weekly ingredient samples were taken to assess the dry matter and nutrient content of the diet. Feed samples were weighed and then dried in a 60°C oven (method no. 935.29; AOAC, 2012). Once the dry weight of feed was recorded, diet DM was calculated by dividing dry weight by the original weight. The difference between the two weights was the measurement of diet water that does not contribute to overall feed intake. Dry matter intake was calculated by determining the overall DM percentage of the diet, then determining individual total intake for each 24-d period and multiplying dry matter % by total feed intake.

Data Collection

Daily individual DMI, water intake, rumination, and activity data were collected. Individual feed and water intake were collected using the Insentec RIC feeding system as described by Ahlberg *et al*. (2018). Only 9 of the available 12 Insentec RIC feed bunks were used for this experiment to allow for a uniform average stocking density per feeder. Three bunks were assigned to each treatment and three steers were assigned to each bunk (n = 9 animals per treatment group). For this experiment, water intake and drinking duration were collected; however, no treatment was assigned within the Insentec watering system.

Feed and water intakes were evaluated for outliers or errors (steers accessing bunks from an incorrect treatment group) and these data were excluded. Water intake and as-fed feed intake were calculated for each day of the feeding period. Total water intake was calculated by combining the water proportion of as-fed intake (determined when DMI was calculated) with liquid water intake in L. Rumination and activity were calculated based on time (min) within a 24-h period using Sense Hub Beef monitoring tags (Allflex livestock intelligence, Madison, WI). There was a tag system outage during the final two days of the study, consequently, rumination and activity data were only recorded for 68d.

Cattle were processed through a hanging silencer chute (Moly Manufacturing, LLC, Lorraine KS). The chute is also equipped with a Tru-Test XR5000 scale (readability: 0.91 kg; Tru-Test Inc., Mineral Wells, TX).

Statistical Analysis

Carcass data for two steers (one from ACT, one from ACT + DIET) were unavailable because of lost ID at the abattoir. This study was analyzed as a completely randomized design using treatment as a fixed effect with individual animals as the experimental unit. A Kenward-Roger estimation of the Degrees of Freedom (DF) structure was used to estimate fixed effects because of the small sample size. The autoregressive covariate structure for the repeated effect of the day was determined to be the best fit for the model based on the smallest AIC value. The model, DF, and covariate structures were the same for all parameters. The dependent variables DMI (d1-14 and d1-70), water intake, rumination, and activity were analyzed using repeated measures in PROC MIXED in SAS 9.4 (SAS Inst. Cary, NC). The model included the fixed effect of treatment and the random effects of day and treatment × day interaction. Carcass-adjusted final body weight (BW), carcass traits, and growth performance were analyzed using PROC GLIMMIX in SAS 9.4 (SAS Inst. Cary, NC) because these dependent variables were not normally distributed. Dry matter intake for the cumulative feeding period was determined and analyzed using summed totals based on feed batching and delivery records and dry matter content determination. Initial shrunk BW was used as a covariate for analyzing growth performance with the same fixed and random effects as described previously. The baseline data for rumination and activity collected from the Sense Hub Beef tags 7d prior to re-implanting for all 27 steers was used as a covariate in analyzing rumination and activity. Significance was determined using an α less than 0.05 with an α greater than 0.05 but less than 0.10 considered a tendency. If significant treatment effects were detected, means were separated using the PDIFF statement in SAS.

Results

Two time periods were investigated: d1-14-70 after re-implantation. Days 1-14 after re-implantation were investigated to determine the short-term effects of re-implantation on DMI, water intake (diet water and liquid water), rumination, and activity. Days 1-70 were investigated to determine the longer-term effects of re-implantation on DMI, water intake (diet water and liquid water), rumination, activity, growth performance, and carcass traits.

Dry Matter Intake

During d1-14, there was a treatment × days on feed interaction ($p = 0.03$; Fig. 1). Steers on CON consumed more DM on d5 ($p \leq 0.05$) and tended to consume more on d4 ($p = 0.06$) compared to both ACT and ACT + DIET. Dry matter intake was also greater than ACT + DIET on d6 ($p = 0.03$). On d910, ACT + DIET consumed less feed than CON or ACT ($p \leq 0.05$). There was a tendency for reduced DMI for ACT + DIET from d1-14 when analyzed for that period ($p = 0.10$, Table 2). However, DMI differences observed from d1-14 proved to be transitory, as post-reimplanting management did not affect DMI for the cumulative 70-d feeding period ($p = 0.71$; Table 3).

Rumination and *Activity*

There was a treatment × day interaction for rumination time from d1–14 ($p = 0.02$; Fig. 2). Steers on ACT and ACT + DIET spent more time ruminating than CON on d5 and ACT steers ruminated longer on d14 than either CON or ACT + DIET. From d1-70, the treatment also affected the average minutes per day spent ruminating ($p \leq 0.001$; Fig. 3). Steers on ACT and ACT + DIET spent more time ruminating compared to CON (215, 258, and 257 min for CON, ACT and ACT + DIET, respectively).

The activity was calculated by collecting the total minutes of the day spent eating, standing, walking, and drinking (Lee and Seo, 2021). Steers from ACT tended to be less active than CON or ACT + DIET during the 14-d period post-re-implantation ($p = 0.06$; Fig. 4). When measured from d1-70, treatment-affected activity time ($p = 0.001$; Fig. 5) with recorded mins of 357, 361 and 365 min/d for CON, ACT and ACT + DIET, respectively.

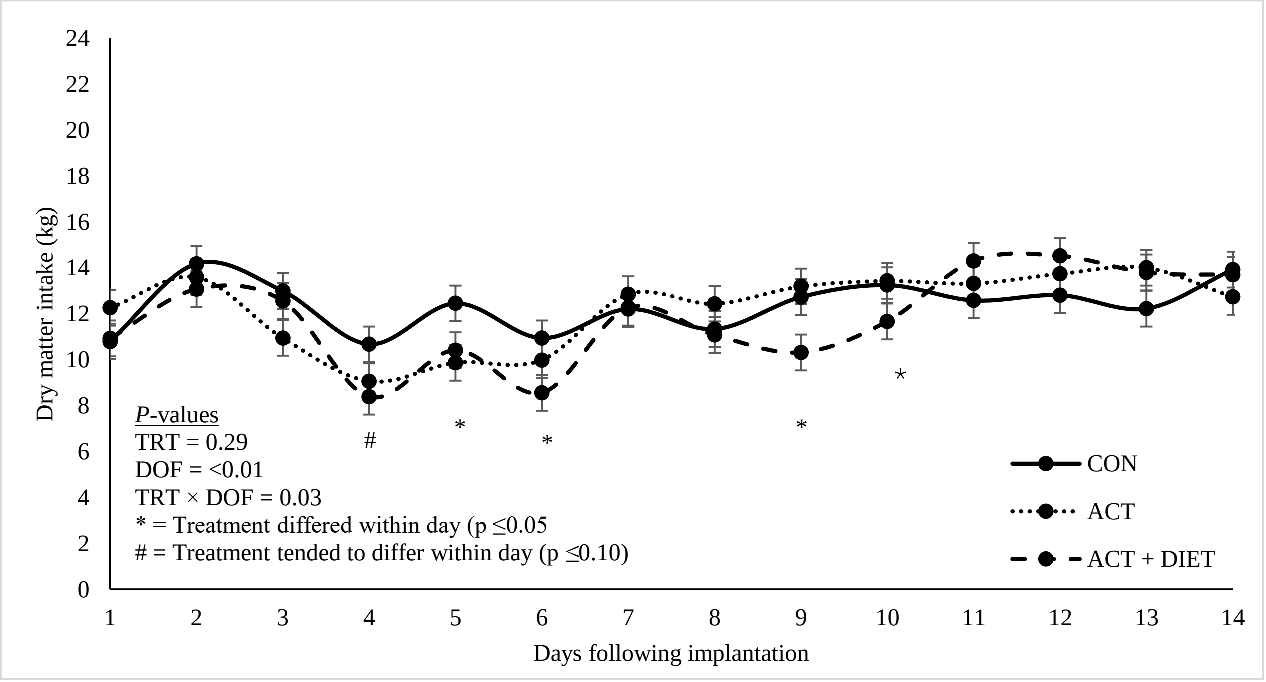

Fig. 1: Effects of locomotion and diet change on DMI in finishing beef steers after terminal implant administration. Treatments: CON = steers were implanted and returned to pen; ACT = steers were implanted and walked 1.05 km; ACT + DIET = steers were implanted, walked 1.05 km, and received increased forage inclusion for 7d after re-implantation

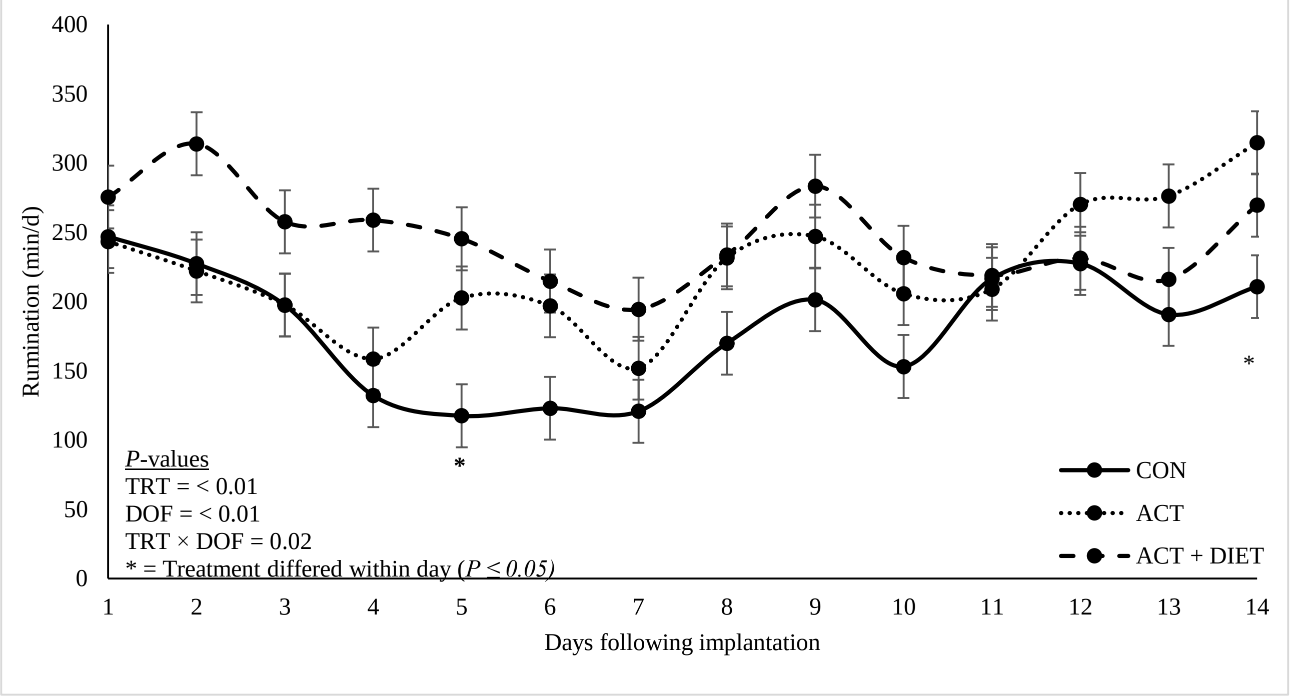

Fig. 2: Effects of locomotion and diet change on rumination (min) in finishing beef steers after terminal implant administration. Treatments: CON = cattle were implanted and returned to the pen, ACT = cattle were implanted and walked 1.05 km, ACT + DIET = cattle were implanted, walked 1.05 km, and received increased forage inclusion for 7 days after re-implantation

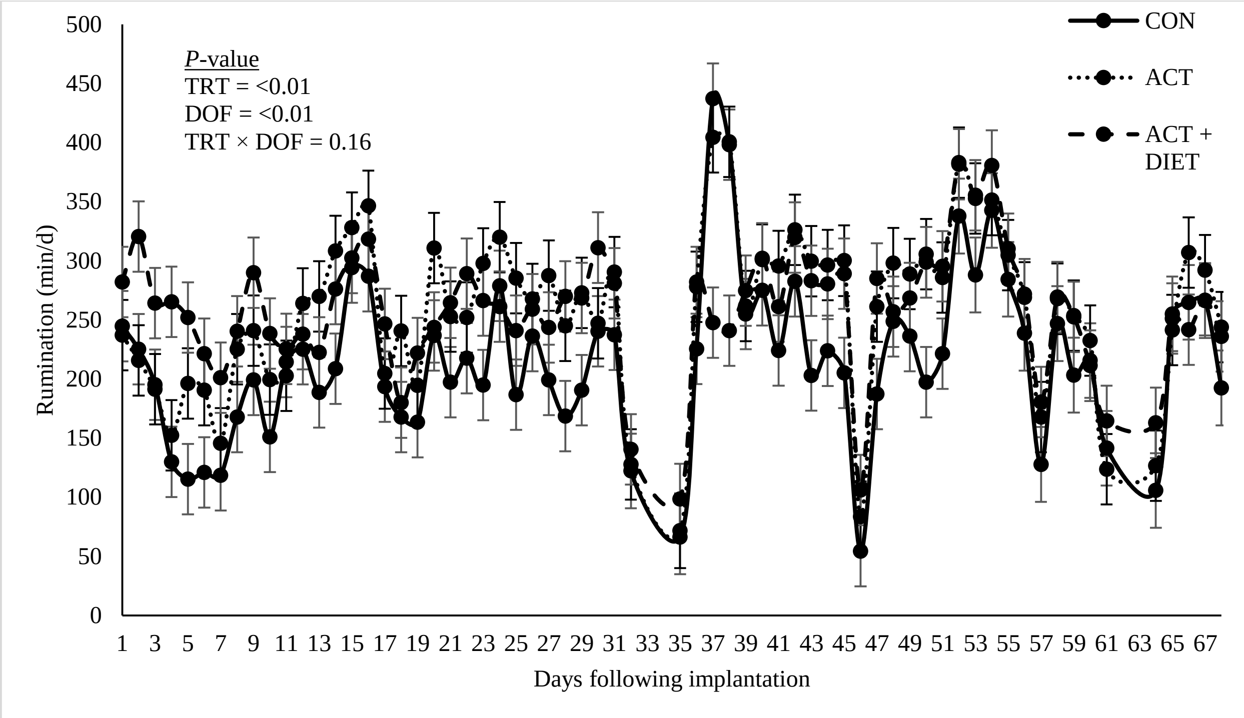

Fig. 3: Effects of locomotion and diet change on average rumination time in finishing beef steers after terminal implant administration. Treatments: CON = cattle were implanted and returned to the pen, ACT = cattle were implanted and walked 1.05 km, ACT + DIET = cattle were implanted, walked 1.05 km, and received increased roughage inclusion for 7 days after re-implantation

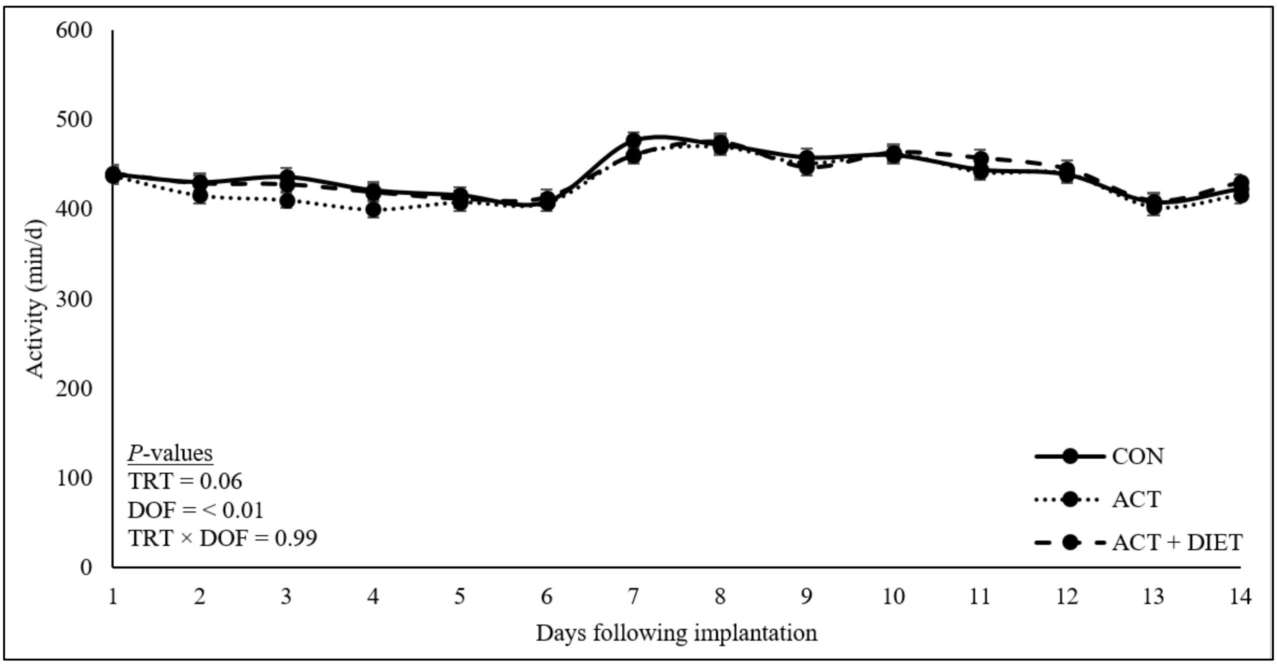

Fig. 4: Effects of locomotion and diet change on average activity (min) in finishing beef steers after terminal implant administration. Treatments: CON = cattle were implanted and returned to the pen, ACT = cattle were implanted and walked 1.05 km, ACT + DIET = cattle were implanted, walked 1.05 km, and received increased forage inclusion for 7 days after re-implantation

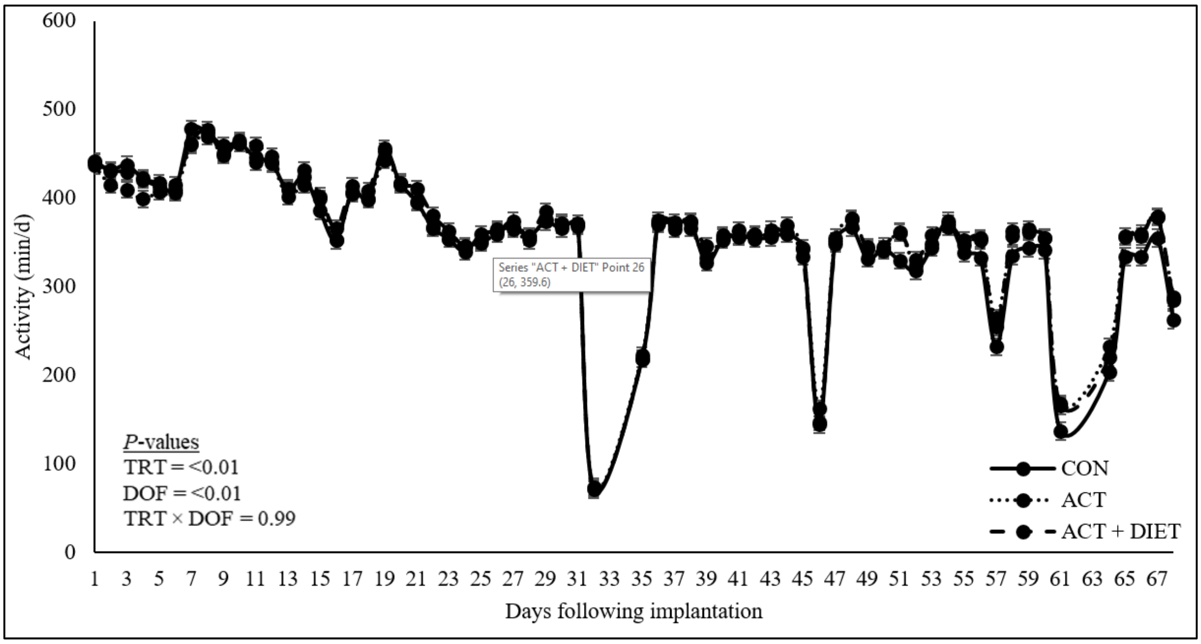

Fig. 5: Effects of locomotion and diet change on average activity (min) in finishing beef steers after terminal implant administration. Treatments: CON = cattle were implanted and returned to the pen, ACT = cattle were implanted and walked 1.05 km, ACT + DIET = cattle were implanted, walked 1.05 km, and received increased forage inclusion for 7 days after re-implantation

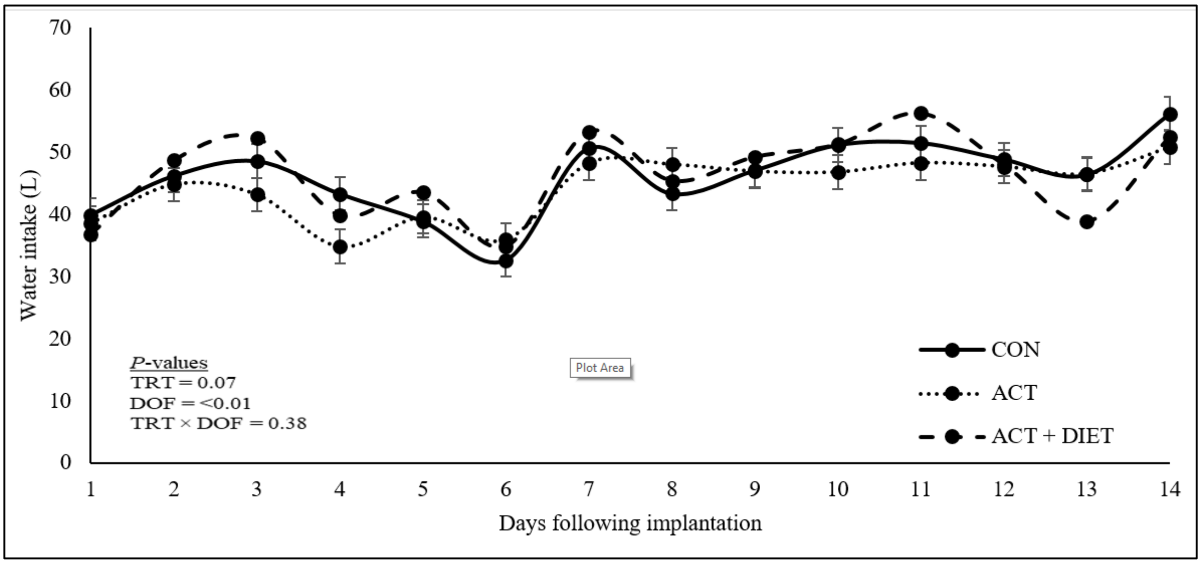

Fig. 6: Effects of locomotion and diet change on total water intake (diet water plus liquid water intake) in finishing beef steers after terminal implant administration. Treatments: CON = cattle were implanted and returned to the pen, ACT = cattle were implanted and walked 1.05 km, ACT + DIET = cattle were implanted, walked 1.05 km, and received increased forage inclusion for 7 days after re-implantation

Water Intake

Water intake was calculated by adding the water content of the diet, determined from DM content and feed intake data, with daily water intake measurements. From d1–14, treatment tended ($p = 0.07$; Fig. (6) to influence water intake and did affect water intake when measured for 70 d post-re-implantation ($p = 0.001$; Fig. (7). Steers in the ACT treatment consumed less total water from d1–70 (42.7 L/d) compared to either CON (44.3 L/d) or ACT + DIET (44.7 L/d).

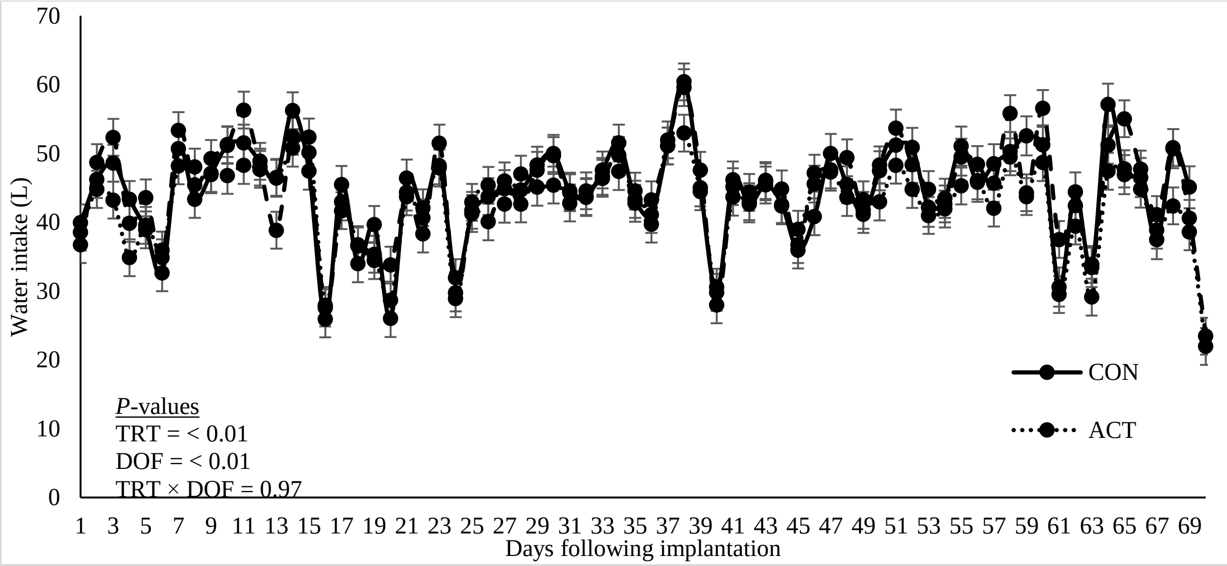

Fig. 7: Effects of locomotion and diet change on total water intake (diet water plus liquid water intake) in finishing beef steers after terminal implant administration. Treatments: CON = cattle were implanted and returned to the pen, ACT = cattle were implanted and walked 1.05 km, ACT + DIET = cattle were implanted, walked 1.05 km, and received increased forage inclusion for 7 days after re-implantation

Table 2: Effect of reimplanting management on d1-14 growth performance, dry matter intake, and feed efficiency in finishing beef steers

	Treatment				
Item	CON	ACT	ACT + DIET	SEM[b]	*P*-value
Steers, n	9	9	9	--	--
Initial shrunk body weight (kg)[c]	554	569	550	11.5500	0.46
d 14 shrunk body weight (kg)[c]	576	573	577	4.2600	0.75
Average daily gain (kg)	1.280	1.060	1.390	0.3040	0.75
Dry matter intake (kg)	12.490	12.660	11.290	0.4690	0.10
G: F[d]	0.101	0.081	0.122	0.0240	0.51

[a]Treatments: CON, steers implanted and returned to home pen; ACT, steers were implanted, walked 1.05 km; ACT + DIET, steers were implanted, walked 1.05 km, and fed a diet with increased forage inclusion for 7 d after re-implantation
[b]Pooled standard error of the mean
[c]Weights shrunk by 4% to account for gastrointestinal tract fill
[d]Calculated as average daily gain divided by dry matter intake

Table 3: Effect of post-implanting event management on growth performance, dry matter intake, and feed efficiency in finishing beef steers from 1-70 d post-re-implantation

	Treatment[a]				
Item	CON	ACT	ACT + DIET	SEM[b]	*P*-value
Steers, n	9	9	9	--	--
Initial shrunk body weight (kg)[c]	554	569	550	11.5500	0.46
Final shrunk body weight (kg)[c]	680	675	672	7.5300	0.72
Average daily gain (kg)	1.730	1.660	1.610	0.1080	0.72
Dry matter intake (kg)	14.270	14.510	13.960	0.4610	0.71
G: F[d]	0.123	0.113	0.116	0.0076	0.67

[a]Treatments: CON, steers implanted and returned to home pen; ACT, steers were implanted, walked 1.05 km; ACT + DIET, steers were implanted, walked 1.05 km, and fed a diet with increased forage inclusion for 7 d after re-implantation
[b]Pooled standard error of the mean
[c]Weights shrunk by 4% to account for gastrointestinal tract fill
[d]Calculated as average daily gain divided by dry matter intake km, ACT + DIET = cattle were implanted, walked 1.05 km, and received increased forage inclusion for 7 days after re-implantation

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Table 4: Effect of post-implanting management on carcass traits of finishing beef steers

	Treatment[a]				
Item	CON	ACT	ACT + DIET	SEM[b]	*P*-value
Steers, n	8	8	8	--	--
Hot carcass weight (kg)	428	428	422	10.130	0.89
Dressing percentage[c]	62.99	62.68	63.42	0.617	0.70
Rib fat (cm)	1.76	1.75	1.80	0.136	0.97
Rib eye area (cm^2)	101.40	96.10	97.10	3.350	0.51
Marbling score[d]	550	542	625	44.000	0.36
Calculated USDA Yield Grade	3.25	3.51	3.45	0.265	0.78
USDA Quality Grade					
Select, %	12.50	12.50	12.50	--	1.00
Choice, %	75.00	75.00	62.50		
Prime, %	12.50	12.50	25.00		
USDA Yield Grade					
YG 1, %	12.50	0.00	0.00	--	0.93
YG 2, %	12.50	12.50	25.00		
YG 3, %	62.50	75.00	50.00		
YG 4, %	12.50	12.50	25.00		

[a]Treatments: CON, steers implanted and returned to home pen; ACT, steers were implanted, walked 1.05 km; ACT + DIET, steers were implanted, walked 1.05 km, and fed a diet with increased forage inclusion for 7 d after re-implantation
[b]Pooled standard error of the mean
[c]Hot carcass weight / final shrunk (4%) body weight
[d]400 = Small^{00} (USDA Low Choice)

Growth Performance and *Carcass Traits*

Post-reimplanting management did not affect BW, ADG, or gain-to-feed ratio (G: F), either from d1-14 ($p \geq 0.51$; Table 2) or d 1-70 ($p \geq 0.67$; Table 3). Similarly, carcass measurements and distributions of USDA Quality and Yield Grades also were unaffected by treatment ($p \geq 0.36$; Table 4).

Discussion

Dry matter intake in the current experiment was greater for CON compared to both ACT and ACT + DIET for the 14-d period after re-implantation. This result agrees with previous research where cattle that intentionally walked a greater distance tended to have reduced DMI for the next 7 d compared to cattle that moved a shorter distance (Helmuth *et al*., 2022). An analysis of delivery reports from a 321-pen data set showed that 61% of pens had decreased DMI with an average depression of 0.2 kg per day when cattle were away from their home pens for an average of 102 min (Wallace *et al*., 2008). In the current experiment, DMI calculated for the entire post-re-implantation period did not differ among treatments, indicating that these steers were able to compensate for the depressed DMI observed during the 14 d after re-implanting. In contrast, Helmuth *et al*. (2022) observed that cumulative post-reimplanting DMI tended to be decreased for steers that walked a greater distance. Cattle activity has been proposed to account for approximately 9% of the variation in feed intake (Herd and Arthur, 2009). Llonch *et al*. (2018) observed that cattle taking fewer steps had greater DMI. Our results provide further evidence that additional locomotion associated with reimplanting can result in decreased DMI in the days immediately following processing events.

Contrary to our hypothesis, providing additional roughage did not mitigate decreased DMI associated with added cattle movement. Greater inclusion of roughage has been associated with increased DMI (Galyean and Defoor, 2003). A 7-d period of increased roughage inclusion may be insufficient to elicit an intake response post-re-implanted. Alternatively, the additional stress imposed by locomotion was sufficiently large to limit the ability to respond to signals that would normally induce greater DMI.

Increased rumination in ACT + DIET steers is consistent with other research reporting greater rumination time when roughage inclusion was increased (Gentry *et al*., 2016; Chibisa *et al*., 2020). Interestingly, ACT + DIET steers continued to exhibit increased rumination even though the additional roughage inclusion only lasted for 7 d. Increased time ACT steers spent ruminating during both the d1-14 period and cumulatively in the current study was unexpected and not easily explained. The tendency for reduced activity for ACT steers observed in the current study is consistent with that reported by Helmuth *et al*. (2022) and could be a response to increased activity. However, in the current study, both ACT and ACT + DIET were more active than CON over the cumulative feeding period. This response corresponds with the observed differences in rumination, but it is not clear why management interventions would result in activity differences weeks later. We expected that any differences in animal activity would have disappeared by the end of the experiment.

To our knowledge, this experiment was the first to examine the effects of locomotion at reimplanting on water intake. Reduced water intake post re-implantation that was observed for the ACT steers could be biologically important, particularly during periods of heat stress when inadequate water intake can have serious animal health implications (Arias and Mader, 2011).

The tendencies for treatment effects on DMI observed immediately following re-implantation did not result in cumulative differences in growth performance. Admittedly, the current study lacked sufficient statistical power to detect moderate differences in growth performance, feed efficiency, or carcass characteristics which likely explains the lack of difference observed. However, the 5.5% decrease in cumulative ADG observed in the current experiment closely aligns with the 7.7% ADG reduction from reimplant to end of the feeding period for steers that were walked a greater difference reported by Helmuth *et al*. (2022).

Conclusion

Taken together, these data support the recommendation to limit locomotion as much as practical following reimplanting. In the current experiment, increased activity following reimplanting reduced DMI which could result in lost performance. Providing additional roughage did not increase DMI in this experiment. Cattle managers should consider the impacts of locomotion following cattle handling events as part of the management decision-making process.

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Author’s Contributions

Alexandria Kelly: Conducted the experiment, collaborated with statistical analysis, and wrote the initial manuscript draft.

Warren Rusche: Collaborated with statistical analysis and data interpretation, final manuscript revision, and preparation.

Forest Francis: Data analysis and visualization, collaborated with data interpretation, reviewed manuscript.

Michael Gonda and Cody Wright: Experimental design and supervision, collaborated with data interpretation, reviewed the manuscript.

Zachary Smith: Experimental design, collaborated with data interpretation, reviewed the manuscript.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

References

Ahlberg, C. M., Allwardt, K., Broocks, A., Bruno, K., McPhillips, L., Taylor, A., Krehbiel, C. R., Calvo-Lorenzo, M. S., Richards, C. J., Place, S. E., DeSilva, U., VanOverbeke, D. L., Mateescu, R. G., Kuehn, L. A., Weaber, R. L., Bormann, J. M., & Rolf, M. M. (2018). Environmental Effects on Water Intake and Water Intake Prediction in Growing Beef Cattle1,2. *Journal of Animal Science*, *96*(10), 4368–4384. https://doi.org/10.1093/jas/sky267

AOAC. (2012). *Official Method of Analysis: Association of Analytical Chemists* (19th ed., Vol. 19, pp. 121–130). ISBN-10: 0-935584-83-8.

Arias, R. A., & Mader, T. L. (2011). Environmental Factors Affecting Daily Water Intake on Cattle Finished in Feedlots. *Journal of Animal Science*, *89*(1), 245–251. https://doi.org/10.2527/jas.2010-3014

Beauchemin, K. A. B. (1991). Ingestion and Mastication of Feed by Dairy Cattle. *Veterinary Clinics of North America: Food Animal Practice*, *7*(2), 439–463. https://doi.org/10.1016/s0749-0720(15)30794-5

Chibisa, G. E., Beauchemin, K. A., Koenig, K. M., & Penner, G. B. (2020). Optimum Roughage Proportion in Barley-Based Feedlot Cattle Diets: Total Tract Nutrient Digestibility, Rumination, Ruminal Acidosis, Short-Chain Fatty Absorption and Gastrointestinal Tract Barrier Function. *Journal of Animal Science*, *98*(6), skaa160. https://doi.org/10.1093/jas/skaa160

DailyMed. (2024). *Synovex Choice*. https://dailymed.nlm.nih.gov/dailymed/fda/fdaDrugXsl.cfm?setid=721167af-d5a2-4a5e-afca 6b17465256ed&type=display

Galyean, M. L., & Defoor, P. J. (2003). Effects of Roughage Source and Level on Intake by Feedlot Cattle. *Journal of Animal Science*, *81*(14_suppl_2), E8–E16. https://doi.org/10.2527/2003.8114_suppl_2E8x

Gentry, W. W., Weiss, C. P., Meredith, C. M., McCollum, F. T., Cole, N. A., & Jennings, J. S. (2016). Effects of Roughage Inclusion and Particle Size on Performance and Rumination Behavior of Finishing Beef Steers1. *Journal of Animal Science*, *94*(11), 4759–4770. https://doi.org/10.2527/jas.2016-0734

Helmuth, C. L., Woerner, D. R., Ballou, M. A., Manahan, J. L., Coppin, C. M., Long, N. S., Hoffman, A. A., Young, J. D., Smock, T. M., & Hales, K. E. (2022). Effects of Physical Activity and Feed and Water Restriction at Reimplanting Time on Feed Intake Patterns, Growth Performance and Carcass Characteristics of Finishing Beef Steers. *Translational Animal Science*, *6*(1), txac008. https://doi.org/10.1093/tas/txac008

Herd, R. M., & Arthur, P. F. (2009). Physiological Basis for Residual Feed Intake. *Journal of Animal Science*, *87*(suppl_14), E64–E71. https://doi.org/10.2527/jas.2008-1345

Johnson, B. J., Anderson, P. T., Meiske, J. C., & Dayton, W. R. (1996). Effect of a Combined Trenbolone Acetate and Estradiol Implant on Feedlot Performance, Carcass Characteristics and Carcass Composition of Feedlot Steers. *Journal of Animal Science*, *74*(2), 363–371. https://doi.org/10.2527/1996.742363x

Lee, M., & Seo, S. (2021). Wearable Wireless Biosensor Technology for Monitoring Cattle: A Review. *Animals*, *11*(10), 2779. https://doi.org/10.3390/ani11102779

Llonch, P., Somarriba, M., Duthie, C. A., Troy, S., Roehe, R., Rooke, J., Haskell, M. J., & Turner, S. P. (2018). Temperament and Dominance Relate to Feeding Behaviour and Activity in Beef Cattle: Implications for Performance and Methane Emissions. *Animal*, *12*(12), 2639–2648. https://doi.org/10.1017/s1751731118000617

Merck Animal Health. (2020). *The Effect of Revalor®-XH Compared to Revalor®-IH/200 in Finishing Heifers: A Pooled Analysis of Six Large-Pen Feedlot Studies*. Tech Bulletin. https://www.merck-animal-health-usa.com/wp-content/uploads/sites/54/2020/12/Revalor-XH-Techincal-Bulletin.pdf

N.A.S.E.M. (2016). *Nutrient Requirements of Beef Cattle: Eighth Revised Edition*. The National Academies Press. ISBN-10: 978-0-309-27335-0. https://doi.org/10.17226/19014

Owens, F. N., Secrist, D. S., Hill, W. J., & Gill, D. R. (1998). Acidosis in Cattle: A Review. *Journal of Animal Science*, *76*(1), 275–286. https://doi.org/10.2527/1998.761275x

Price, E. O., Harris, J. E., Borgwardt, R. E., Sween, M. L., & Connor, J. M. (2003). Fenceline contact of beef calves with their dams at weaning reduces the negative effects of separation on behavior and growth rate1. *Journal of Animal Science*, *81*(1), 116–121. https://doi.org/10.2527/2003.811116x

Smith, Z. K., & Rusche, W. C. (2022). 92 Management, Technology and Growth Composition: Have They Affected Carcass End Goals. *Journal of Animal Science*, *100*(Suppl.3), 40. https://doi.org/10.1093/jas/skac247.078

Stanton, T. (1997). *Cost of Reworking Cattle. Proceedings of Impact of Implants on Performance and Carcass Value of Beef Cattle*. Oklahoma Agricultural Experiment Station.

Smith, Z. K., Renter, D. G., Holland, B. P., Word, A. B., Crawford, G. I., Nichols, W. T., Nuttelman, B. L., Streeter, M. N., Walter, L.-A. J., Hutcheson, J. P., Dicke, B., Brandt, R. T., Szasz, J. I., Bryant, T. C., Pringle, L. F. G., Carlson, Z. E., Erickson, G. E., & Johnson, B. J. (2020). A Pooled Analysis of Six Large-Pen Feedlot Studies: Effects of a Noncoated Initial and Terminal Implant Compared with a Single Initial and Delayed-Release Implant on Arrival in Feedlot Heifers. *Translational Animal Science*, *4*(3), txaa109. https://doi.org/10.1093/tas/txaa109

U.S. GPO. (2013). *The Use of Growth-Promoting Implants in U.S. Feedlots* (Animal and Plant Health Inspection Service). United States Department of Agriculture.

Wallace, J. O., Reinhardt, C. D., Nichols, W. T., Hutcheson, J. P., Johnson, B. J., & Drouillard, J. S. (2008). The Costs Associated with Reimplanting. *Plains Nutrition Council Spring Conference*.