2016

Effect of increasing initial implant dosage on feedlot performance and carcass characteristics of long-fed steer and heifer calves1,2

F. H. Hilscher
University of Nebraska-Lincoln, henry.hilscher@unl.edu

M. N. Streeter
Merck Animal Health

K. J. Vander Pol
Merck Animal Health

B. D. Dicke
Cattlemen's Nutrition Services LLC

R. J. Cooper
Cattlemen's Nutrition Services LLC

See next page for additional authors

Authors
F. H. Hilscher, M. N. Streeter, K. J. Vander Pol, B. D. Dicke, R. J. Cooper, D. J. Jordon, T. L. Scott, A. R. Vogstad, R. E. Peterson, B. E. Depenbusch, and G. E. Erickson

The Professional Animal Scientist 32 (2016):53–62; http://dx.doi.org/10.15232/pas.2015-01389

Effect of increasing initial implant dosage on feedlot performance and carcass characteristics of long-fed steer and heifer calves[1,2]

F. H. Hilscher Jr.,* M. N. Streeter,† K. J. Vander Pol,†[3] B. D. Dicke,‡ PAS, R. J. Cooper,‡ D. J. Jordon,‡ PAS, T. L. Scott,‡ A. R. Vogstad,§ R. E. Peterson,§ B. E. Depenbusch,# and G. E. Erickson,*[4] PAS

*Department of Animal Science, University of Nebraska, Lincoln 68583; †Merck Animal Health, De Soto, KS 66018; ‡Cattlemen's Nutrition Services LLC, Lincoln, NE 68506; §Bos Terra LP., Hobson, MT 59452; and #Innovative Livestock Services Inc., Great Bend, KS 67530

ABSTRACT

Three experiments evaluated initial implant strategies for finishing cattle. In Exp. 1, heifers (n = 1,405; initial BW = 282 kg) were given (1) Revalor-IH followed by Revalor-200 (REV-IH/200), (2) Revalor-H followed by Revalor-200 (REV-H/200), or (3) Revalor-200 followed by Revalor-200 (REV-200/200). Intake, ADG, and G:F were not affected ($P \geq 0.14$) by implant strategies, nor were HCW and LM area ($P \geq 0.16$). Percent USDA Choice was greater ($P < 0.01$) for Rev-IH/200 compared with Rev-H/200 and Rev-200/200. Experiment 2 used steers (n = 1,858; initial BW = 250 kg) given (1) Revalor-IS reimplanted with Revalor-200 (Rev-IS/200), (2) Revalor-XS followed by Revalor-IS (Rev-XS/IS), (3) Revalor-XS followed by Revalor-S (Rev-XS/S), or (4) Revalor-XS followed by Revalor-200 (Rev-XS/200). Implanting strategies did not affect ($P \geq 0.32$) DMI or G:F. Carcass traits were not different ($P \geq 0.18$) among treatments, except steers implanted with Rev-XS/200 had greater ($P < 0.01$) LM area. In Exp. 3, steers (n = 1,408; initial BW = 305 kg) were given (1) Rev-IS/200, (2) Rev-200/200, or (3) Rev-XS/200. Gain and G:F did not differ ($P \geq 0.36$) among the 3 implant strategies, nor did HCW or marbling score ($P \geq 0.15$). Steers given Rev-XS/200 had greater ($P < 0.01$) LM area and decreased ($P \leq 0.05$) 12th-rib fat and YG compared with Rev-200/200 and Rev-IS/200. Using Rev-200/200 and Rev-XS/200 increased ($P = 0.03$) USDA Select compared with Rev-IS/200. Using greater-initial-dose implant strategies may not affect ADG or G:F but appears to increase leanness.

Key words: carcass characteristic, finishing performance, implant strategy

INTRODUCTION

Growth-promoting implants provide considerable improvements in production efficiencies to the beef cattle industry (Folmer et al., 2009; Nichols et al., 2014). Despite these improvements, the majority of implants only last 60 to 120 d, depending on the dose, before they are no longer effective. Because many cattle require more than 120 d to reach slaughter weight, reimplanting becomes an

[1] A contribution of the University of Nebraska Agricultural Research Division, supported in part by funds provided through the Hatch Act.
[2] Funding provided by Merck Animal Health (De Soto, KS).
[3] Current address: Adams Land and Cattle Co., Broken Bow, NE 68822.
[4] Corresponding author: gerickson4@unl.edu

important management strategy to improve animal efficiency (Preston, 1999). For instance, cattle implanted with 2 consecutive combination implants containing trenbolone acetate (**TBA**) and estradiol-17β (**E2**) have demonstrated a 20.0% increase in ADG and a 13.5% improvement in BW gain efficiency compared with nonimplanted cattle (Duckett and Pratt, 2014). Implanting strategies use different combinations of implants based on cattle, age, weight, sex, production goals, and estimated days on feed to target gain efficiency, lean meat yield, and carcass quality (Mader, 1997; Reinhardt, 2007; Johnson et al., 2013). With demand for increased gain efficiency and lean meat yield, usage of greater-dose implants has increased; however, data are limited on the use of these implant combinations in long-fed calves over 170 d. Therefore, the objectives of these experiments were to compare feedlot and carcass performance of long-fed heifers and steers receiving different aggressive initial implant strategies in commercial feedlots.

MATERIALS AND METHODS

The following experiments were conducted in collaborations between Merck Animal Health (De Soto, KS), Cattlemen's Nutrition Service LLC (Lincoln, NE), Bos Terra LP. (Hobson, MT), Innovative Livestock Services Inc. (Great Bend, KS), and the University of Nebraska–Lincoln. Research was conducted at commercial facilities and followed the guidelines stated in the *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching* (FASS, 2010).

Exp. 1

Animals and Treatments. British and British × Continental heifer calves (n = 1,405; 282 ± 3 kg of initial BW) were fed at a commercial feedyard in central Nebraska from May 2011 to November 2011 (days on feed across blocks averaged 173 d). Heifers were sourced from several sale barns located in Oklahoma. Treatments were (1) Revalor-IH (80 mg of TBA + 8 mg of E2; Merck Animal Health, Madison, NJ) at initial processing followed 89 d later by Revalor-200 (200 mg of TBA + 20 mg of E2; Merck Animal Health; **REV-IH/200**); (2) Revalor-H (140 mg of TBA + 14 mg of E2; Merck Animal Health) at initial processing followed 89 d later by Revalor-200 (**REV-H/200**); or (3) Revalor-200 at initial processing followed 89 d later by Revalor-200 (**REV-200/200**).

Heifers were allotted randomly to pen by arrival block (n = 6) by sorting every 2 heifers into 1 of 3 pens before initial processing. Implant treatments were assigned randomly to pen (n = 1) within a block, for a total of 18 pens. After heifers were randomized into their respective pens, each pen was group weighed on a platform scale before processing to establish pen initial BW. Only products approved by the USDA and United States Food and Drug Administration were administered according to label directions during this study. At processing, heifers received a combination vaccine (Bovi-Shield Gold, Zoetis Inc., Florham Park, NJ) against infectious bovine rhinotracheitis (**IBR**) virus, bovine virus diarrhea (**BVD**) virus types 1 and 2, parainfluenza 3 (**PI_3**) virus, and bovine respiratory syncytial virus (**BRSV**). Additionally, heifers received an oral dose of 10% fenbendazole solution (Safe-Guard, Merck Animal Health) for treatment of internal parasites, an injection of 1% moxidectin (Cydectin, Boehringer Ingelheim/Vetmedica St. Joseph, MO) for treatment of external parasites, and an implant based on the specified treatment assigned. At reimplant (d 90), all pens within a block were brought to the processing facility, reimplanted with Revalor-200, and pen weighed.

Cattle were housed in 18 open lots with earthen mounds. Each animal had ad libitum access to clean water and their respective diet. Cattle were started on feed with a 56% concentrate, 44% roughage diet. Over a 26-d period, 2 intermediate diets were used to transition cattle to a finishing diet. The finishing diet consisted of 49.1% dry-rolled corn, 40% wet distillers grains plus solubles, 6.5% mixed hay, and 4.4% supplement (DM basis). The supplement was formulated to provide 300 mg per heifer daily of monensin (Rumensin; Elanco Animal Health, Indianapolis, IN), 90 mg per heifer daily of tylosin phosphate (Tylan; Elanco Animal Health), and 0.45 mg per heifer daily of melengestrol acetate (Heifermax; Elanco Animal Health). All heifers were fed zilpaterol hydrochloride at 8.33 mg/kg of DM (Zilmax; Merck Animal Health) for 20 d followed by a 3-d withdrawal before slaughter. Heifers were fed twice daily at approximately 0700 and 1300 h in concrete, fence-line feedbunks, with feedbunks visually evaluated each morning. Feedbunks were managed to allow trace amounts of feed to remain in the bunk before feed delivery. Diet samples were obtained monthly from feedbunks and composited for nutrient analysis (Servi-Tech Laboratories, Hastings, NE). Diets provided protein and minerals to meet or exceed NRC (1996) requirements and contained greater than 1.45 Mcal/kg of NE_g.

Carcass Evaluation. Slaughter date was determined based on reimplant weight. Prior to shipping for slaughter, heifers from each pen were group weighed on platform scales and shrunk 4% to calculate DP and final live BW. After weighing, heifers were immediately loaded onto trucks and transported 201 km to a commercial abattoir (JBS, Grand Island, NE). Carcass-adjusted final BW was calculated as average HCW divided by the average DP of 65.85% across all animals. Carcass data were collected by personnel from West Texas A&M University (Canyon, TX). Individual HCW were collected at slaughter, and following a 24-h chill, 12th-rib fat thickness, LM area, DP, KPH, marbling scores, percent USDA QG, and percent USDA YG were collected for each pen. Yield grade was calculated using the equation of YG, where YG

= 2.50 + (6.35 × 12th-rib fat depth, cm) − (2.06 × LM area, cm^2) + (0.2 × KPH, %) + (0.0017 × HCW, kg) (Boggs and Merkel, 1993).

Exp. 2

Animals and Treatments. Crossbred steer calves (n = 1,858; initial BW 250 ± 19 kg) sourced from auction markets or ranches between October 11 and November 11, 2011, were fed at a commercial feedyard in central Montana (days on feed ranged from 196 to 238; average = 215). Treatments were (1) Revalor-IS (80 mg of TBA and 16 mg of E2; Merck Animal Health) implant at initial processing followed by Revalor-200 implant on d 120 (**Rev-IS/200**), (2) Revalor-XS (200 mg of TBA and 40 mg of E2; Merck Animal Health) implant at initial processing followed by Revalor-IS implant on d 140 (**Rev-XS/IS**), (3) Revalor-XS implant at initial processing followed by Revalor-S (120 mg of TBA and 24 mg of E2; Merck Animal Health) implant on d 140 (**Rev-XS/S**), or (4) Revalor-XS implant at initial processing followed by Revalor-200 implant on d 140 (**Rev-XS/200**).

Upon arrival steers were blocked by BW into heavy (>272 kg) or light (<272 kg) blocks. Once a replication was full (approximately 200 steers), cattle were assigned randomly at processing to treatment and pen (n = 32 total pens; 49 to 86 steers per pen). Altogether there were 8 pens per treatment, with 5 replications of treatment in the heavy block and 3 replications of treatment in the light block. At processing, steers were individually weighed and received an individual electronic and visual feedlot identification tag; prophylactic administration based on label recommendations of tulathromycin (Draxxin; Zoetis); a vaccine consisting of IBR virus, BVD virus (types I and II), PI_3 virus, BRSV, *Mannheimia haemolytica* and *Pasteurella multocida* (Vista Once; Merck Animal Health); a vaccine consisting of *Clostridium chauvoei*, *Clostridium septicum*, *Clostridium novyi*, *Clostridium sordellii*, *Clostridium perfringens* types C&D (enterotoxemia), and *Haemophilus somnus* (Vision 7 Somnus; Merck Animal Health). Additionally, they received an oral dose of 10% fenbendazole solution (Safe-Guard; Merck Animal Health) for control of internal parasites; an injection of ivermectin (Ivomec; Merial, Duluth, GA) for control of internal and external parasites; and an implant based on the specified treatment assignment. At time of reimplant, steers were given a terminal implant based on treatment protocol and also received a booster vaccine consisting of IBR, BVD (types I and II), PI_3, and BRSV (Vista 5; Merck Animal Health) and an injection of ivermectin. All USDA and United States Food and Drug Administration approved products were used according to label directions. Within replication, steers in Rev-IS/200 pens were reimplanted at 120 d on feed, and Rev-XS/IS, Rev-XS/S, and RevXS/200 pens were reimplanted at 140 d on feed. Differences in reimplant date differed because the recommended length of Rev-IS lasts up to 120 d, whereas Rev-XS can last up to 220 d.

Following initial processing, steers were group weighed by pen on a platform scale to establish pen initial BW to be used in performance calculations. Steers were housed in open feedlot pens and had ad libitum access to feed and water. Cattle were adapted to a common finishing diet over a 21-d period, and cattle were fed once daily at approximately 0700 h. The finishing diet contained 61.24% wheat or barley, 20% corn dry distillers grains plus solubles, 7.5% mixed wheat and barley silage, 7.5% alfalfa hay, and 3.76% supplement (DM basis). Diets were common across all pens over the feeding period, and any grain source changes were made to all treatments simultaneously. The supplement was formulated to provide monensin (Rumensin; Elanco Animal Health) at 300 mg per steer daily and tylosin phosphate (Tylan-40; Elanco Animal Health) at 90 mg per steer daily on a DM basis. Steers were fed zilpaterol hydrochloride (Zilmax; Merck Animal Health) at 8.33 mg/kg of DM for 20 d followed by a 3-d withdrawal before slaughter. Diet samples were obtained monthly from feedbunks and composited for nutrient analysis (Dairy One Labs, Ithaca, NY). Diets provided protein and minerals to meet or exceed NRC (1996) requirements and contained greater than 1.38 Mcal/kg of NEg.

Carcass Evaluation. Slaughter date was determined based on reimplant weight. Steers were weighed by pen on platform scales and shrunk 4% before shipping to determine final shrunk BW. After weighing, steers were immediately loaded on trucks and transported approximately 1,036 km to a commercial abattoir (JBS, Greeley, CO) for slaughter. Carcass-adjusted final BW was calculated as HCW divided by a fixed DP of 61.0% across all steers. Carcass measurements were reported by the abattoir based on USDA grades. Individual carcass measurements were collected using the procedures described in Exp. 1.

Exp. 3

Animals and Treatments. Experiment 3 was conducted at a commercial feedlot in central Nebraska from February 2, 2013, to October 15, 2013 (days on feed ranged from 181 to 209; average = 195 d). Cross-bred steers (n = 1,408; initial BW = 305 ± 10 kg) from ranches and auction barns in Nebraska, Nevada, and Utah were used for the trial. Treatments were (1) Revalor-IS given on d 1 followed by Revalor-200 on d 115 (**Rev-IS/200**); (2) Revalor-200 given on d 1 followed by Revalor-200 on d 115 (**Rev-200/200**); or (3) Revalor-XS given on d 1 followed by Revalor-200 on d 115 (**Rev-XS/200**).

Steers were blocked (n = 3) by arrival date and projected slaughter date based on initial weight. Prior to processing, steers were allocated into 1 of 3 sort pens by sorting every 2 steers in the alley. Sort pens were assigned randomly to 1 of 3 treatments (n = 18; 68 to 95 steers per pen; 6 pens per treatment).

During initial processing, cattle were individually weighed; vaccinated against IBR, BVD (types I and II), PI_3, and BRSV (Vista 3 SQ; Merck Animal Health); given an oral dose of 10% fenbendazole solution (Safe-Guard, Merck Animal Health) for treatment of internal parasites and an injection of 1% moxidectin (Cydectin, Boehringer Ingelheim/Vetmedica) for treatment of external parasites; and individually identified. Following initial processing, steers were group weighed by pen on a platform scale to establish pen initial BW to be used in performance calculations. At time of reimplantation, all cattle within a replication were brought to the processing facility based on a random assignment of processing order and reimplanted with Revalor-200.

Steers were adapted to a common finishing diet over a 23-d transition period consisting of 3 adaptation diets. The finishing diets were the same for each treatment but varied across time because of availability of ingredients. Weighted averages were 49.9% dry-rolled corn (range 41.1–54.6%), 19.2% ADM-Synergy (ADM, Columbus, NE; range 0–28%), and 19.6% wet distillers grains with solubles (range 12–35%). The finishing diet also contained 5% liquid supplement (range 4.1–5.2%), 3.9% mixed hay (range 3.5–4.0%), and 2.4% corn silage (range 0–3%). The supplement was formulated to provide 360 mg per steer daily of monensin (Rumensin; Elanco Animal Health) and 90 mg per steer daily of tylosin phosphate (Tylan; Elanco Animal Health). Because of timing of the trial, at the end of the feeding period, 3 replications were fed zilpaterol hydrochloride (Zilmax; Merck Animal Health) and 3 replications were fed ractopamine hydrochloride (Optaflexx; Elanco Animal Health). Zilpaterol was fed at a rate of 8.33 mg/kg of DM for 20 d followed by a 3-d withdrawal before slaughter. Ractopamine was fed at a rate of 300 mg per steer daily for the last 28 d of the feeding period. Feeding of a β-agonist was equal across treatments and within a replication as all cattle were fed either Zilmax or Optaflexx and therefore not included in the statistical model. Diet samples were obtained monthly from the feedbunks and composited for nutrient analysis (Servi-Tech Laboratories). Diets provided protein and minerals to meet or exceed NRC (1996) requirements and contained greater than 1.45 Mcal/kg of NE_g while on the finishing diet.

Carcass Evaluation. Steers were weighed by pen on platform scales and shrunk 4% before shipping to determine final shrunk BW. After weighing, cattle were immediately loaded on trucks and transported approximately 189 km to a commercial abattoir (JBS, Grand Island, NE) for slaughter. Carcass-adjusted final BW was calculated as HCW divided by the DP of 64.5% across all animals. Carcass data were collected by personnel from West Texas A&M University. Individual carcass measurements were the same as described in Exp. 1.

Deads-In and Deads-Out Calculations and Statistical Analysis

Deads-In Calculations. Calculations were made for initial weight by taking the initial pen average (no shrink) divided by the total number of cattle at the start of the trial (Exp. 1, 2, and 3). Final live BW was calculated using the total weight of pen at shipping (shrunk 4%) plus the weight of cattle sold early because of chronic sickness or injury, divided by the number of animals that started the trial (Exp. 1, 2, and 3). Deads-in ADG was calculated from the total kilograms gained (total final weight plus weight of cattle sold early minus total initial weight) divided by total number of animal days (Exp. 1, 2, and 3). Total DMI was calculated by dividing total feed delivered to the pen by the total number of animal days (Exp. 1, 2, and 3). Gain-to-feed ratio was calculated using the deads-in ADG divided by DMI (Exp. 1, 2, and 3).

Deads-Out Calculations. Deads-out initial weight was calculated the same as deads-in (Exp. 1 and 2). Deads-out initial BW was calculated by subtracting individual weight of dead steers or removals from the total initial pen weight, divided by the number of animals slaughtered (Exp. 3). Final live BW was calculated using the total weight of cattle at shipping (shrunk 4%) divided by the total number of cattle shipped excluding deads and cattle sold early (Exp. 1, 2, and 3). Deads-out ADG was determined by dividing the total weight gain (average final weight − average starting weight) by days on feed (Exp. 1, 2, and 3). Deads-out DMI was the same as deads-in, and G:F was calculated using deads-out ADG divided by DMI (Exp. 1, 2, and 3). Carcass-adjusted ADG and G:F were calculated using the same calculations as deads-out ADG and G:F (Exp. 1, 2, and 3).

Statistical Analysis. Live performance and carcass data were analyzed as a randomized complete block design using the Glimmix procedure of SAS (9.2, SAS Institute Inc., Cary, NC). Pen was the experimental unit and the model included the fixed effect of treatment, with block as a random effect (Exp. 1 and 3). The model included replication as a random effect with experimental treatment and weight block as fixed effects (Exp. 2). Treatment averages were calculated using the LSMEANS option of SAS. Treatment differences were significant at an α value equal to or less than 0.05. Frequency data were analyzed using the Glimmix procedure of SAS. The model specified a logistic link function for the binary response, with the number of animals slaughtered identified in the denominator. The means and SE of the proportions for the frequency data were determined using the ILINK option. Treatment differences were significant at an α value equal to or less than 0.05.

RESULTS AND DISCUSSION

Exp. 1—Performance

Deads-out live and carcass-adjusted BW, DMI, and ADG were not different ($P \geq 0.14$) between the 3 implant strategies (Table 1). Carcass-adjusted

Table 1. Effects of increased initial implant dose on growth performance and carcass characteristics of heifer calves fed for 173 d (Exp. 1)

	Treatment[1]				
Item	Rev-IH/200	Rev-H/200	Rev-200/200	SE	*P*-value
No. of heifers (pens)	473 (6)	466 (6)	466 (6)	—	—
Initial BW,[2] kg	282	281	283	3.1	0.74
DMI,[3] kg/d	9.70	9.57	9.69	0.05	0.14
Deads-in performance[4]					
Live performance					
Final BW, kg	529	542	532	12.3	0.35
ADG, kg	1.50	1.56	1.51	0.06	0.44
G:F	0.155	0.163	0.156	0.006	0.27
Deads-out performance[5]					
Live performance					
Final BW, kg	566	565	568	3.9	0.73
ADG, kg	1.65	1.65	1.65	0.02	0.95
G:F	0.170	0.172	0.171	0.001	0.28
Carcass-adjusted performance[6]					
Final BW, kg	568	564	568	3.9	0.16
ADG, kg	1.65	1.64	1.66	0.15	0.33
G:F	0.171	0.171	0.171	0.001	0.94
HCW, kg	374	371	374	2.6	0.16
DP, %	65.98	65.64	65.93	0.10	0.09
12th-rib fat thickness, cm	1.52	1.44	1.53	0.06	0.08
LM area, cm^2	98.87	99.98	99.88	0.94	0.29
Marbling score[7]	428[a]	401[b]	400[b]	4.9	0.01
Calculated YG	2.61	2.46	2.58	0.09	0.06
USDA QG,[8] %					
Prime	0.69	0.45	0.92	0.46	0.72
Choice	60.55[a]	49.10[b]	42.53[b]	2.38	<0.01
Select	32.11[a]	43.89[b]	43.45[b]	2.38	<0.01
≤Standard	6.65[a]	6.56[a]	13.10[b]	1.62	0.01
USDA YG,[8] %					
1	11.81[a]	17.05[b]	18.14[b]	1.86	0.05
2	38.43	36.36	42.33	2.34	0.22
3	39.12[a]	37.27[a]	27.21[b]	2.35	<0.01
4	10.19	8.18	10.93	1.51	0.39
5	0.46	1.14	1.40	0.57	0.42

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

[1]Rev-IH/200 = Revalor-IH at processing and Revalor-200 at reimplant on d 89; Rev-H/200 = Revalor-H at processing and Revalor-200 at reimplant on d 89; Rev-200/200 = Revalor-200 at processing and Revalor-200 at reimplant on d 89. Revalor-IH, Revalor-H, Revalor-200, Merck Animal Health (De Soto, KS).

[2]Initial BW: total pen weight of cattle with no shrink divided by total number of starting heifers (deads-in and deads-out).

[3]DMI: calculated from total kilograms delivered to the pen divided by total number of animal days.

[4]Deads-in performance: ADG was calculated from total kilograms gained (total final weight plus removed weight after subtracting total starting weight) divided by total number of animal days. G:F was calculated from deads-in ADG divided by pen DMI.

[5]Deads-out performance: live ADG was calculated from total kilograms gained (average final weight subtracting average starting weight) divided by average days on feed. Live G:F was calculated from deads-out ADG divided by pen DMI. Carcass-adjusted performance ADG was calculated the same as live performance using carcass-adjusted final BW.

[6]Carcass-adjusted final BW was calculated as average HCW divided by the average DP of 65.85% across all animals.

[7]Marbling score: 400 = small^{00}, 500 = modest^{00}.

[8]The numbers represent by treatment the proportion of carcasses within each QG and YG category.

G:F was not different ($P = 0.94$) and was 0.171 across all 3 implant treatments. Similarly, there were no differences ($P \geq 0.27$) in deads-in ADG and G:F. Folmer et al. (2009) reported that when comparing similar initial implant dosages, there were no differences in DMI and live and carcass-adjusted final BW. There were differences in live and carcass-adjusted G:F in heifers fed for 177 d (Folmer et al., 2009). Guiroy et al. (2002) reported no differences in ADG and G:F for heifers implanted with either Rev-IH or Rev-H as an initial implant and Rev-H as a common terminal implant and fed for 189 d.

Carcass characteristics were not different ($P \geq 0.16$) among the 3 strategies for HCW and LM area. The Rev-H/200 implant combination did have a numerically lesser ($P \geq 0.08$) DP and 12th-rib fat thickness, which could have contributed to a numerically lesser ($P = 0.06$) calculated YG compared with Rev-IH/200 and Rev-200/200. Similar to this study, Schneider et al. (2007) reported no differences in 12th-rib fat thickness, HCW, LM area, and YG between carcasses of heifers that received similar implant protocols. Heifers that received Rev-IH/200 had significantly greater ($P = 0.01$) marbling scores compared with the Rev-H/200 and Rev-200/200 treatments. Quality grade distribution reflected this difference in marbling score with the Rev-IH/200 treatment having a greater percentage ($P < 0.01$) of carcasses that graded Choice and a lesser percentage ($P < 0.01$) of carcasses that graded Select compared with the Rev-H/200 and Rev-200/200 treatments. Additionally, the Rev-IH/200 and Rev-H/200 treatments had a lesser percentage ($P = 0.01$) of carcasses that graded less than or equal to Standard compared with the Rev-200/200 treatment. Schneider et al. (2007) and Folmer et al. (2009) reported no differences in marbling score; additionally, Folmer et al. (2009) reported no difference in the total number of carcasses grading Choice but a greater percentage of carcasses graded in the upper two-thirds of Choice when a milder Rev-IH/200 implant protocol was used.

The percentage of YG 1 carcasses was greater ($P = 0.05$) for Rev-H/200 and Rev-200/200 than for Rev-IH/200. The percentage of YG 3 carcasses was greater ($P < 0.01$) for Rev-IH/200 and Rev-H/200 compared with Rev-200/200. In contrast to the current study, Folmer et al. (2009) reported no differences in the YG distribution. Consistent with our observations Hutcheson et al. (2002) reported no differences in gain during the finishing period but a decrease in marbling score as implant dosage was increased. Increasing the dosage of initial implant seems to have little effect on animal gains and feed efficiency; however, the increased dosage could have negative effects on carcass fatness as evidenced by decreased yield and QG. Hutcheson et al. (2002) reported no differences in gain during the finishing period but a decrease in marbling score as implant dosage was increased.

Exp. 2—Performance

While previous studies have used Rev-XS as a single implant strategy for steers fed for 131 to 243 d on feed (Parr et al., 2011; Nichols et al., 2014), there is little information available on using Rev-XS in combination with other implants to maximize production efficiency.

Cattle from different implanting strategies did not differ ($P \geq 0.11$) in live or carcass-adjusted final BW; however, cattle that received Revalor-XS as an initial implant numerically had heavier live and carcass-adjusted final BW (Table 2). Intake was not different ($P = 0.38$) across implant strategy. Although not statistically different ($P \geq 0.13$), steers that received Rev-XS/IS, Rev-XS/S, and Rev-XS/200 had numerically greater deads-in and deads-out live or carcass-adjusted ADG compared with Rev-IS/200. Efficiency of gain was not different ($P \geq 0.32$) among implant strategy on a live or carcass-adjusted basis. Parr et al. (2011) reported no differences in live and carcass-adjusted final BW, DMI, ADG, and G:F for cattle implanted with Rev-IS followed by Rev-S at reimplant compared with a single implant of Rev-XS at d 131, 174, and 243 on feed. Similarly, Nichols et al. (2014) reported no differences in feedlot gain and efficiency after 157 d on feed when cattle were implanted with Rev-IS followed by Rev-S at reimplant compared with a single Rev-XS. Parr et al. (2011) reported an increase in carcass-adjusted final BW and ADG when using a single Rev-XS implant for 197 d compared with a Rev-IS/S implant program and suggested that this could be due to decreased concentrations of TBA and E2 before reimplanting (d 90 to 103), which caused a decrease in overall gain. Samber et al. (1996) evaluated different implant strategies using multiple implants with similar overall concentrations of TBA and E2 as those used in the current study, noting no differences in final BW, DMI, ADG, and G:F between the treatments.

In Exp. 2, HCW, DP, 12th-rib fat thickness, and marbling scores were not different ($P \geq 0.18$) among implant treatments. Nichols et al. (2014) reported no differences in HCW, 12th-rib fat thickness, or marbling score when comparing Rev-XS with Rev-IS/S. Similarly, Parr et al. (2011) reported no differences in HCW, DP, and 12th-rib fat thickness between implant programs in cattle fed for 174 or 243 d. Contrary to the current study, Samber et al. (1996) reported that cattle implanted 3 times with Rev-S compared with 2 times with Rev-S had less 12th-rib fat thickness.

Longissimus muscle area was largest ($P < 0.01$) for Rev-XS/200 implant programs, with Rev-XS/IS and Rev-XS/S treatments being intermediate and Rev-IS/200 having the smallest LM area. Samber et al. (1996) also reported that increasing the amount of TBA and E2 used in the implant program increased LM area but had no effect on HCW or DP.

In Exp. 2, QG distributions were not different ($P \geq 0.19$) by implant treatment. No significant differences ($P \geq 0.07$) were observed between

Table 2. Effects of increased implant dose combinations on growth performance and carcass characteristics of steer calves fed for 216 d (Exp. 2)

	Treatment[1]					
Item	Rev-IS/200	Rev-XS/IS	Rev-XS/S	Rev-XS/200	SE	*P*-value
No. of steers (pens)	463 (8)	467 (8)	465 (8)	463 (8)	—	—
Initial BW,[2] kg	255	257	257	256	2.9	0.60
DMI,[3] kg/d	10.71	10.88	10.97	10.83	0.14	0.38
Deads-in performance[4]						
Live performance						
Final BW, kg	584	602	592	603	9.9	0.11
ADG, kg/d	1.56	1.63	1.59	1.63	0.04	0.13
G:F	0.146	0.150	0.145	0.151	0.004	0.32
Deads-out performance[5]						
Live performance						
Final BW, kg	615	624	621	624	8.0	0.11
ADG, kg/d	1.60	1.70	1.68	1.70	0.03	0.13
G:F	0.156	0.156	0.153	0.157	0.003	0.46
Carcass-adjusted performance[6]						
Final BW, kg	625	636	632	636	7.2	0.18
ADG, kg/d	1.72	1.76	1.73	1.76	0.03	0.14
G:F	0.160	0.161	0.158	0.163	0.002	0.36
HCW,[7] kg	381	388	386	388	4.1	0.18
DP, %	62.28	62.63	62.52	62.63	0.6	0.40
12th-rib fat thickness, cm	1.23	1.23	1.23	1.18	0.04	0.47
LM area, cm^2	88.75[c]	90.37[b]	90.16[bc]	91.96[a]	1.89	<0.01
Marbling score[8]	421	417	407	411	6.9	0.27
Calculated YG	2.90	2.88	2.87	2.75	0.09	0.06
USDA QG,[9] %						
Prime	0.96	1.38	1.18	1.62	0.61	0.86
Premium Choice	14.94	11.24	10.85	10.65	1.75	0.20
Low Choice	41.20	43.58	37.74	40.28	2.42	0.39
Select	39.52	39.22	44.81	43.75	2.42	0.25
≤Standard	2.17	3.44	3.77	3.00	0.93	0.58
Dark cutter	1.21	1.15	1.65	0.69	0.62	0.66
USDA YG,[9] %						
1	10.36	10.78	13.68	12.96	1.67	0.38
2	45.54	48.17	43.63	52.78	2.45	0.07
3	37.35	35.55	36.56	30.32	2.38	0.16
4 and 5	6.75	5.51	6.13	3.94	1.23	0.34

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

[1]Rev-IS/200 = Revalor-IS on d 0, Revalor-200 implant on d 120; Rev-XS/IS = Revalor-XS on d 0, Revalor-IS implant on d 140; Rev-XS/S = Revalor-XS on d 0, Revalor-S implant on d 140; Rev-XS/200 = Revalor-XS on d 0, Revalor-200 implant on d 140. Revalor-IS, Revalor-S, Revalor-XS, Revalor-200, Merck Animal Health (De Soto, KS).

[2]Initial BW: total pen weight of cattle with no shrink divided by total number of starting steers (deads-in and deads-out).

[3]DMI: calculated from total kilograms delivered to the pen divided by total number of animal days.

[4]Deads-in performance: ADG was calculated from total kilograms gained (total final weight plus removed weight after subtracting total starting weight) divided by total number of animal days. G:F was calculated from deads-in ADG divided by pen DMI.

[5]Deads-out performance: live ADG was calculated from total kilograms gained (average final weight subtracting average starting weight) divided by average days on feed. Live G:F was calculated from deads-out ADG divided by pen DMI. Carcass-adjusted performance ADG were calculated the same as live performance using carcass-adjusted final BW.

[6]Carcass-adjusted final BW was calculated as HCW divided by the average DP of 61.0% across all steers.

[7]One replication was slaughtered early and no data were collected, so carcass characteristics were analyzed with only 7 replications.

[8]Marbling score: 400 = small^{00}, 500 = modest^{00}.

[9]The numbers represent by treatment the proportion of carcasses within each QG and YG category.

Table 3. Effects of increased implant dose combinations on growth performance and carcass characteristics of steer calves fed for 195 d (Exp. 3)

Item	Treatment[1]			SE	*P*-value
	Rev-IS/200	Rev-200/200	Rev-XS/200		
No. of steers (pens)	473 (6)	471 (6)	464 (6)	—	—
Initial BW,[2] kg	307	305	306	4.6	0.81
DMI,[3] kg/d	11.05	11.12	10.98	0.16	0.58
Deads-in performance[4]					
Live performance					
Final BW, kg	633	633	632	7.0	0.99
ADG, kg/d	1.72	1.72	1.71	0.06	0.95
G:F	0.155	0.156	0.156	0.002	0.96
Deads-out performance[5]					
Live performance					
Final BW, kg	670	671	667	4.7	0.70
ADG, kg/d	1.86	1.88	1.85	0.02	0.51
G:F	0.168	0.170	0.169	0.002	0.49
Carcass adjusted performance[6]					
Final BW, kg	674	672	676	6.6	0.64
ADG, kg/d	1.88	1.88	1.90	0.02	0.68
G:F	0.170	0.170	0.173	0.003	0.36
HCW, kg	435	434	436	4.3	0.64
DP, %	64.88	64.67	65.31	0.4	0.11
LM area, cm^2	96.73[a]	97.86[a]	100.75[b]	0.66	<0.01
12th-rib fat thickness, cm	1.78[a]	1.79[a]	1.67[b]	0.07	0.05
Marbling score[7]	475	457	461	13.3	0.15
Calculated YG	3.51[a]	3.44[a]	3.20[b]	0.10	0.01
USDA QG,[8] %					
Prime	2.50	1.13	1.37	0.74	0.28
Premium Choice	27.73	23.13	25.06	2.13	0.32
Low Choice	50.45	48.30	47.38	2.38	0.65
≤Select	19.32[b]	27.44[a]	26.20[a]	2.13	0.03
USDA YG,[8] %					
1	3.91[a]	5.91[ab]	8.95[b]	1.12	0.03
2	22.07	25.45	29.59	2.19	0.07
3	45.06	40.68	44.27	2.39	0.40
4	25.75[a]	23.41[a]	15.83[b]	2.10	0.01
5	3.22	4.55	1.38	0.99	0.06

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

[1]Rev-IS/200 = Revalor-IS at processing and Revalor-200 at reimplant on d 115; Rev-200/200 = Revalor-200 at processing and Revalor-200 at reimplant on d 115; Rev-XS/200 = Revalor-XS at processing and Revalor-200 at reimplant on d 115. Revalor-IS, Revalor-200, Revalor-XS, Merck Animal Health (De Soto, KS).

[2]Initial BW: total pen weight of cattle with no shrink subtracting individual weights of dead or removed animals divided by the number of remaining animals (deads-out).

[3]DMI: calculated from total kilograms delivered to the pen divided by total number of animal days.

[4]Deads-in performance: ADG was calculated from total kilograms gained (total final weight subtracting total starting weight with deads and removed included) divided by total number of animal days. G:F was calculated from deads-in ADG divided by pen DMI.

[5]Deads-out performance: live ADG was calculated from total kilograms gained (average final weight subtracting average starting weight) divided by average days on feed. Live G:F was calculated from deads-out ADG divided by pen DMI. Carcass-adjusted performance ADG were calculated the same as live performance using carcass-adjusted final BW.

[6]Carcass-adjusted final BW was calculated as HCW divided by the DP of 64.5% across all animals.

[7]Marbling score: 400 = small^{00}, 500 = modest^{00}.

[8]The numbers represent by treatment the proportion of carcasses within each QG and YG category.

Table 4. Health data for calf-fed heifers and steers implanted with different aggressive implant strategies

Item[1]	Treatment[2]				SE	*P*-value
	Rev-IH/200	Rev-H/200		Rev-200/200		
Exp. 1						
Morbidity (total pulls),[3] %	10.57[b]	16.31[a]		12.23[ab]	1.71	0.05
Mortalities,[4] %	3.59	1.29		2.58	0.86	0.12
Removal,[5] %	2.96	2.58		3.86	0.89	0.53
	Rev-IS/200	Rev-XS/IS	Rev-XS/S	Rev-XS/200		
Exp. 2						
Morbidity (total pulls),[3] %	15.98[ab]	16.92[ab]	21.08[a]	12.53[b]	1.89	0.02
Mortalities,[4] %	5.62	3.64	4.30	3.02	1.07	0.26
Removal,[5] %	0.00	0.21	0.86	0.86	0.43	0.63
	Rev-IS/200	Rev-200/200		Rev-XS/200		
Exp. 3						
Morbidity (total pulls),[3] %	15.64	13.38		14.01	1.67	0.60
Mortalities,[4] %	1.48	1.06		1.51	0.57	0.81
Removal,[5] %	4.23	4.67		3.66	0.97	0.75

[1]The numbers represent by treatment the proportion of animals within each category treated for morbidity, mortalities, or removed.

[2]Exp. 1: Rev-IH/200 = Revalor-IH at processing and Revalor-200 at reimplant on d 89; Rev-H/200 = Revalor-H at processing and Revalor-200 at reimplant on d 89; Rev-200/200 = Revalor-200 at processing and Revalor-200 at reimplant on d 89. Exp. 2: Rev-IS/200 = Revalor-IS at initial processing followed by Revalor-200 implant on d 120; Rev-XS/IS = Revalor-XS at initial processing followed by Revalor-IS implant on d 140; Rev-XS/S = Revalor-XS implant at initial processing followed by Revalor-S implant on d 140; Rev-XS/200 = Revalor-XS implant at initial processing followed by Revalor-200 implant on d 140. Exp. 3: Rev-IS/200 = Revalor-IS at processing and Revalor-200 at reimplant on d 115; Rev-200/200 = Revalor-200 at processing and Revalor-200 at reimplant on d 115; Rev-XS/200 = Revalor-XS at processing and Revalor-200 at reimplant on d 115. Revalor-IH, Revalor-H, Revalor-200, Revalor-IS, Revalor-S, Revalor-XS, Merck Animal Health (De Soto, KS).

[3]Morbidity = any animals treated for sickness during the trials.

[4]Mortality = any animals that died from d 0 to the end of the trial.

[5]Removal = any animals that were removed from the trial and sold early because of chronic sickness or injury.

treatments for any of the YG categories; however, the Rev-IS/200 and the Rev-XS/S numerically had a lesser percentage of YG 2 carcasses, which led to an increase in YG 3 carcasses compared with Rev-XS/IS and Rev-XS/200. Parr et al. (2011) and Nichols et al. (2014) noted differences in the percentage of Choice and Select carcasses in cattle fed for 131, 157, and 243 d, with cattle receiving a single Rev-XS implant having more Choice and less Select grading carcasses compared with RevIS/S. Parr et al. (2011), however, reported no differences in QG distribution in cattle fed for 174 and 197 d. Varying the timing of reimplant could have affected QG distribution in these studies. Similarly, Nichols et al. (2014) reported no differences in YG distribution.

Exp. 3—Performance

There were no differences ($P \geq 0.36$) in live or carcass-adjusted cattle performance among the 3 implant strategies (Table 3). As in Exp. 2, final live and carcass-adjusted BW did not differ ($P \geq 0.64$) among implant programs. Similarly, deads-out carcass-adjusted ADG and G:F were not different ($P \geq 0.36$) between implant strategy, agreeing with observations from Exp. 2. These results are consistent with Samber et al. (1996) and Nichols et al. (2014), who reported no differences in DMI, ADG, G:F, and final BW between implant strategies of increased TBA and E2 dose. Additionally, there were no differences ($P \geq 0.15$) in HCW or USDA marbling score when comparing the 3 treatments (Table 3). The Rev-XS/200 treatment group had greater ($P < 0.01$) LM area, decreased ($P \leq 0.05$) 12th-rib fat thickness, and calculated YG compared with the Rev-200/200 and Rev-IS/200 treatments. Similar to Exp. 2, the Rev-IS/200 and Rev-XS/200 treatments were used; however, reimplant occurred on the same day on feed (d 115) in Exp. 3 but differed between Rev-IS/200 (d 120) and Rev-XS/200 (d 140) in Exp. 2. This delay in implanting between the Rev-IS/200 and Rev-XS/200 treatments could explain why there were no differences observed for carcass characteristics in Exp. 2 but a difference in Exp. 1. Samber et al. (1996) reported no differences in HCW between aggressive implant strategies but noted a decrease in 12th-rib fat thickness and calculated YG as implant dosage increased.

The percentage of YG 1 carcasses was greater ($P = 0.03$) for Rev-XS/200 compared with Rev-IS/200 carcasses. There was a decrease ($P = 0.01$) in the percentage of YG 4 carcasses in Rev-XS/200 carcasses compared with Rev-200/200 and Rev-IS/200 carcasses. This shift in YG distribution is the result of differences in LM area and 12th-rib fat thickness.

There were no differences ($P \geq 0.28$) in the percentage of cattle that graded Choice or greater; however, the Rev-200/200 and Rev-XS/200 treatments had an increase ($P = 0.03$) in the percentage of carcasses that graded USDA Select compared with Rev-IS/200. Samber et al. (1996) reported that there was a decrease in the percentage of Choice and Prime grading carcasses as implant dosage was increased. Similarly, Nichols et al. (2014) reported no differences in QG distribution between steers implanted with Rev-IS/S or Rev-XS. Differences in carcass characteristics between Exp. 2 and 3 could be due to differences in reimplant date, cattle weight, BW, and cattle handling at reimplant in addition to environmental factors as similar differences between implant strategies were noted by Parr et al. (2011) and Nichols et al. (2014).

Animal Health

Morbidity differences ($P < 0.05$) were detected with Rev-IH/200 having the least, Rev-200/200 being intermediate, and Rev-H/200 having the greatest ($P = 0.05$) percentage of morbidity (Table 4). However, there were no differences ($P \geq 0.12$) in mortality or rejected-percentage. Rev-XS/200 had the lowest morbidity percentage, and Rev-XS/S had the greatest ($P = 0.02$). However, as noted in Exp. 1, there were no differences ($P \geq 0.26$) in the mortality or rejected-percentage. In Exp. 3 there were no differences ($P \geq 0.60$) in the number of animals treated for illness, mortalities, or removed animals. Munson et al. (2012) reported that there were numerical differences in steer morbidity and no differences in steer mortality when comparing an initial to a delayed implant treatment similar to a lesser- and greater-dose initial implant, which is in agreement with the current steer studies. Additionally, Gruber et al. (2011) reported no differences in morbidity between implant treatments in both steers and heifers. Whereas differences in morbidity in Exp. 1 and 2 were detected and not in Exp. 3, these data would suggest that increased initial implant dosage does not have an effect on animal health.

IMPLICATIONS

Economic incentives have led to use of more aggressive implant strategies to illicit a greater gain and efficiency response. However, it appears the use of aggressive implant strategies and increased dosages may not be beneficial for daily gain and efficiency of gain during the finishing phase in steers and heifers. Use of aggressive implant strategies could decrease carcass fatness and improve YG but reduce QG in heifer and steer calves when compared with a traditional implant strategy that uses a lesser-dose initial implant followed by a greater-dose terminal implant.

LITERATURE CITED

Boggs, D. L., and R. A. Merkel. 1993. Beef carcass evaluation, grading, and pricing. Pages 105–130 in Live Animal Carcass Evaluation and Selection Manual. Kendel/Hunt Publ. Co., Dubuque, IA.

Duckett, S. K., and S. L. Pratt. 2014. Meat Science and Muscle Biology Symposium—Anabolic implants and meat quality. J. Anim. Sci. 92:3–9.

FASS. 2010. Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching. 3rd rev. ed. FASS, Champaign, IL.

Folmer, J. D., T. B. Farran, G. E. Erickson, T. J. Klopfenstein, C. D. Reinhardt, B. D. Dicke, J. S. Drouillard, M. N. Streeter, and J. T. Vasconcelos. 2009. Evaluation of Revalor-IH and Revalor-IS as initial implants compared with traditional initial implants for finishing heifers and steers. Prof. Anim. Sci. 25:580–585.

Gruber, S. L., J. D. Tatum, T. E. Engle, P. L. Chapman, R. M. Enns, K. E. Belk, and G. C. Smith. 2011. Effects of genetic markers and implant strategy on longissimus and gluteus muscle tenderness of calf-fed steers and heifers. J. Anim. Sci. 89:1401–1411.

Guiroy, P. J., L. O. Tedeschi, D. G. Fox, and J. P. Hutcheson. 2002. The effects of implant strategy on finished body weight of cattle. J. Anim. Sci. 80:1791–1800.

Hutcheson, J. P., K. Hanson, W. T. Nichols, C. D. Reinhardt, and G. E. Sides. 2002. The effect of different implanting strategies on heifer performance and carcass characteristics (Texas). Revalor-200 Tech. Bull. 4. Intervet Inc., Millsboro, DE.

Johnson, B. J., F. R. B. Ribeiro, and J. L. Beckett. 2013. Application of growth technologies in enhancing food security and sustainability. Anim. Front. 3:8–13.

Mader, T. L. 1997. Carryover and lifetime effects of growth promoting implants. Pages 88–94 in Proc. Symp. Impact Implants Perform. Carcass Value Beef Cattle. Oklahoma State Univ., Stillwater.

Munson, R. D., D. U. Thomson, and C. D. Reinhardt. 2012. Effects of delayed implanting on health performance, and carcass quality in high health risk, auction market-sourced feedlot steers. J. Anim. Sci. 90:4037–4041.

Nichols, C. A., G. E. Erickson, J. T. Vasconcelos, M. N. Streeter, B. D. Dicke, D. J. Jordon, R. J. Cooper, T. L. Scott, and T. J. Klopfenstein. 2014. Comparison of Revalor XS, a new single-dose implant, to Revalor IS and Revalor S implant strategy in finishing steers. Prof. Anim. Sci. 30:51–55.

NRC. 1996. Nutrient Requirements of Beef Cattle. 7th rev. ed. (update 2000) Natl. Acad. Press, Washington, DC.

Parr, S. L., K. Y. Chung, J. P. Hutcheson, W. T. Nichols, D. A. Yates, M. N. Streeter, R. S. Swingle, M. L. Galyean, and B. J. Johnson. 2011. Dose and release pattern of anabolic implants affects growth of finishing beef steers across days on feed. J. Anim. Sci. 89:863–873.

Preston, R. L. 1999. Hormone containing growth promoting implants in farmed livestock. Adv. Drug Deliv. Rev. 38:123–138.

Reinhardt, C. D. 2007. Growth-promotant implants: Managing the tools. Vet. Clin. North Am. Food Anim. Pract. 23:309–319.

Samber, J. A., J. D. Tatum, M. I. Wray, W. T. Nichols, J. B. Morgan, and G. C. Smith. 1996. Implant program effects on performance and carcass quality of steer calves finished for 212 days. J. Anim. Sci. 74:1470–1476.

Schneider, B. A., J. D. Tatum, T. E. Engle, and T. C. Bryant. 2007. Effects of heifer finishing implants on beef carcass traits and longissimus tenderness. J. Anim. Sci. 85:2019–2030.