Effects of a single initial and delayed release implant on arrival compared with a non-coated initial implant and a non-coated terminal implant in heifers fed across various days on feed

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ABSTRACT: Two experiments evaluated the effect of implant number, type, and total steroidal dose on live animal performance and carcass traits in heifers fed for three different days on feed (DOF). In experiment 1, heifers (*n* = 3,780; 70 heifers/pen and 9 pens/treatment; initial body weight [BW] = 309 kg) were used in a 2 × 3 factorial arrangement of treatments. Factors were as follows: 1) implant (all from Merck Animal Health, De Soto, KS): 200 mg trenbolone acetate (TBA) and 20 mg estradiol-17β (E_2) administered on arrival (SINGLE), or 80 mg TBA and 8 mg E_2 administered on arrival followed by 200 mg TBA and 20 mg E_2 after approximately 90 d (REPEATED) and 2) duration of DOF: harvested after approximately 172, 193, and 214. In experiment 2, heifers (*n* = 3,719; 65 to 70 heifers/pen and 9 pens/treatment; initial BW = 337 kg) were used with the same factors as experiment 1, except DOF were 150, 171, and 192. No implant × DOF interaction ($P \geq 0.06$) was noted for any performance parameters in either experiment. Heifers administered REPEATED had improved ($P \leq 0.05$) live gain to feed ratio (G:F) and carcass-adjusted G:F and tended ($P = 0.09$) to have greater hot carcass weight (HCW) in experiment 1. Increasing DOF resulted in greater ($P \leq 0.01$) live and carcass-adjusted final BW and decreased ($P = 0.01$) live ADG in experiment 1. As DOF increased, HCW, HCW gain, and dressing% ($P \leq 0.01$) increased in experiment 1. The mean carcass transfer was 79.6% across the 42 d terminal window in experiment 1. In experiment 2, REPEATED had improved ($P = 0.03$) carcass-adjusted G:F compared with SINGLE, but HCW was not different ($P = 0.36$) between treatments. Increased DOF resulted in greater ($P \leq 0.01$) final live and carcass-adjusted BW, decreased ($P \leq 0.01$) live and carcass-adjusted ADG, and poorer ($P \leq 0.01$) live and carcass-adjusted G:F in experiment 2. In experiment 2, dressing percentage was greater ($P = 0.02$) in REPEATED compared with SINGLE. Heifers given SINGLE had greater ($P = 0.01$) back fat and estimated empty body fat (EBF), whereas REPEATED had fewer ($P = 0.01$) Yield Grade 4 carcasses and greater ($P = 0.01$) longissimus muscle (LM) area. Increased DOF resulted in greater ($P \leq 0.04$) HCW, HCW gain, dressing%, back fat, LM area, marbling, EBF%, and United States Department of Agriculture (USDA) Prime-grading carcasses, Yield Grade 4 and 5, and over 454-kg carcasses in experiment 2. Carcass ADG and carcass transfer indicate a 0.70 kg carcass ADG between 150 and 192 DOF, resulting in an average carcass transfer of 72.2% in experiment 2. Although feedlot growth performance and HCW did not differ between the implant regimens tested, increasing DOF resulted in decreased live growth performance while increasing the proportion of USDA prime carcasses and HCW.

Key words: beef, estradiol, heifer, implant, trenbolone acetate

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INTRODUCTION

Using multiple implants or increasing implant potency results in improvements in final shrunk body weight, average daily gain (ADG), and gain to feed ratio (G:F) over single implant animals (Reinhardt and Wagner, 2014). More than 90% of cattle entering the feedlot are administered an anabolic implant at least once, and approximately 80% of steers and 99% of heifers weighing less than 318 kg, at feedlot arrival, receive two or more anabolic implants (APHIS, 2013). The average payout period of non-coated implants is 60 to 120 d (Johnson *et al.*, 1996; Mader, 1998; Smith *et al.*, 2018). Because a large majority of feedlot animals receive two or more implants during the feedlot phase of production due to duration of days on feed (DOF), pharmaceutical companies have begun to produce and market coated implants that extend the payout of hormones from the implant pellets in excess of 200 d (FOIA, 2007). At present, a new combination implant, Revalor-XH (200 mg trenbolone acetate [TBA] and 20 mg E_2, Merck Animal Health, De Soto, KS), has been approved for use in heifers fed in confinement for slaughter (FOIA, 2017a). Revalor-XH has a unique payout because of a polymer coating on 6 of the 10 implant pellets. After implantation, the uncoated pellets begin to release TBA and E_2, and the coated pellets do not begin to degrade until approximately 70 d after implant administration (FOIA, 2017a; Smith *et al.*, 2018). This initial and delayed-release implant formulation essentially eliminates the need to reimplant heifers that are on feed in excess of 200 d. The objective of this research was to evaluate the effects of number, type (coated vs. non-coated), and total anabolic dose have on growth performance and carcass traits in heifers fed for varying DOF.

MATERIALS AND METHODS

The following experiments were a collaborative effort between Merck Animal Health, Cactus Research Ltd., South Dakota State University, and Texas Tech University. Institutional animal care and use committee approval was not obtained at South Dakota State University or Texas Tech University because all research herein was conducted at commercial research facilities and followed the guidelines stated in the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1999).

Animals and Treatments

In experiment 1, between July 22, 2015 and August 31, 2015 a total of 4,213 heifers were received at the commercial research feedlot in Texas. Heifers were of British and British × Continental breeding (*Bos Taurus*). At initial processing, all heifers were vaccinated against viral respiratory pathogens (Vista Once SQ, Merck Animal Health, De Soto, KS) and clostridia species (Vision 8, Merck Animal Health) and administered anti-parasiticides: Cydectin Injectable (Bayer, Shawnee, KS) and Ultra Saber Pour-On (Merck Animal Health) for the control of internal and external parasites according to label directions. On the day of initial processing and randomization, heifers were excluded from the candidate population due to extremes in body weight (BW; i.e., having a BW greater or less than 2 SD away from the mean). Heifers were also excluded if they were considered unfit for the experiment (visually ill, lame, or of unlike breed type), or if they were determined to be bred at the time of processing, there was 433 heifers excluded from the enrollment pool. A total of 3,780 (initial allotment BW = 309 kg) heifers were blocked by arrival date (n = 9 blocks) and assigned to one of six treatments as they passed through the processing shed, resulting in nine pen replications per simple effect treatment (n = 70 heifers/pen and 630 heifers/simple effect treatment) and were used in a randomized complete block design.

Implants (all from Merck Animal Health) included:

1. Revalor-XH (80 mg TBA and 8 mg E_2, uncoated; 120 mg TBA and 12 mg E_2, coated; 200 mg TBA and 20 mg E_2, total) administered on arrival (SINGLE).
2. Revalor-IH (80 mg TBA and 8 mg E_2, uncoated) administered on arrival followed by Revalor-200

(200 mg TBA and 20 mg E_2, uncoated) after approximately 90 d (REPEATED).

Duration of DOF included:

1. Harvested after approximately 172 DOF (172).
2. Harvested after approximately 193 DOF (193).
3. Harvested after approximately 214 DOF (214).

Heifers in the SINGLE treatment were not removed from their pens when the REPEATED heifers were administered their terminal implant.

Heifers were housed in outdoor, soil-surfaced, pipe constructed pens measuring 53 m deep and 18 m wide in experiment 1 and had *ad libitum* access to water. Pens were stocked so that each animal had approximately 14 m^2 of pen space and 25 cm of bunk space. Feed bunks were visually checked three times daily for the presence of residual feed. Feed calls were made to provide feed to appetite and such that feed carry-over in the bunk was minimized.

In experiment 2, between March 13, 2018 and May 3, 2018 a total of 4,233 heifers were received at the commercial feedlot in Texas. Heifers were of British and British × Continental and British × *Bos Indicus* breeding. At initial processing, heifers were vaccinated against viral respiratory pathogens (Vista 5, Merck Animal Health) and the anti-parasiticides: Dectomax (Zoetis, Parsippany, NJ) and Safe-Guard oral drench (Merck Animal Health) were given for the control of internal and external parasites according to label directions. On the day of initial processing and randomization, heifers were excluded from the candidate population due to extremes in BW. Heifers were also excluded if they were considered unfit for the experiment (visually ill, lame, or of unlike breed type), or if they were determined to be bred at the time of initial processing. A total of 3,719 (initial allotment BW = 337 kg) heifers were blocked by arrival date (n = 9 blocks) and assigned to one of six treatments as they passed through the processing shed, resulting in nine pen replications per simple effect treatment (n = 65 to 70 heifers/pen and 585 to 630 heifers/simple effect treatment) and were used in a randomized complete block design.

Implants included: 1) SINGLE and 2) REPEATED.

Duration of DOF differed from experiment 1 due to differences in initial BW, cattle type, and estimated days required to reach an acceptable level of finish.

The duration of DOF in experiment 2 was as follows:

1. 150 DOF (150).
2. 171 DOF (171).
3. 192 DOF (192).

Heifers in the SINGLE treatment were not removed from their pens when the REPEATED heifers were administered their terminal implant.

Heifers used in experiment 2 were housed in outdoor, soil-surfaced, pipe constructed pens measuring 53 m deep and 18 m wide and had *ad libitum* access to water. Pens were stocked so that each animal had approximately 14 to 15 m^2 of pen space and 25 to 28 cm of bunk space. Feed bunks were visually checked three times each day for the presence of residual feed in the bunk. Feed calls were made to provide feed to appetite and such that feed carry-over in the bunk was minimized from day to day.

The starter diet used in both experiments was Ramp (Cargill Corn Milling, Bovina, TX). In addition, loose hay was top-dressed to the feed bunk for at least 3 d after arrival. Transition to the finishing diet was done using a two-ration approach where replacement of 10% to 15% of the daily feed call of Ramp was replaced with the finishing ration. Increases in the amount of finish ration were made every 2 to 4 d.

The finish diet used in experiment 1 was prepared in the on-site feed mill and contained steam-flaked corn, Sweet Bran Plus (Cargill Corn Milling), wet distiller's grains plus solubles, and other ingredients common to the Texas cattle feeding region (Table 1). Microingredients were weighed using a Micro Machine (Micro Technologies, Amarillo, TX) and added to the feed batch. Monensin sodium (Rumensin, Elanco Animal Health, Greenfield, IN) was included in the Ramp (20.0 mg/kg) and finish diet (42.0 mg/kg) throughout the experiment. Tylosin phosphate (Tylan, Elanco Animal Health) was included at 9.6 mg/kg. To control cycling of heifers, melengestrol acetate (MGA, Zoetis) was included in the diet at 0.40 mg/heifer daily. All cattle were fed 27.3 mg/kg ractopamine HCl (Optaflexx, Elanco Animal Health) for approximately 28 d before slaughter (all feed additives on a dry matter [DM] basis). Samples of each ration were collected daily from the feed bunk and subsamples dried at 100 °C. Daily DM were averaged weekly and used for the calculation of DM intake (DMI). The finishing diet provided protein and minerals to meet or exceed requirements (NRC, 1996).

The finishing diets used in experiment 2 were prepared in the on-site feed mill and contained steam-flaked corn, Sweet Bran Plus (Cargill Corn Milling), wet distiller's grains plus solubles, and other ingredients common to the Texas cattle feeding region

Table 1. Diet formulation and tabular nutrient composition from both experiments (DM basis)[a]

Item	Experiment 1 Finisher	Experiment 2 Finisher 1[b]	Experiment 2 Finisher 2[c]
Steam flaked corn, %	48.50	55.16	55.16
Wet corn gluten feed, %[d]	11.03	17.85	17.85
Wet corn distillers grain	34.16	17.22	17.22
Corn stalks, %	5.56	7.18	0.00
Cotton burrs, %	0.00	0.00	7.18
Yellow grease, %	0.72	0.00	0.00
Corn oil, %	0.00	1.52	1.52
Glycerin, %	0.00	1.04	1.04
Micro ingredients, %	0.03	0.03	0.03
Nutrient composition[e]			
Diet DM, %	56.00	64.95	64.50
CP, %	17.51	15.02	14.73
NDF, %	26.25	22.35	22.53
NEm, Mcal/kg	2.28	2.23	2.25
NEg, Mcal/kg	1.53	1.48	1.51
Ether extract, %	6.55	6.40	6.35
Vitamin A, IU/kg	2646	2646	2646
Vitamin E, IU/kg	265	265	265
Monensin sodium, mg/kg	42.00	40.00	40.00
Tylosin phosphate, mg/kg	9.60	9.20	9.20
Melengesterol acetate, mg/heifer daily	0.40	0.40	0.40

[a]All values except Diet DM on a DM basis.

[b]When roughage source was ground corn stalks from March 20, 2018 to September 22, 2018.

[c]When roughage source was cotton burrs from September 23, 2018 to November 19, 2019 (study end).

[d]Sweet Bran wet corn gluten feed (Cargill Corn Milling, Bovina, TX) with added calcium carbonate (4% as fed), salt (1.8%), urea (1.1%) and trace mineral premix (0.2%).

[e]Tabular values (NRC, 1996).

(Table 1). Microingredients were weighed using a Micro Machine (Micro Technologies) and added to the feed batch. Monensin sodium (Rumensin, Elanco Animal Health) was included in the Ramp (20.0 mg/kg) and finish diet (40.0 mg/kg) throughout the experiment. Tylosin phosphate (Tylan, Elanco Animal Health) was included only in the finishing diet at 9.2 mg/kg. To control cycling of heifers, MGA (Zoetis) was included in the diet at 0.40 mg/heifer daily. All cattle were fed 27.3 mg/kg ractopamine HCl (Optaflexx, Elanco Animal Health) for approximately 31 d before slaughter (all feed additives on a DM basis). Samples of each diet were collected daily from the feed bunk and subsamples dried at 100 °C. Daily DM were averaged weekly and used for the calculation of DMI. The finishing diets provided protein and minerals to meet or exceed requirements (NRC, 1996).

In both experiments, heifers were weighed as a group by pen using a platform scale on study day 0 and the morning of shipment for the calculation of live growth performance. Body weights were measured before the morning feeding and a 4% pencil shrink was applied to initial and final BW. Carcass-adjusted performance was calculated from hot carcass weight (HCW)/0.625, and HCW gain was calculated as: HCW-(initial shrunk BW × 0.58).

In experiment 1, trained personnel from the Beef Carcass Research Center (West Texas A&M University, Canyon, TX) recorded individual animal ear tag numbers in the sequence of harvest and affixed a harvest sequence number to each carcass. Plant carcass ID and HCW were recorded and verified by carcass sequence number. Carcasses were graded after chilling for approximately 36 h and United States Department of Agriculture (USDA) Quality Grade (assigned by USDA Grader) and Yield Grade (assigned by camera system) were obtained from the packing plant records. Dressing percentage (DP) for each pen was calculated as the mean HCW/mean shrunk live weight × 100.

In experiment 2, trained personnel from the Beef Carcass Research Center recorded individual animal ear tag numbers in the sequence of harvest and affixed a harvest sequence number to each carcass. Plant carcass ID and HCW were recorded and verified by carcass sequence number. Carcasses were graded after approximately 36 h of chilling. United States Department of Agriculture Quality Grade (assigned by USDA Grader) and Yield Grade (assigned by camera system), and grading camera measurements were obtained from the packing plant records. The DP for each pen was calculated as the mean HCW/mean shrunk live weight × 100.

Statistical Analyses

In experiment 1, finishing growth performance was calculated on a deads and removals- excluded basis. Finishing performance and HCW were analyzed as a randomized complete block design using the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC) with pen as the experimental unit. The model included fixed effects of implant, DOF and their interaction and block was included as a random effect. Categorical data (USDA Quality Grade and Yield Grade distributions, and heavy carcasses) were analyzed as a binomial proportions in the GLIMMIX procedure of SAS 9.4 with fixed and random effects as described previously. All results are reported as least-squares means. Means were separated and denoted to be different using the PDIFF and lines option of SAS 9.4 (SAS Inst. Inc.) if a significant preliminary *F*-test was detected. An α level of 0.05 was used to determine significance, with tendencies discussed at *P*-values between 0.05 and 0.10.

In experiment 2, finishing growth performance was calculated on a deads and removals- excluded basis. Finishing performance, carcass traits (back fat, DP, HCW, *longissimus* muscle [LM] area, USDA marbling score [400 = small[00]]) and estimated empty body fat (EBF) percentage (Guiroy *et al.*, 2002), calculated from carcass traits, were analyzed as a randomized complete block design using the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc.) with pen as the experimental unit. The model included fixed effects of implant, DOF and their interaction and block were included as a random effect. Categorical data (USDA Quality Grade and Yield Grade distributions, and heavy carcasses) were analyzed as a binomial proportions in the GLIMMIX procedure of SAS 9.4 with fixed and random effects as described previously. All results are reported as least-squares means. Means were separated and denoted to be different using the PDIFF and lines option of SAS 9.4 (SAS Inst. Inc.) if a significant preliminary *F*-test was detected. An α level of 0.05 was used to determine significance, with tendencies discussed at *P*-values between 0.05 and 0.10.

RESULTS

Heifer performance results from experiment 1 are reported in Table 2. No implant × DOF interaction ($P \geq 0.19$) was detected for any live or carcass-adjusted performance traits, except for a tendency ($P = 0.06$) for an interaction on cumulative DMI (Figure 1). Heifers from SINGLE/172, REPEATED/172, and SINGLE/214 consumed greater DMI throughout the course of the study compared with REPEATED/214, whereas all other treatments were intermediate. Implant regimen did not alter ($P \geq 0.16$) live-basis final BW or ADG in these heifers. The REPEATED heifers had improved ($P = 0.05$) live-basis G:F compared with

Table 2. Cumulative heifer performance in experiment 1[1]

	Implant				Days on feed (DOF)					Implant × DOF
Item	SINGLE	REPEATED	SEM[2]	*P*-value	172	193	214	SEM[2]	*P*-value	*P*-value
n[3]	1,866	1,860	—	—	1,244	1,243	1,239	—	—	—
Initial BW[4], kg	309	309	0.8	0.79	308	309	309	1.0	0.83	0.72
Final BW[4], kg	594	595	1.6	0.23	571[c]	596[b]	616[a]	2.0	0.01	0.33
ADG, kg	1.48	1.49	0.084	0.16	1.53[a]	1.49[b]	1.44[c]	0.010	0.01	0.19
DMI, kg/d	9.62	9.53	0.044	0.06	9.67[a]	9.54[b]	9.53[b]	0.054	0.02	0.06
G:F	0.154	0.156	0.0009	0.05	0.158[a]	0.156[a]	0.151[b]	0.0011	0.01	0.94
Carcassadjusted[5]										
Final BW, kg	611	614	1.9	0.09	584[c]	613[b]	641[a]	2.4	0.01	0.67
ADG, kg	1.57	1.59	0.010	0.06	1.60[a]	1.58[a]	1.55[b]	0.011	0.01	0.47
G:F	0.163	0.166	0.0010	0.01	0.166	0.166	0.163	0.0012	0.08	0.86

[1]Treatments were: Implanted with either Revalor-XH (80 mg TBA and 8 mg E_2, uncoated; 120 mg TBA and 12 mg E_2, coated; 200 mg TBA and 20 mg E_2, total) on arrival or Revalor-IH (80 mg TBA and 8 mg E_2, uncoated) on arrival followed by Revalor-200 (200 mg TBA and 20 mg E_2, uncoated) at approximately 90 DOF and cattle harvest at 172, 193, or 214 days on feed.

[2]The SE of the difference between treatment means (SAS Inst. Inc., Cary, NC).

[3]Harvested.

[4]Shrunk 4% to account for gastrointestinal tract fill.

[5]Final BW was calculated as HCW/0.625.

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

SINGLE heifers, as well as improved ($P = 0.01$) carcass-adjusted basis G:F compared with SINGLE heifers. The REPEATED heifers tended to have greater carcass-adjusted final BW ($P = 0.09$) and carcass-adjusted ADG ($P = 0.06$) compared with SINGLE heifers.

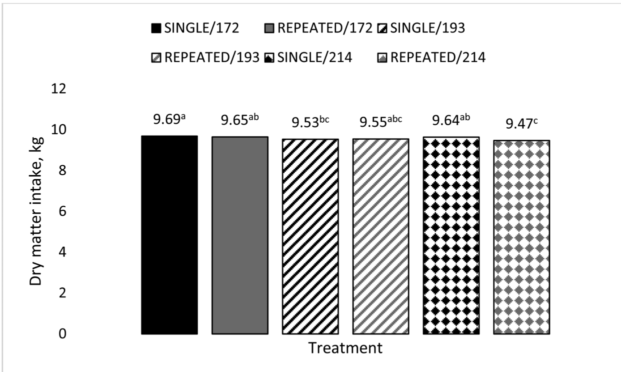

Figure 1. The interaction of implant strategy (all implants from Merck Animal Health, De Soto, KS) and days on feed ($P = 0.06$) on cumulative dry matter intake in experiment 1. Treatments include: Revalor-XH (80 mg TBA and 8 mg E_2, uncoated; 120 mg TBA and 12 mg E_2, coated; 200 mg TBA and 20 mg E_2, total) administered on arrival and harvested after approximately 172 DOF (SINGLE/172), Revalor-IH (80 mg TBA and 8 mg E_2, uncoated) administered on arrival followed by Revalor-200 (200 mg TBA and 20 mg E_2, uncoated) after approximately 90 d and harvested after approximately 172 DOF (REPEATED/172), Revalor-XH administered on arrival and harvested after approximately 193 DOF (SINGLE/193), Revalor-IH administered on arrival followed by Revalor-200 after approximately 90 d and harvested after approximately 193 DOF (REPEATED/193), Revalor-XH administered on arrival and harvested after approximately 214 DOF (SINGLE/214), Revalor-IH administered on arrival followed by Revalor-200 after approximately 90 d and harvested after approximately 214 DOF (REPEATED/214). [a,b]Means without a common superscript differ ($P < 0.05$). The SE of the difference between treatment means = 0.077.

Increasing DOF resulted in greater ($P \le 0.01$) live and carcass-adjusted final BW. As DOF increased, live-basis ADG decreased ($P = 0.01$) by 2.6% and 5.8% for 193 DOF and 214 DOF compared with 172 DOF. Heifers in the 214 DOF group had decreased ($P = 0.01$) carcass-adjusted ADG compared with 172 and 193 DOF. Heifers in the 214 DOF group also had decreased ($P = 0.01$) live-basis G:F compared with 172 and 193 DOF. A tendency ($P = 0.08$) was detected for poorer carcass-adjusted G:F in the 214 DOF treatment.

Live performance results from experiment 2 are presented in Table 3. No implant × DOF interaction ($P \ge 0.20$) was detected for any live or carcass-adjusted performance parameter. Therefore, only the main effects of implant and DOF will be discussed. There were no implant differences ($P \ge 0.14$) in final live or carcass-adjusted BW, ADG, or live-basis G:F. There was a tendency ($P = 0.06$) for lesser cumulative DMI in REPEATED heifers compared with SINGLE heifers. The REPEATED heifers had improved ($P = 0.03$) carcass-adjusted G:F compared with SINGLE heifers.

Increasing DOF resulted in improvements ($P \le 0.01$) in final live and carcass-adjusted BW, decreased ($P \le 0.01$) live and carcass-adjusted ADG, and poorer ($P \le 0.01$) live and carcass-adjusted G:F. Increasing DOF did not alter DMI ($P = 0.97$).

Table 3. Cumulative heifer performance in experiment 2[1]

	Implant				Days on feed (DOF)					Implant × DOF
Item	SINGLE	REPEATED	SEM[2]	*P*-value	150	171	192	SEM[2]	*P*-value	*P*-value
n[3]	1,795	1,811	—	—	1,217	1,197	1,192	—	—	—
Initial BW[4], kg	337	337	0.6	0.36	338	337	336	0.8	0.07	0.88
Final BW[4], kg	596	594	1.9	0.25	574[c]	596[b]	615[a]	2.4	0.01	0.79
ADG, kg	1.51	1.49	0.011	0.14	1.55[a]	1.50[b]	1.44[c]	0.014	0.01	0.81
DMI, kg	9.65	9.53	0.061	0.06	9.59	9.60	9.58	0.074	0.97	0.32
G:F	0.156	0.156	0.0013	0.99	0.162[c]	0.156[b]	0.150[a]	0.0016	0.01	0.84
Carcass-adjusted[5]										
Final BW, kg	610	611	1.7	0.36	586[c]	611[b]	633[a]	2.1	0.01	0.25
ADG, kg	1.58	1.61	0.010	0.57	1.63[a]	1.58[b]	1.54[c]	0.013	0.01	0.20
G:F	0.164	0.166	0.0011	0.03	0.170[c]	0.165[b]	0.160[a]	0.0013	0.01	0.92

[1]Treatments were: Implanted with either Revalor-XH (80 mg TBA and 8 mg E_2, uncoated; 120 mg TBA and 12 mg E_2, coated; 200 mg TBA and 20 mg E_2, total) on arrival or Revalor-IH (80 mg TBA and 8 mg E_2, uncoated) on arrival followed by Revalor-200 (200 mg TBA and 20 mg E_2, uncoated) at approximately 90 DOF and cattle harvest at 150, 171, or 192 days on feed.

[2]The SE of the difference between treatment means (SAS Inst. Inc., Cary, NC).

[3]Harvested.

[4]Shrunk 4% to account for gastrointestinal tract fill.

[5]Final BW was calculated as HCW/0.625.

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

Carcass weight, HCW gain, and DP from experiment 1 are presented in Table 4. No implant × DOF interaction ($P \geq 0.47$) was detected for any traits as shown in Table 4. There was a tendency ($P = 0.09$) for greater HCW in REPEATED heifers compared with SINGLE heifers, as well as a tendency ($P = 0.06$) for increased HCW gain in REPEATED heifers compared with SINGLE heifers. As DOF increased, HCW ($P = 0.01$), HCW gain ($P = 0.01$), and DP ($P = 0.01$) increased. Carcass ADG and carcass transfer, calculated as (HCW ADG/live ADG) × 100, indicate a 0.85 kg carcass ADG between 172 and 214 DOF, resulting in an average carcass transfer of 79.6% in these heifers.

Carcass traits from experiment 2 are presented in Table 5. No implant × DOF interactions ($P \geq 0.19$) were detected for any carcass traits. HCW did not differ because of implant treatment ($P = 0.36$) for SINGLE and REPEATED heifers, respectively. Likewise, HCW gain did not differ ($P = 0.65$) due to implant regimen. DP was greater ($P = 0.02$) in REPEATED heifers compared with SINGLE heifers. Heifers given SINGLE had greater ($P = 0.01$). In addition, LM area was nearly 2.5% greater ($P = 0.01$) in REPEATED heifers compared with SINGLE heifers. Marbling scores were not affected by implant regimen. The SINGLE heifers had greater ($P = 0.01$) estimated EBF compared with REPEATED heifers. Increasing DOF resulted in increased ($P \leq 0.03$) HCW, HCW gain, DP, back fat, LM area, marbling, and estimated EBF increased. Carcass ADG and carcass transfer data indicate a 0.70 kg carcass ADG between 150 and 192 DOF, resulting in an average carcass transfer of 72.5% in these heifers.

Carcass grade distribution data from experiment 1 are presented in Table 6. A tendency ($P = 0.07$) for an implant × DOF interaction for proportion of USDA Yield Grade 1 carcasses was

Table 4. Carcass traits of heifers in experiment 1[1]

	Implant				Days on feed (DOF)					Implant × DOF
Item	SINGLE	REPEATED	SEM[2]	*P*-value	172	193	214	SEM[2]	*P*-value	*P*-value
Carcasses, *n*	1,865	1,857	—	—	1,243	1,242	1,237	—	—	—
HCW, kg	382	384	1.2	0.09	365[c]	383[b]	400[a]	1.5	0.01	0.67
HCW gain, kg[3]	202	205	1.2	0.06	186[c]	204[b]	221[a]	1.4	0.01	0.47
Dress, %[4]	64.30	64.46	0.115	0.19	63.86[b]	64.29[ab]	64.99[a]	0.141	0.01	0.83

[1]Treatments were: Implanted with either Revalor-XH (80 mg TBA and 8 mg E_2, uncoated; 120 mg TBA and 12 mg E_2, coated; 200 mg TBA and 20 mg E_2, total) on arrival or Revalor-IH (80 mg TBA and 8 mg E_2, uncoated) on arrival followed by Revalor-200 (200 mg TBA and 20 mg E_2, uncoated) at approximately 90 DOF and cattle harvest at 172, 193, or 214 days on feed.

[2]The SE of the difference between treatment means (SAS Inst., Cary, NC).

[3]Initial HCW = initial BW × 0.58.

[4]Calculated as (HCW/final BW pencil shrunk 4%).

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

Table 5. Carcass traits of heifers in experiment 2[1]

	Implant				Days on feed (DOF)					Implant × DOF
Item	SINGLE	REPEATED	SEM[2]	*P*-value	150	171	192	SEM[2]	*P*-value	*P*-value
Carcasses, *n*	1,790	1,793	—	—	1,209	1,191	1,183	—	—	—
HCW, kg	381	382	1.1	0.36	367[c]	382[b]	396[a]	1.3	0.01	0.24
HCW gain, kg[3]	186	186	1.1	0.65	171[c]	186[b]	201[a]	1.3	0.01	0.22
Dress, %[4]	63.90	64.31	0.169	0.02	63.86[b]	64.03[ab]	64.43[a]	0.207	0.03	0.56
Back fat, cm	1.88	1.80	0.023	0.01	1.73[c]	1.83[b]	1.98[a]	0.028	0.01	0.23
LM area, sq cm	93.48	95.81	0.432	0.01	92.26[c]	95.23[b]	96.45[a]	0.374	0.01	0.61
Marbling[5]	510	510	6.6	0.98	502[b]	501[b]	528[a]	8.0	0.01	0.65

[1]Treatments were: Implanted with either Revalor-XH (80 mg TBA and 8 mg E_2, uncoated; 120 mg TBA and 12 mg E_2, coated; 200 mg TBA and 20 mg E_2, total) on arrival or Revalor-IH (80 mg TBA and 8 mg E_2, uncoated) on arrival followed by Revalor-200 (200 mg TBA and 20 mg E_2, uncoated) at approximately 90 DOF and cattle harvest at 150, 171, or 192 days on feed.

[2]The SE of the difference between treatment means (SAS Inst., Cary, NC).

[3]Initial HCW = initial BW × 0.58.

[4]Calculated as (HCW/final BW pencil shrunk 4%).

[5]400 = small0

[6]Estimated empty body fat (%) according to Guiroy *et al.*, 2002.

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

Table 6. Carcass Quality and Yield grade of heifers in experiment 1[1]

	Implant				Days on feed (DOF)					Implant × DOF
Item	SINGLE	REPEATED	SEM[2]	*P*-value	172	193	214	SEM[2]	*P*-value	*P*-value
Prime, %	4.9	3.7	0.59	0.12	3.1[b]	3.3[b]	6.5[a]	0.70	0.01	0.42
Choice, %	78.6	78.3	1.19	0.87	76.0	80.7	78.5	1.45	0.09	0.35
Select, %	12.8	14.6	1.26	0.23	19.4[a]	12.6[b]	9.2[b]	1.45	0.01	0.43
No roll, %	3.7	3.4	0.96	0.77	1.5[b]	3.4[ab]	5.8[a]	1.10	0.01	0.69
Yield Grade 1, %	4.5	6.5	0.85	0.03	6.3	5.9	4.4	0.97	0.21	0.07
Yield Grade 2, %	27.5	29.5	2.03	0.17	30.9[a]	30.2[a]	24.4[b]	2.16	0.01	0.60
Yield Grade 3, %	42.9	44.1	1.40	0.48	45.0	43.8	41.7	1.68	0.40	0.37
Yield Grade 4, %	20.8	17.3	1.90	0.02	15.4[b]	17.2[b]	24.4[a]	2.03	0.01	0.70
Yield Grade 5, %	4.3	2.6	0.58	0.01	2.4[b]	2.9[b]	5.1[a]	0.66	0.01	0.73
HCW ≥ 454 kg, %	3.0	4.3	0.56	0.02	0.7[c]	2.4[b]	7.9[a]	0.63	0.01	0.39

[1]Treatments were: Implanted with either Revalor-XH (80 mg TBA and 8 mg E_2, uncoated; 120 mg TBA and 12 mg E_2, coated; 200 mg TBA and 20 mg E_2, total) on arrival or Revalor-IH (80 mg TBA and 8 mg E_2, uncoated) on arrival followed by Revalor-200 (200 mg TBA and 20 mg E_2, uncoated) at approximately 90 DOF and cattle harvest at 172, 193, or 214 days on feed.

[2]Pooled within factor SE from the ILINK option (SAS Inst., Cary, NC).

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

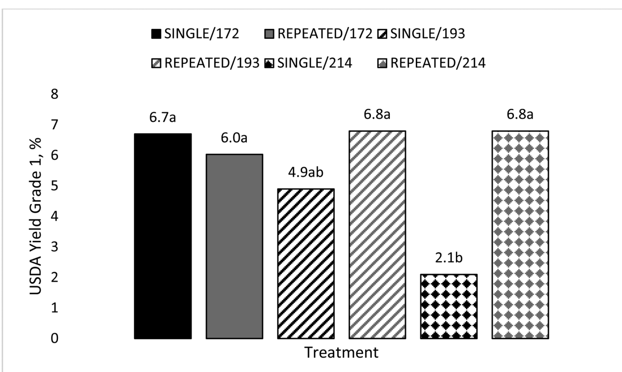

Figure 2. The interaction of implant strategy (all implants from Merck Animal Health, De Soto, KS) and days on feed ($P = 0.07$) on the proportion of USDA Yield Grade 1 carcasses in experiment 1. Treatments include: Revalor-XH (80 mg TBA and 8 mg E_2, uncoated; 120 mg TBA and 12 mg E_2, coated; 200 mg TBA and 20 mg E_2, total) administered on arrival and harvested after approximately 172 DOF (SINGLE/172), Revalor-IH (80 mg TBA and 8 mg E_2, uncoated) administered on arrival followed by Revalor-200 (200 mg TBA and 20 mg E_2, uncoated) after approximately 90 d and harvested after approximately 172 DOF (REPEATED/172), Revalor-XH administered on arrival and harvested after approximately 193 DOF (SINGLE/193), Revalor-IH administered on arrival followed by Revalor-200 after approximately 90 d and harvested after approximately 193 DOF (REPEATED/193), Revalor-XH administered on arrival and harvested after approximately 214 DOF (XH/214), Revalor-IH administered on arrival followed by Revalor-200 after approximately 90 d and harvested after approximately 214 DOF (REPEATED/214). [a,b-]Means without a common superscript differ ($P < 0.05$). The SE of the mean = 1.56.

detected (Figure 2). Heifers from SINGLE/214 had the fewest carcasses classified as USDA Yield Grade 1 compared with SINGLE/172, REPEATED/172, REPEATED/193, and REPEATED/214, whereas heifers from SINGLE/193 were intermediate, not differing ($P \geq 0.10$) from others. The SINGLE heifers had fewer ($P = 0.03$) carcasses classified as USDA Yield Grade 1 compared with REPEATED heifers, greater USDA Yield Grade 4 ($P = 0.02$), and greater USDA Yield Grade 5 carcasses ($P = 0.01$) compared with REPEATED heifers. In addition, SINGLE heifers had fewer ($P = 0.02$) carcasses over 454 kg compared with REPEATED heifers. There was an increase in the proportion of carcasses grading USDA Prime as DOF increased to 214 ($P = 0.01$). The percentage of carcasses grading USDA Select decreased with increasing DOF. Carcasses classified as No Roll (i.e., not USDA Prime, Choice, or Select) increased with increasing DOF. Heifers fed for 172 and 193 DOF had a greater ($P = 0.01$) proportion of carcasses classified as USDA Yield Grade 2 compared with 214 DOF. As DOF increased the percentage of carcasses classified as USDA Yield Grade 4 ($P = 0.01$) and Yield Grade 5 ($P = 0.01$) increased. Heifers fed for 214 DOF had the greatest ($P = 0.01$) amount of heavy carcasses (> 454 kg) compared with others, whereas heifers fed for 172 DOF had fewer carcasses classified as heavy compared with 193 DOF.

Carcass grade distribution data from experiment 2 are presented in Table 7. An implant × DOF interaction was detected for the proportions of carcasses grading USDA Yield Grade 2 and 3. The implant × DOF interaction ($P = 0.01$) for USDA Yield Grade 2 carcasses is shown in Figure 3. The REPEATED heifers from 150 and 171 DOF had a greater ($P \leq 0.05$) proportion of carcasses grading USDA Yield Grade 2 compared with all other groups, but proportion of carcasses grading Yield Grade 2 was similar between implant treatments at 192 DOF. The implant × DOF interaction

Table 7. Carcass Quality and Yield grade of heifers in experiment 2[1]

	Implant				Days on feed (DOF)					Implant × DOF
Item	SINGLE	REPEATED	SEM[2]	*P*-value	150	171	192	SEM[2]	*P*-value	*P*-value
Prime, %	7.0	5.5	1.14	0.10	4.7[b]	6.6[ab]	7.5[a]	1.23	0.04	0.13
Choice, %	78.1	77.9	1.91	0.92	78.2	77.0	78.8	2.08	0.65	0.56
Select, %	14.3	15.5	2.39	0.49	16.2	16.0	12.5	2.53	0.14	0.93
No roll, %	0.6	1.1	0.29	0.17	0.9	0.4	1.2	0.34	0.15	0.12
Yield Grade 1, %	7.8	9.7	1.30	0.10	8.4	10.2	7.7	1.43	0.21	0.87
Yield Grade 2, %	28.2	36.2	1.12	0.01	35.2	33.7	27.8	1.35	0.01	0.01
Yield Grade 3, %	41.2	38.3	1.43	0.06	42.5	38.2	38.6	1.63	0.05	0.01
Yield Grade 4, %	19.1	13.3	1.17	0.01	12.4[b]	15.2[b]	21.2[a]	1.34	0.01	0.26
Yield Grade 5, %	3.7	2.5	0.60	0.15	1.5[b]	2.7[b]	4.7[a]	0.72	0.01	0.91
HCW ≥ 454 kg, %	1.6	2.2	0.37	0.22	0.3	1.5	4.0	0.45	0.01	0.06

[1]Treatments were: Implanted with either Revalor-XH (80 mg TBA and 8 mg E_2, uncoated; 120 mg TBA and 12 mg E_2, coated; 200 mg TBA and 20 mg E_2, total) on arrival or Revalor-IH (80 mg TBA and 8 mg E_2, uncoated) on arrival followed by Revalor-200 (200 mg TBA and 20 mg E_2, uncoated) at approximately 90 DOF and cattle harvest at 150, 171, or 192 days on feed.

[2]Pooled within factor SE from the ILINK option (SAS Inst., Cary, NC).

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

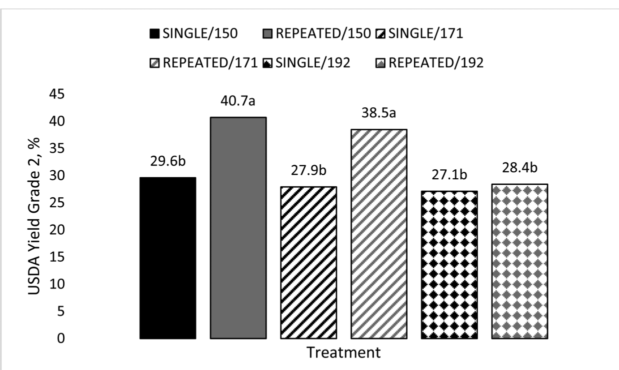

Figure 3. The interaction of implant strategy (all implants from Merck Animal Health, De Soto, KS) and days on feed ($P = 0.01$) on the proportion of USDA Yield Grade 2 carcasses in experiment 2. Treatments include: Revalor-XH (80 mg TBA and 8 mg E_2, uncoated; 120 mg TBA and 12 mg E_2, coated; 200 mg TBA and 20 mg E_2, total) administered on arrival and harvested after approximately 150 DOF (SINGLE/150), Revalor-IH (80 mg TBA and 8 mg E_2, uncoated) administered on arrival followed by Revalor-200 (200 mg TBA and 20 mg E_2, uncoated) after approximately 90 d and harvested after approximately 150 DOF (REPEATED/150), Revalor-XH administered on arrival and harvested after approximately 171 DOF (SINGLE/171), Revalor-IH administered on arrival followed by Revalor-200 after approximately 90 d and harvested after approximately 171 DOF (REPEATED/171), Revalor-XH administered on arrival and harvested after approximately 192 DOF (SINGLE/192), Revalor-IH administered on arrival followed by Revalor-200 after approximately 90 d and harvested after approximately 192 DOF (REPEATED/192). [a,b-]Means without a common superscript differ ($P < 0.05$). The SE of the mean = 1.89.

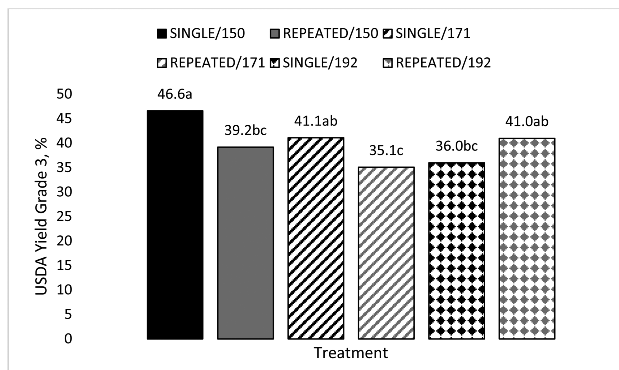

Figure 4. The interaction of implant strategy (all implants from Merck Animal Health, De Soto, KS) and days on feed ($P = 0.01$) on the proportion of USDA Yield Grade 3 carcasses in experiment 2. Treatments include: Revalor-XH (80 mg TBA and 8 mg E_2, uncoated; 120 mg TBA and 12 mg E_2, coated; 200 mg TBA and 20 mg E_2, total) administered on arrival and harvested after approximately 150 DOF (SINGLE/150), Revalor-IH (80 mg TBA and 8 mg E_2, uncoated) administered on arrival followed by Revalor-200 (200 mg TBA and 20 mg E_2, uncoated) after approximately 90 d and harvested after approximately 150 DOF (REPEATED/150), Revalor-XH administered on arrival and harvested after approximately 171 DOF (SINGLE/171), Revalor-IH administered on arrival followed by Revalor-200 after approximately 90 d and harvested after approximately 171 DOF (REPEATED/171), Revalor-XH administered on arrival and harvested after approximately 192 DOF (SINGLE/192), Revalor-IH administered on arrival followed by Revalor-200 after approximately 90 d and harvested after approximately 192 DOF (REPEATED/192). [a,b-]Means without a common superscript differ ($P < 0.05$). The SE of the mean = 2.10.

($P = 0.01$) for USDA Yield Grade 3 carcasses is shown in Figure 4. Heifers in SINGLE/150 treatment had the greatest proportion of carcasses grading USDA Yield Grade 3 and heifers from REPEATED/171 had the fewest carcasses grading USDA Yield Grade 3. Heifers in SINGLE/171 and REPEATED/192 treatments were intermediate to SINGLE/150, REPEATED/150, and SINGLE/192. Heifers in REPEATED/150 and SINGLE/192 did not differ from heifers in REPEATED/171. There was a tendency for an implant × DOF interaction ($P = 0.06$) for the proportion of carcasses over

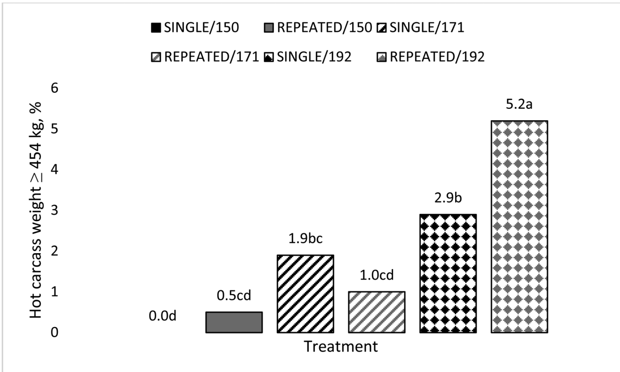

Figure 5. The interaction of implant strategy (all implants from Merck Animal Health, De Soto, KS) and days on feed (P = 0.06) on the proportion of carcasses greater than 454-kg in experiment 2. Treatments include: Revalor-XH (80 mg TBA and 8 mg E_2, uncoated; 120 mg TBA and 12 mg E_2, coated; 200 mg TBA and 20 mg E_2, total) administered on arrival and harvested after approximately 150 DOF (SINGLE/150), Revalor-IH (80 mg TBA and 8 mg E_2, uncoated) administered on arrival followed by Revalor-200 (200 mg TBA and 20 mg E_2, uncoated) after approximately 90 d and harvested after approximately 150 DOF (REPEATED/150), Revalor-XH administered on arrival and harvested after approximately 171 DOF (SINGLE/171), Revalor-IH administered on arrival followed by Revalor-200 after approximately 90 d and harvested after approximately 171 DOF (REPEATED/171), Revalor-XH administered on arrival and harvested after approximately 192 DOF (SINGLE/192), Revalor-IH administered on arrival followed by Revalor-200 after approximately 90 d and harvested after approximately 192 DOF (REPEATED/192). [a,b]Means without a common superscript differ ($P < 0.05$). The SE of the mean = 0.64.

454 kg in experiment 2 (Figure 5). Heifers from SINGLE/150 had the fewest heavy carcasses and heifers from REPEATED/192 had the greatest proportion of carcasses classified as over 454 kg compared with all other treatments ($P < 0.05$). Heifers from REPEATED/150 and REPEATED/171 did not differ ($P > 0.05$) from heifers in SINGLE/150. Heifers in SINGLE/171 treatment had a greater amount of carcasses classified as over 454 kg compared ($P < 0.05$) with heifers in the SINGLE/150 treatment and did not differ ($P \geq 0.05$) from heifers in REPEATED/150, REPEATED/171, or SINGLE/192 treatments. Heifers from SINGLE/192 had a greater proportion ($P < 0.05$) of carcasses over 454 kg compared with SINGLE/150, REPEATED/150, and REPEATED/171.

DISCUSSION

The average time on feed for feedlot cattle is approximately 201 d (Samuelson *et al.*, 2016). The payout period in first-generation, non-coated combination TBA + E_2 implants is approximately 90 d (Mader, 1998). At present, coated, long-acting implants in an initial and delayed-release formulation have become commercially available to extend the payout of hormones in excess of 200 d (FOIA, 2007, 2017a). The first initial and delayed-release combination implant made commercially available was the Revalor-XS (Merck Animal Health) implant (FOIA, 2007). Since 2007, a variety of other coated implants have been made available to producers for use in their operations (FOIA, 2007, 2014, 2017a, 2017b).

A challenge to using steroidal implants to improve heifer growth is the payout of the implant. This payout period is typically 60 to 120 d (Mader, 1998). Thus, cattle must be removed from pens to be reimplanted if these implants are used. Reimplantation allows for cattle to have hormonal payout throughout the entire feeding period when using first-generation, non-coated implants that typically only have an effective payout period of approximately 90 d (Mader, 1998), resulting in improvements in ADG, G:F, and HCW. The use of coated implants is an attractive alternative to producers who do not want to reimplant cattle. The reimplanting process has the potential to result in additional stress to the cattle and processing crew and can cause major disruptions in cattle DMI. This reduction in DMI can in turn result in negative effects on cattle performance and increase the cost of BW gain (Stanton, 1997). Reimplantation certainly has benefits for producers who perform terminal sorting or have the ability to reimplant cattle in a low-stress manner. These benefits include lower product cost of non-coated implants and the ability to market cattle within a pen as they become market-ready, thus reducing the impact of carcass discounts received for overly fat or heavy carcasses.

The use of combination TBA + E_2 implants has been demonstrated to increase final BW by 30 kg over non-implanted controls (Guiroy *et al.*, 2002; Parr et al., 2011a, 2011b; Smith *et al.*, 2018). Also, cattle receiving more than one combination TBA + E_2 implant, or greater total doses of TBA + E_2 have improvements in performance and HCW (Reinhardt and Wagner, 2014). Although no negative control was included in either of the current experiments, both experiments provide evidence that greater total doses of TBA and E_2 did not improve live or carcass-adjusted BW measures, which is inconsistent with what others have demonstrated previously (Reinhardt and Wagner, 2014). Although greater total doses of anabolic steroid hormones in steers and heifers have been reported to not alter final BW, ADG, or G:F (Guiroy *et al.*, 2002; Hilscher *et al.*, 2016; Ohnoutka *et al.*, 2018), it was alternatively noted that steers administered a coated implant (initial and delayed-release implant), Revalor-XS (Merck Animal Health, 200 mg TBA and 40 mg E_2) 213 d before harvest had greater final BW, ADG, and improved G:F compared with steers administered a Revalor-200 (Merck Animal Health, 200 mg TBA and 20 mg E_2) at 213 or 143 d before harvest (Smith *et al.*, 2018). Reasons for greater total doses of steroid hormones in heifers not resulting in performance responses could be attributed to greater levels of endogenous E_2 in circulation compared with steers (Heitzman, 1976).

In the current experiments, DMI was only moderately affected by implant treatment, and as DOF increased daily DMI was decreased in one of the two studies. Variable responses on DMI across day of serial harvest in the two different studies warrants further investigation; however, it has been demonstrated by others that DMI is not decreased as DOF increase in finishing heifers (Sissom *et al.*, 2007). Increasing DOF resulted in greater live and carcass-adjusted final BW in both studies, which is similar to what has been reported previously in heifers (Sissom *et al.*, 2007; Ohnoutka *et al.*, 2018). Likewise, as days of serial harvest increased, both live and carcass-adjusted ADG and G:F were decreased, similar to what others have reported in heifers previously (Sissom *et al.*, 2007; Ohnoutka *et al.*, 2018). As BW increases and cattle get closer to their mature BW, so does the amount of fat in live weight gain. Increased fat accumulation, as indicated by increased EBF with greater DOF, results in poorer gain efficiency, which occurred in the present experiment.

Alterations in HCW except for a tendency in experiment 1 or HCW gain did not occur in either experiment from this study because of implant treatment. Some have reported that greater total doses of anabolic steroids do not increase HCW in steers or heifers (Hilscher *et al.*, 2016), others have demonstrated this is not the case in steers (Smith *et al.*, 2018). Alterations in DP of heifers because of implant treatment were only noted in one of the two studies presented here. This variable response across the two experiments could be due to differences in DOF and overall carcass transfer between the two studies. Others have demonstrated that greater doses of steroid hormones improve DP (Reinhardt and Wagner, 2014); however, it has also been demonstrated previously that greater total doses of anabolic steroids do not alter DP in steers or heifers (Hilscher *et al.*, 2016). Lack of differences for DP with greater doses of steroid hormones could be attributable to differing durations of DOF, feeding season, and feeding location.

Back fat, LM area, marbling, and estimated EBF was only available for heifers in experiment 2. In experiment 2, marbling scores and HCW were not different between implant treatments, suggesting increased back fat accumulation was likely the cause of greater estimated EBF (Guiroy *et al.*, 2002) observed in the SINGLE group from experiment 2. Implant regimen did not alter the proportion of carcasses grading USDA Prime, Choice, Select, or No Roll in either experiment. This is consistent with what has been demonstrated in steers given increasing doses of anabolic hormones; however, alterations in the proportion of USDA Choice and Select carcasses have previously been reported in heifers administered greater doses of anabolic steroid hormones (Hilscher *et al.*, 2016). The use of greater doses of anabolic hormones in this study resulted in alterations in the proportion of carcasses classified as USDA Yield Grade 1, 4, and 5 in experiment 1 and Yield Grade 4 in experiment 2. Similar responses to alterations in USDA Yield Grade have been demonstrated previously in heifers administered increasing doses of anabolic steroids, but this response was not noted in steers (Hilscher *et al.*, 2016). The REPEATED heifers had a greater proportion of carcasses over 454 kg in experiment 1, but not in experiment 2 and this is likely a function of differing DOF.

The interaction of implant and DOF on the proportion of carcasses classified as USDA Yield Grade 2 and 3 in experiment 2 was not detected in experiment 1. The responses mirror each other in that the reduction in USDA Yield Grade 2 carcasses was attributable to increases in USDA Yield Grade 3 carcasses for each group, and the lack of consistency between the 2 experiments might be related to differing cattle types and duration of DOF between the two experiments.

Increasing DOF resulted in greater HCW, HCW gain, and DP in both experiments. These data agree with what has been reported previously for HCW responses in heifers fed for 129, 150, or 170 DOF (Sissom *et al.*, 2007) or 127, 148, and 167 DOF (Rathmann *et al.*, 2012). In experiment 2, increasing DOF resulted in greater BF, LM area, marbling scores, and estimated EBF%. Sissom *et al.* (2007) and Rathmann *et al.* (2012) demonstrated similar findings in that as DOF increase, there was a concomitant increase in BF, LM area, and marbling scores in heifers. In addition, the increases in marbling scores resulted a greater proportion of carcasses classified as USDA Prime in both of the current studies and a decrease in the proportion of carcasses classified as USDA Select in experiment 1, where heifers were fed for a greater amount of days than in experiment 2. As DOF increased, the proportion of carcasses classified as USDA Yield Grade 4 and 5 increased in both experiments in the present study. In addition, the amount of carcasses over 454 kg was also increased in both experiments as days of serial harvest increased.

The 9.8% difference in carcass transfer values between the two experiments is likely a function of differing durations of DOF. In experiment 1, heifers were on feed for a longer period than in experiment 2. The heifers in experiment 1 were also a fed high-concentrate finishing diet for a greater period of time. The influence of greater caloric intake might be related to alterations in carcass transfer of these heifers across the days of serial harvest.

These data indicate that growth and HCW did not differ between a single initial and delayed-release implant administered on arrival and an initial and reimplant protocol using non-coated implants. The fact that greater doses of TBA and E_2 did not improve performance in heifers should be exploited. Increasing DOF resulted in poorer ADG and G:F but increased HCW, which could be beneficial to carcass sellers in certain feeding environments. Also, increasing DOF resulted in fatter carcasses. Heifers administered REPEATED had less EBF accumulation at equal DOF compared with SINGLE. A repeated implant protocol could result in greater gain and HCW if all heifers would have been harvested at equal chemical maturity.

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Conflict of interest statement. None declared.

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