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Effects of feeding duration, implant dose, and terminal window duration on growth performance and carcass characteristics of feedyard steers and heifers

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ABSTRACT

Objective: Our objective was to evaluate effects of feeding duration (days on feed, DOF), terminal window (TW), and implant program dose on growth performance and carcass characteristics of beef steers and heifers.

Materials and Methods: Heifers in Exp. 1 (n = 3,360; 351 ± 31 kg) and Exp. 2 (n = 3,778; 310 ± 28 kg) were used in randomized complete block designs with 3 × 2 factorial treatment arrangements. In Exp. 1, factor 1 was DOF (139, 162, and 183) and factor 2 was TW (60 or 100). In Exp. 2, factor 1 was implant program {(1) IH/H—Component TE-IH with Tylan on d 0 followed by a Component TE-H with Tylan [140 mg of trenbolone acetate (TBA):14 mg of estradiol; Elanco], (2) IH/200—Component TE-IH with Tylan on d 0 followed by a Component TE-200 with Tylan, and (3) 200/200—Component TE-200 with Tylan on d 0 and at reimplant} and factor 2 was TW (60 or 100). In Exp. 3, feedlot data from an industry database (Benchmark, Elanco Knowledge Solutions, Kansas City, KS) was used in an observational study and organized by sex and implant program [steers = IS/200 (total of 280 mg of TBA and 36 mg of estradiol), XS (200 mg of TBA and 40 mg of estradiol), and 200/200 (a total dose of 400 mg of TBA and 40 to 56 mg of estradiol or estradiol benzoate); heifers = IH/200 (total of 280 mg of TBA and 28 mg of estradiol) and 200/200]. Repeated-measure and nonlinear broken-slope models were used to evaluate TW on live performance.

Results and Discussion: In Exp. 1, ADG decreased ($P = 0.03$) and final BW, marbling score, hot carcass weight (HCW), backfat thickness, and calculated empty body fat (EBF) increased ($P < 0.03$) as DOF increased. In Exp. 2, greater implant program dose tended ($P \leq 0.10$) to increase ADG and DMI and increase ($P \leq 0.02$) G:F, HCW, DP, and LM area. Furthermore, overall dose reduced ($P \leq 0.03$) marbling score and EBF. In Exp. 3, interactions between implant program, live performance, and TW were detected ($P < 0.001$). Steers given 200/200 exhibited the greatest ($P < 0.05$) ADG, followed by XS and IS/200 from TW 50 to 100. Inversely, steers given XS had the greatest ($P < 0.05$) F:G, followed by IS/200 and 200/200 from TW 50 to 90. Heifers administered 200/200 exhibited greater ($P < 0.05$) ADG between TW 50 to 70 and reduced ($P < 0.05$) F:G through TW 110 compared with IH/200.

Conclusions and Applications: Increased DOF resulted in reduced ADG and increased HCW and EBF. Increased implant dose improved live performance and HCW. There is a finite number of TW days before growth suffers from inadequate stimuli. Furthermore, cattle type, implant program dose, DOF, and TW all require consideration when designing implant programs.

Key words: implant, terminal window, days on feed, trenbolone acetate, estradiol

INTRODUCTION

Growth-promoting implants routinely offer the greatest return on investment relative to all other growth-enhancing technologies available to beef producers (Griffin and Mader, 1997). This is accomplished by improvements in ADG, hot carcass weight (**HCW**), and feed efficiency (Reinhardt and Wagner, 2014). As such, more than 90% of cattle entering the feedlot phase of production receive at least one implant, and a majority (≥80%) of lighter (BW <318 kg) steers and heifers receive at least 2 (APHIS, 2013; Smith et al., 2019). This is due to the average payout of compressed pellet implants generally believed to be 60 to 120 d, which is on average less than the days on feed (**DOF**) required to reach an optimum endpoint in feedyard cattle (Hilscher et al., 2016; Smith et al., 2018). The goal of an implant program is to maximize lean muscle

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growth while still achieving desired carcass quality outcomes. To accomplish these goals, cattle type, age, initial weight, sex, and DOF must be considered when designing an implant program (Hilscher et al., 2016). Terminal window (**TW**), which is the duration between terminal implant administration and slaughter, is also an important factor in the design of implant programs because it coincides with the portion of the feeding period when live growth performance is least efficient. However, literature to define an optimum TW is lacking and most recommendations come from practical experience or closeout comparisons (Ohnoutka et al., 2019). Therefore, the objectives of this research were to evaluate the interactions between DOF, implant program dose, and TW in finishing heifers within controlled experiments as well as evaluate the effects of TW in steer and heifer population data.

MATERIALS AND METHODS

All experimental methods were conducted at commercial research facilities following the guidelines stated in the *Guide for the Care and Use of Agricultural Animals in Research and Teaching* (FASS, 2020).

Exp. 1: DOF by TW

Animals, Blocking, and Study Design. A total of 3,360 (initial BW = 351 ± 31 kg) British × Continental heifers procured from stocker and backgrounding operations in the Texas Panhandle and eastern New Mexico were used in a randomized complete block study design conducted at a commercial feedyard in the Texas Panhandle. Heifers were blocked by arrival date and sorted randomly based on chute presentation into 1 of 6 pens. There was 1 replication per block and 8 total replications with 70 heifers per pen. Within block, pens were assigned randomly to 1 of 6 treatments within a 3 × 2 factorial treatment arrangement.

Treatments. The first factor of DOF duration (139, 162, or 183 d) was used to evaluate a linear increase of fat composition in heifers. Within block, a projected endpoint (~150 DOF) was determined based on the site's experience with historical performance of the source of similar heifers and an acceptable degree of finish for the anticipated marketing time. Therefore, DOF for the experiment were selected to be 11 d before and 11 and 33 d after projected endpoint. The 3 slaughter groups were separated by 23 or 21 d, and pens in the same DOF treatment within block were slaughtered on the same day.

The second treatment factor was differing lengths of TW. At enrollment, all heifers were implanted with Component TE-IH with Tylan [80 mg of trenbolone acetate (**TBA**):8 mg of estradiol, Elanco Animal Health], and all heifers received a Component TE-200 with Tylan (200 mg of TBA:20 mg of estradiol, Elanco) for the terminal implant. Each DOF duration was assigned to TW of either 60 or 100 d in this 3 × 2 factorial treatment arrangement, for a total of 6 treatments. The number of days on the initial implant (39 to 123 d) varied due to DOF and TW.

BW, Feed Delivery, and Carcass Measurements. For the calculation of growth performance, heifers were group weighed by pen on a certified platform scale on study d 0 (the day after processing) and on the days of reimplant for both 60 and 100 TW treatments. Body weights were measured before feeding, and a 4% pencil shrink was applied. On the day of reimplant, cattle in both TW treatments were weighed on the platform scale before processing. Cattle that were not reimplanted on that day were immediately returned to the home pens. On the morning of shipment for slaughter, heifers were weighed to determine final BW on the truck after loading. Heifers from each pen were loaded in 2 trucks, and no truck contained heifers from multiple pens.

Feed bunks were visually checked daily, and feed calls were made to provide feed to appetite and such that feed carryover in the bunk was minimized. Feed was delivered 3 times daily, and the amount of feed delivered was recorded electronically to the nearest 4.54 kg (10 lb). The starter diet for all treatments was Ramp (Cargill Corn Milling). In addition, loose feeder hay was top dressed onto the starter for a minimum of 3 d after arrival. Transition to the finishing diet was done using a 2-ration approach where 10 to 15% of the daily feed call of Ramp was systematically replaced with finish diet. Increases in the amount of finish diet were made every 2 to 4 d, resulting in an average of 19 d until the animals were fed only the finish diet (18 to 20 d depending on block). The finish diet would be consistent with other finish diets fed in the High Plains, with most of the megacalories coming from steamed-flaked corn and corn gluten feed. Finish diets were prepared in the on-site feed mill, and microingredients were weighed and added to the feed batch using a Micro Machine (Micro Technologies). Monensin (Rumensin 90, Elanco) was included in Ramp (20 g/907 kg of DM) and finish diets (42.1 g/907 kg of DM) throughout the experiment. Tylosin (Tylan, Elanco) was included in the finish diet at 9.6 g/907 kg of DM, and melengestrol acetate (MGA, Zoetis) was included in the finish diet at 0.40 mg/heifer·d^{-1}. All heifers were fed 27.3 g of ractopamine HCl (Optaflexx, Elanco)/907 kg of DM for precisely 29 d before slaughter.

Cattle from the study were transported to the slaughter facility (Tyson Foods, Amarillo, TX) such that pens and cattle within were maintained as lots and were presented randomly for slaughter. 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 slaughter and affixed a slaughter sequence number to each carcass. Plant carcass ID and HCW were recorded and verified by slaughter sequence number. After approximately 36 h of chill time, carcasses were evaluated based on USDA QG standards (USDA, 1997) as assigned by a USDA grader; YG was assigned by camera system. Measurements were obtained from packing plant records and verified against the initial tag transfer and carcass ID. Dressing percentage for each pen was calculated as the mean HCW/mean shrunk live weight × 100. Empty body fat was calculated using equations from Guiroy et al. (2002).

Statistical Analysis. Data were analyzed using the mixed procedure of Stata 14 (Statacorp) with pen as the experimental unit. The model included fixed effects of DOF treatment, TW treatment, DOF × TW interaction, and the random effect of block. Categorical data (carcass grade and yield distributions, and liver scores) were analyzed using logistic regression (binreg; Stata 14) with fixed effects as described above. There were no differences ($P > 0.05$) in the frequency of mortality or removal of cattle between the treatments; therefore, growth performance was calculated after excluding dead and removed cattle. Multiple comparisons of LSM were conducted within the mixed procedure using the Tukey adjustment.

Exp. 2: Implant Program Dose by TW

Animals, Blocking, and Study Design. A total of 3,778 (initial BW = 310 ± 28, kg) British × Continental heifers procured from the High Plains (New Mexico, Texas, and Oklahoma) and Southeast (Alabama, Georgia, Kentucky, and Tennessee) were used in this randomized complete block study conducted at a commercial feedyard in the Texas Panhandle. Heifers were blocked by arrival date and sorted randomly based on presentation to the chute, into 1 of 6 pens. There was 1 replication per block and 9 total replications with 69 or 70 heifers per pen. Within block, pens were assigned randomly to 1 of 6 treatments within a 3 × 2 factorial treatment arrangement.

Treatments. The first factor was 1 of 3 implant programs: (1) **IH/H**—Component TE-IH with Tylan on d 0 followed by a Component TE-H with Tylan (140 mg of TBA:14 mg of estradiol; Elanco), (2) **IH/200**—Component TE-IH with Tylan on d 0 followed by a Component TE-200 with Tylan, and (3) **200/200**—Component TE-200 with Tylan on d 0 and at reimplant.

The second treatment factor was a TW of 60 or 100 d before slaughter.

BW, Feed Delivery, and Carcass Measurements. Pens of heifers within block were moved to the scale and were then weighed by pen using a certified platform scale on study d 0 (the day after initial processing), the morning of reimplant, and the morning of shipment for the calculation of live growth performance. Bodyweight measurements were conducted before initial feeding, and a 4% pencil shrink was applied to interim and final BW (0% shrink on d 0 BW). On the morning of shipment to slaughter, each pen was loaded after weighing into 2 trucks, and no truck contained heifers from multiple pens.

Feed bunks were visually checked daily, and feed calls were made to provide feed to appetite and such that feed carryover in the bunk was minimized. Feed was delivered 3 times daily, and the amount delivered was recorded electronically to the nearest 4.54 kg (10 lb). The starter diet for all treatments was Ramp (Cargill Corn Milling). In addition, loose feeder hay was top dressed onto the starter for a minimum of 3 d after arrival. Transition to the finishing diet was done using a 2-ration approach where 10 to 15% of the daily feed call of Ramp was systematically replaced with finish the diet. Increases in the amount of finish diet were made every 2 to 4 d. Finish diets were prepared in the on-site feed mill, and microingredients were weighed and added to the feed batch using a Micro Machine (Micro Technologies). Monensin (Rumensin 90, Elanco) was included in the Ramp (20 g/907 kg of DM) and finish diets (42.1 g/907 kg of DM) throughout the experiment. Tylosin (Tylan, Elanco) was included in the finish diet at 9.2 g/907 kg of DM, melengestrol acetate (MGA, Zoetis) was included in the finish diet at 0.40 mg per animal daily, and all heifers were fed 27.3 g/907 kg of ractopamine HCl (Optaflexx, Elanco) for an average of 30.5 d (range 30 to 31) before slaughter. Slaughter dates were selected based on previous knowledge of cattle and visual appraisal of finish; all treatments were slaughtered on the same DOF.

Heifers in this study were slaughtered at the same facility (Tyson Foods, Amarillo, TX), and the methods of tag transfer and data collection were the same as outlined in the previous experiment.

Statistical Analysis. Data were analyzed using the mixed procedure of Stata 14 (Statacorp) with pen as the experimental unit. The model included the fixed effects of implant program, TW treatment, and DOF × TW interaction and the random effect of block. Categorical data (removals, mortality, carcass grade and yield distributions, and liver scores) were analyzed using logistic regression (binreg; Stata 14) with fixed effects as described above. There were no differences ($P = 0.12$) in the frequency of mortality or the number of animals removed between treatments; therefore, growth performance was calculated with dead and removed animals excluded. Multiple comparisons of LSM were conducted within the mixed procedure using the Tukey adjustment.

Exp. 3: Observational Study

Data Set Creation. This analysis was conducted on data collected from an industry database (Elanco Knowledge Solutions, Kansas City, KS), which receives data from approximately 8 million cattle per year currently and has been used in the US cattle feeding industry since 1995. Producers voluntarily contribute their production and carcass records to the database to further industry knowledge and leverage their production records to improve operational efficiency.

Ten years (January 1, 2009, to December 31, 2018) of data were used for this analysis, which represented 608,158 lot closeout records. Within feedyards cattle were managed by lots, which signifies a group of cattle typically arriving within the same time period that are a similar class. Lots can be made up of cattle from multiple origins or from a sole ranch. By classifying cattle into a lot, feedyards track the financial information of purchased cattle from arrival to slaughter.

To reduce the variability of the data set and select lots that contained the targeted data for the analysis, the data were filtered. All sex classifications except for steers and heifers (e.g., cows, heiferettes, and so on), cattle originating from Mexico, and lots that spanned multiple pens (sorted) were excluded. Only records from feedyards located in the Central Plains, High Plains, North Plains, Midwest, or Pacific Northwest regions of the United States were included. To ensure that performance estimates collected from the closeout data were robust, only lots with ≥35 and ≤500 animals received were included. Only initial weights ≥227 kg and ≤432 kg and final weights ≥432 kg and ≤841 kg were included. To ensure that gain and performance estimates were credible, ADG was required to be ≥0.9 kg and ≤2.3 kg, and F:G needed to be ≥5 and ≤9. Lots were further required to have mortality ≤5%, and the TW needed to ≥50 d and ≤120 d.

These data reduction steps resulted in a data set that contained 84,548 (steers = 47,545; heifers = 37,003) live performance closeout lot records, which represented 11,440,211 (steers = 6,531,670; heifers = 4,908,541) animals.

Treatments. Implant treatments were selected due to their high frequency of use in the database, as well as their varying overall dose of TBA. Steer treatments were **200/200** (a total dose of 400 mg of TBA and 40 to 56 mg of estradiol or estradiol benzoate), **IS/200** (total of 280 mg of TBA and 36 mg of estradiol), and **XS** (200 mg of TBA and 40 mg of estradiol). Heifer treatments were 200/200 and **IH/200** (total of 280 mg of TBA and 28 mg of estradiol). Due to the redundancy of implants across manufacturers, currently available implants with similar dose were grouped together. Implants that contained 200 mg of TBA included Component TE-200 (Elanco), Component TE-200 with Tylan (Elanco), Revalor-200 (Merck), and Synovex Plus (Zoetis). Implants denoted as IS contained 80 mg of TBA and included Component TE-IS with Tylan (Elanco), Component TE-IS (Elanco), and Revalor-IS (Merck). Implants denoted as IH contained 80 mg of TBA and included Component TE-IH with Tylan (Elanco), Component TE-IH (Elanco), and Revalor-IH (Merck). The XS treatment was represented by Revalor-XS (Merck), in which a portion of the compressed pellets are coated for a delayed release. During the time in which data were collected, there were not enough heifers treated with Revalor-XH (Merck) to justify their inclusion in the analysis.

TW Calculation for XS. Steers receiving XS were not reimplanted due to the long-acting nature of XS. Previous research has shown that the coating of the delayed-release portion of the implant dissolves approximately 80 d after implantation and becomes biologically active (Parr et al., 2011). Therefore, the XS implant TW was calculated as slaughter date minus implant date (DOF) minus 80 d. The TW was then converted to an index of TW rounded to the nearest 10 d. For example, a lot with a TW of 64 d would have a TW index of 60, and a 65-d TW would have a TW index of 70.

Statistical Analysis. Repeated-measures times-series models were constructed using PROC GLM (SAS 9.4, SAS Institute Inc.), with TW index as the repeated measure nested within implant treatment. Covariates included in the model were geographic region, close quarter (quarter of the year the lot was closed), close year, arrival weight, medical charges, and mortality percentage. Full and reduced models were constructed to evaluate the effects of the covariates.

Broken-slope models were calculated using the nonlinear function within JMP 15 specialized modeling package. The program fits a nonlinear response based on a predictor formula using a least squares method. The predictor formula was the same for all 3 variables; however, the parameters were fit for each. The predictor formula was as follows:

$$IF\begin{bmatrix}\text{Terminal window index} < c \Rightarrow a + b \times \text{Terminal window index} \\ \text{Else} \Rightarrow a + b \times c + d \times (\text{Terminal window index} - c)\end{bmatrix},$$

where a = intercept; b = prebreak slope; c = model break point; and d = postbreak slope.

RESULTS

Exp. 1

Live Performance. There were no TW × DOF interactions detected ($P \geq 0.27$; Table 1) for any of the growth performance traits. Therefore, main effects are shown. Final BW and total gain increased as DOF increased ($P < 0.01$), whereas ADG decreased as DOF increased ($P = 0.03$) and G:F was unaffected by DOF ($P = 0.30$). Total gain and ADG tended to be greater ($P \leq 0.08$) for the 60-d TW (229 kg and 1.42 kg/d, respectively) compared with the 100-d TW (225 kg and 1.40 kg/d, respectively). Feed conversion was unaffected by TW ($P = 0.98$). There were no effects ($P \geq 0.15$) on DMI from either DOF or TW.

Carcass Performance. A TW × DOF interaction was detected ($P = 0.03$; Table 2) for percentage of carcasses grading Prime, such that the largest percentage of carcasses graded Prime for the 183 DOF and 60-d TW and the 162 DOF and 100-d TW, but other treatments were similar. Hot carcass weight and DP were unaffected by TW ($P \geq 0.34$). Dressing percentage increased ($P = 0.01$) as DOF increased (63.1, 64.3, and 64.7% for 139, 162, and 183 DOF, respectively). Marbling score, HCW, backfat thickness, and calculated empty body fat increased ($P \leq 0.03$) as DOF were extended, indicative of composition changes as physiological maturity advanced.

Table 1. Exp. 1—Finishing performance of heifers with differing terminal implant window and days on feed (DOF)

	DOF[1]			Terminal window (TW)[2]			*P*-value[4]		
Item	**139**	**162**	**183**	**60**	**100**	**SEM[3]**	**DOF**	**TW**	**DOF × TW**
Pens, no.	16	16	16	24	24	—	—	—	—
Days on feed	139[a]	162[b]	183[c]	161	161	0.95	0.01	1.00	1.00
Initial BW, kg	343	343	344	344	344	1.50	0.69	0.62	0.39
Final BW, kg	543[a]	569[b]	601[c]	573	569	4.10	0.01	0.17	0.73
Total gain, kg	199[a]	226[b]	256[c]	229	225	3.64	0.01	0.08	0.29
ADG, kg/d	1.44[b]	1.40[a]	1.40[ab]	1.42	1.40	0.02	0.03	0.06	0.29
DMI, kg/d	9.33	9.43	9.53	9.45	9.41	0.14	0.94	0.15	0.27
F:G	6.50	6.77	6.81	6.65	6.73	0.09	0.30	0.98	0.39
G:F	0.15	0.15	0.15	0.15	0.15	0.002	0.30	0.98	0.39

[a–c]Within main effect, mean values with unlike superscripts are different ($P < 0.05$).

[1]Cattle were projected to require 150 d to reach slaughter weight.

[2]Terminal implant window length (days from terminal implant to slaughter).

[3]SEM = greatest of the 2 SEM.

[4]This study used a 3 × 2 factorial treatment arrangement, with factor 1 being DOF and factor 2 TW.

Table 2. Exp. 1—Carcass performance of heifers with differing terminal implant window and days on feed (DOF)

	DOF[1]			Terminal window (TW)[2]			*P*-value[4]		
Item	**139**	**162**	**183**	**60**	**100**	**SEM[3]**	**DOF**	**TW**	**DOF × TW**
Carcass metrics									
HCW,[5] kg	342[a]	366[b]	388[c]	367	364	2.81	0.01	0.34	0.86
DP, %	63.1	64.3	64.7	64.1	64	0.21	0.01	0.49	0.61
LM area, cm^2	89.7	91.0	93.5	91.0	91.6	1.06	0.31	0.83	0.79
Marbling score	456[b]	494[a]	502[a]	483	479	9.35	0.01	0.70	0.56
Fat thickness, cm	1.37[b]	1.60[a]	1.83[a]	1.60	1.57	0.03	0.01	0.65	0.81
EBF,[6] %	30.0[a]	30.7[b]	32.1[c]	30.6	30.3	0.20	0.01	0.54	0.65
QG									
Prime, %	1.46[b]	3.34[a]	3.70[a]	2.84	2.43	0.99	0.01	0.80	0.03
Choice, %	73.3[b]	78.2[a]	79.8[a]	78.6	75.8	1.92	0.02	0.46	0.56
Select, %	23.5[a]	16.9[b]	13.5[c]	15.7	19.6	1.86	0.01	0.26	0.66
YG									
YG 1, %	20.5[a]	12.2[b]	7.42[c]	10.9	14.3	1.79	0.01	0.20	0.69
YG 2, %	47.3[a]	36.0[b]	30.9[c]	37.8	37.8	2.14	0.01	0.17	0.26
YG 3, %	27.7[b]	38.6[a]	39.1[a]	35.5	34.3	2.12	0.01	0.61	0.49
YG 4, %	3.64[a]	10.6[b]	18.2[c]	9.75	8.43	1.72	0.01	0.22	0.99
YG 5, %	0.24[a]	1.66[b]	3.12[c]	1.04	1.16	0.59	0.01	0.57	0.59

[a–c]Within main effect, mean values with unlike superscripts are different ($P < 0.05$).

[1]Cattle were projected to require 150 d to reach slaughter weight.

[2]Terminal implant window length (days from terminal implant to slaughter).

[3]SEM = greatest of the 2 SEM.

[4]This study used a 3 × 2 factorial treatment arrangement, with factor 1 being DOF and factor 2 TW.

[5]HCW = hot carcass weight.

[6]Empty body fat (EBF) was calculated according to Guiroy et al. (2001).

Table 3. Exp. 2—Finishing performance of heifers with differing implant programs and terminal windows

	Implant program			Terminal window (TW)[1]			*P*-value[3]		
Item	IH/H[4]	IH/200[5]	200/200[6]	60	100	SEM[2]	Dose	TW	Dose × TW
Pens, no.	18	18	18	27	27	—	—	—	—
Days on feed	171	171	171	171	171	—	—	—	—
Initial BW, kg	308	309	308	309	309	5.55	0.59	0.98	0.14
Final BW, kg	568	570	574	570	572	4.99	0.14	0.30	0.79
Total gain, kg	261[a]	262[ab]	266[b]	262	264	4.10	0.09	0.26	0.79
ADG, kg/d	1.52[a]	1.53[ab]	1.56[b]	1.53	1.54	0.02	0.09	0.26	0.81
DMI, kg/d	9.03[a]	8.87[b]	9.01[ab]	8.94	9.00	0.15	0.10	0.39	0.49
F:G	5.94[b]	5.78[a]	5.78[a]	5.84	5.84	0.01	0.01	0.76	0.53
G:F	0.16[b]	0.17[a]	0.17[a]	0.17	0.17	0.001	0.01	0.73	0.53

[a,b]Within main effect, mean values with unlike superscripts are different ($P < 0.05$).

[1]Terminal implant window length (days from terminal implant to slaughter).

[2]SEM = greatest of the 2 SEM.

[3]This study used a 3 × 2 factorial treatment arrangement, with factor 1 being implant program and factor 2 TW.

[4]IH/H = Component TE-IH with Tylan followed by Component TE-H with Tylan (Elanco).

[5]IH/200 = Component TE-IH with Tylan followed by Component TE-200 with Tylan (Elanco).

[6]200/200 = Component TE-200 with Tylan followed by Component TE-200 with Tylan (Elanco).

Exp. 2

Live Performance. There were no implant program × TW interactions detected ($P \geq 0.49$) for any growth performance variables (Table 3). There was a tendency ($P < 0.09$) for an increase in ADG as overall implant program dose increased, with 200/200 exhibiting the greatest (1.56 kg/d), followed by IH/200 (1.53 kg/d) and IH/H (1.52 kg/d). There was an increase ($P = 0.01$) in G:F for both IH/200 and 200/200 relative to IH/H (0.17 and 0.17 compared with 0.16, respectively). There were no effects from TW detected ($P \geq 0.26$) for final BW, ADG, or G:F.

Carcass Performance. There were no implant program × TW interactions detected for HCW or QG distributions ($P \geq 0.62$; Table 4). Heifers receiving 200/200 exhibited greater ($P < 0.02$) HCW, DP, LM area, and number of carcasses grading Select than IH/H, with IH/200 being intermediate. The 200/200 program exhibited reduced ($P < 0.03$) marbling score, fat thickness, calculated empty body fat, and number of carcasses grading Prime and Choice compared with IH/H, with IH/200 being intermediate. A tendency was found ($P = 0.06$) for an implant program × TW interaction for DP such that dress was similar in 100- and 60-d TW for IH/H, greater for the 100-d TW compared with 60 d for IH/200, and reduced in the 100-d TW compared with the 60-d TW for 200/200. Terminal implant window did not affect ($P \geq 0.27$) LM area, fat thickness, or empty body fat; however, marbling score was greater ($P = 0.04$) for the 60-d TW compared with 100 d (480 and 472, respectively).

An implant program × TW interaction tended ($P = 0.08$) to occur for the percentage of carcasses classified YG 1, such that the number of YG 1 carcasses was similar between TW treatments for IH/H and 200/200, whereas the number of YG 1 carcasses was reduced in the 60-d TW compared with 100 d for IH/200. Carcasses were leaner ($P < 0.03$) for 200/200 and similar between IH/H and IH/200. The percentage of carcasses classified as YG 1 was greatest ($P = 0.02$) for 200/200 and similar between IH/H and IH/200. An implant program × TW interaction also tended ($P = 0.07$) to occur for the percentage of YG 2 carcasses. The percentage of YG 2 carcasses was similar between TW for IH/200 but was increased for the 100-d TW for IH/H and was reduced for the 100-d TW for 200/200. Although the percentage of carcasses classified as YG 2 was not different ($P = 0.12$) among implant doses, YG 2 frequency was reduced ($P = 0.04$) for the 60-d TW compared with the 100-d TW. A dose × TW interaction tended ($P = 0.06$) to occur for the percentage of YG 4 carcasses, such that the number of YG 4 carcasses was similar between TW for 200/200 but was reduced for the 100-d TW compared with 60 d for IH/H and was increased in the 100-d TW for IH/200 dose.

Exp. 3: Observational Study

Time-Series Implant Program Comparisons. Implant program, TW, and implant program × TW were significant ($P < 0.05$) in describing the variation of DMI, ADG, and F:G for both steers and heifers. Seasonal and yearly variation along with health status and BW at arrival were used as covariates within the model. The addition of these covariates improved the variation explained by the model and allowed for a more precise comparison

Table 4. Exp. 2—Carcass performance of heifers with differing implant programs and terminal windows

Item	Implant program			Terminal window (TW)[1]			*P*-value[3]		
	IH/H[4]	IH/200[5]	200/200[6]	60	100	SEM[2]	Dose	TW	Dose × TW
Carcass metrics									
HCW,[7] kg	361[a]	363[ab]	366[b]	363	364	3.55	0.02	0.41	0.64
DP, %	63.5[a]	63.6[ab]	63.8[b]	63.7	63.6	0.002	0.02	0.73	0.06
LM area, cm²	88.7[a]	89.3[a]	91.4[b]	89.5	90.1	0.52	0.01	0.27	0.82
Marbling score	489[a]	479[ab]	461[b]	480	472	6.34	0.01	0.04	0.90
Fat thickness, cm	1.66[a]	1.64[ab]	1.59[b]	1.63	1.63	0.03	0.03	0.82	1.00
EBF,[8] %	30.9[a]	30.7[a]	30.3[b]	30.7	30.6	0.21	0.01	0.82	0.97
QG									
Prime, %	4.63[a]	3.86[a]	1.36[b]	2.90	2.91	0.75	0.02	0.37	0.66
Choice, %	72.4[a]	70.8[ab]	67.2[b]	71.4	68.9	2.45	0.04	0.09	0.62
Select, %	21.8[a]	23.9[a]	29.9[b]	26.1	24.0	2.49	0.01	0.24	0.89
YG									
YG 1, %	7.42[a]	7.38[a]	9.67[b]	7.79	8.41	1.19	0.02	0.73	0.08
YG 2, %	35.2	36.1	40.3	35.7	38.6	1.67	0.12	0.04	0.07
YG 3, %	41.6	42.1	39.6	43.1	39.2	1.44	0.66	0.27	0.94
YG 4, %	13.5[a]	12.0[a]	8.14[b]	10.9	11.1	1.31	0.01	0.10	0.06
YG 5, %	0.98	0.98	0.95	0.75	1.25	0.35	0.93	0.21	0.85

[a,b]Within main effect, mean values with unlike superscripts are different ($P < 0.05$).
[1]Terminal implant window length (days from terminal implant to slaughter).
[2]SEM = greatest of the 2 SEM.
[3]This study used a 3 × 2 factorial treatment arrangement, with factor 1 being implant program and factor 2 TW.
[4]IH/H = Component TE-IH with Tylan followed by Component TE-H with Tylan (Elanco).
[5]IH/200 = Component TE-IH with Tylan followed by Component TE-200 with Tylan (Elanco).
[6]200/200 = Component TE-200 with Tylan followed by Component TE-200 with Tylan (Elanco).
[7]HCW = hot carcass weight.
[8]Empty body fat (EBF) was calculated according to Guiroy et al. (2001).

of the interaction between TW and implant program. In steers, the full model accounted for more variation than the reduced (0.12, 0.15, and 0.04, respectively) model for DMI, ADG, and F:G, resulting in R^2 values of 0.45, 0.30, and 0.32, respectively. Similarly, the full model for heifers improved the R^2 compared with the reduced model (0.06, 0.13, and 0.05, respectively), resulting in R^2 of 0.43, 0.28, and 0.30 for DMI, ADG, and F:G, respectively.

Implant program × TW interactions were detected ($P < 0.001$) for DMI, ADG, and F:G in the steer analysis (Figure 1). From TW index d 50 through 90, 200/200 exhibited the greatest ($P < 0.05$) ADG, followed by XS, which was greater ($P < 0.05$) than IS/200. On TW index d 100 and 110, 200/200 and XS had greater ($P < 0.05$) ADG than IS/200. There were no differences between the implant programs on TW index d 120. Implant programs exhibited differentiated F:G from d 50 through 90. Steers given XS had the greatest ($P < 0.05$) F:G, followed by IS/200, which was greater ($P < 0.05$) than 200/200. During d 100 through 110, F:G was reduced for 200/200 compared with both IS/200 and XS. On d 120, F:G for 200/200 was reduced ($P < 0.05$) compared with IS/200, and XS was intermediate. Across all TW indices, XS had greater ($P < 0.05$) DMI than IS/200. The 200/200 had intermediate DMI on d 50, 80, and 90, with 200/200 being greater ($P < 0.05$) and IS/200 being less ($P < 0.05$). On d 60 and 70, 200/200 and XS were greater ($P < 0.05$) than IS/200 but not different from each other. On d 100 and 110, 200/200 and IS/200 were less ($P < 0.05$) than XS but not different from each other.

Similar to the steer analysis, an interaction between implant program and TW index was detected ($P < 0.001$) for heifer DMI, ADG, and F:G (Figure 2) . Heifers receiving 200/200 exhibited greater ($P < 0.05$) ADG than IH/200 from d 50 through 70. Heifers given 200/200 also exhibited improved ($P < 0.05$) F:G from d 50 through 110. Heifers given 200/200 displayed greater ($P < 0.05$) DMI on d 50 through 70 and less ($P < 0.05$) DMI on d 80 through 100.

Time-Series and Broken-Slope TW Comparisons. Comparisons of TW indexes were not evaluated across implant programs to minimize the multiple comparison requirement (Figure 3). Furthermore, multiple comparisons were not made across all TW index values within implant program; rather, comparisons of interest were only made

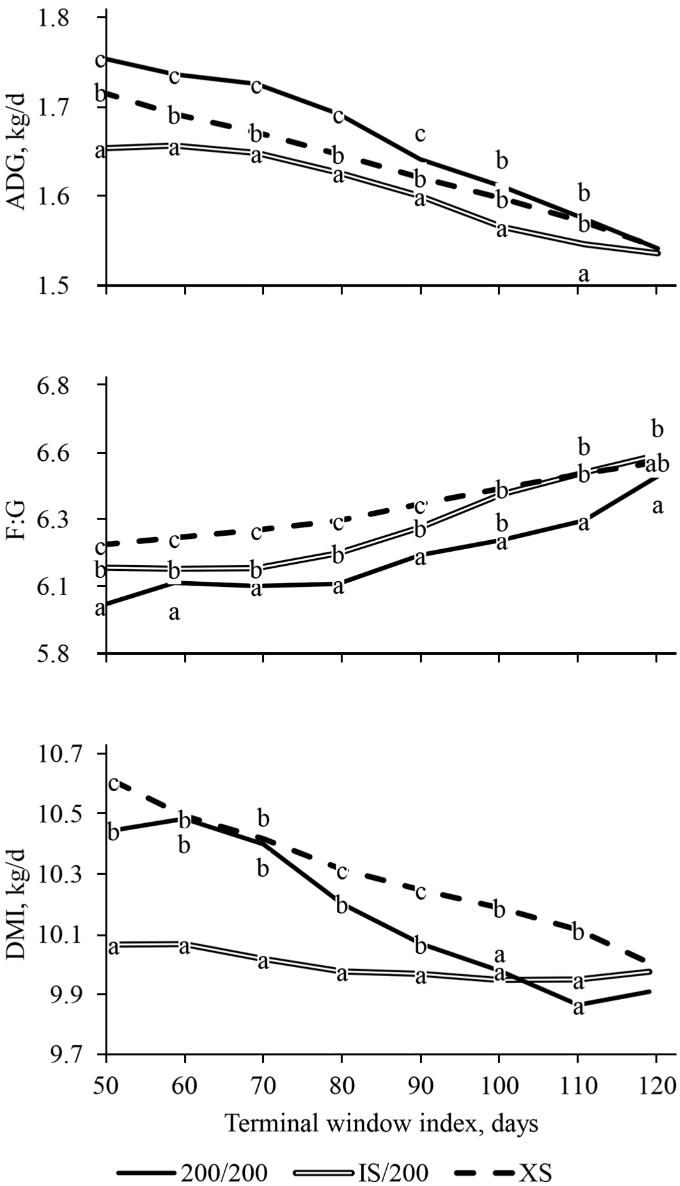

Figure 1. Effects of implant program and terminal window index on ADG (above), feed conversion ratio (F:G, middle), and DMI (below) in steers. 200/200 = a total dose of 400 mg of trenbolone acetate (TBA) and 40 to 56 mg of estradiol or estradiol benzoate; IS/200 = total of 280 mg of TBA and 36 mg of estradiol; and XS = 200 mg of TBA and 40 mg of estradiol. Significance of variation explained by the model was $P < 0.001$, and the implant program × terminal window index interaction was $P < 0.001$ for all variables. Pooled root mean squared errors for ADG, F:G, and DMI, respectively, were 0.35, 0.45, and 1.64. Values containing different letters within a figure panel are different ($P < 0.05$) within terminal window index. Figure not presented on a 0-axis basis.

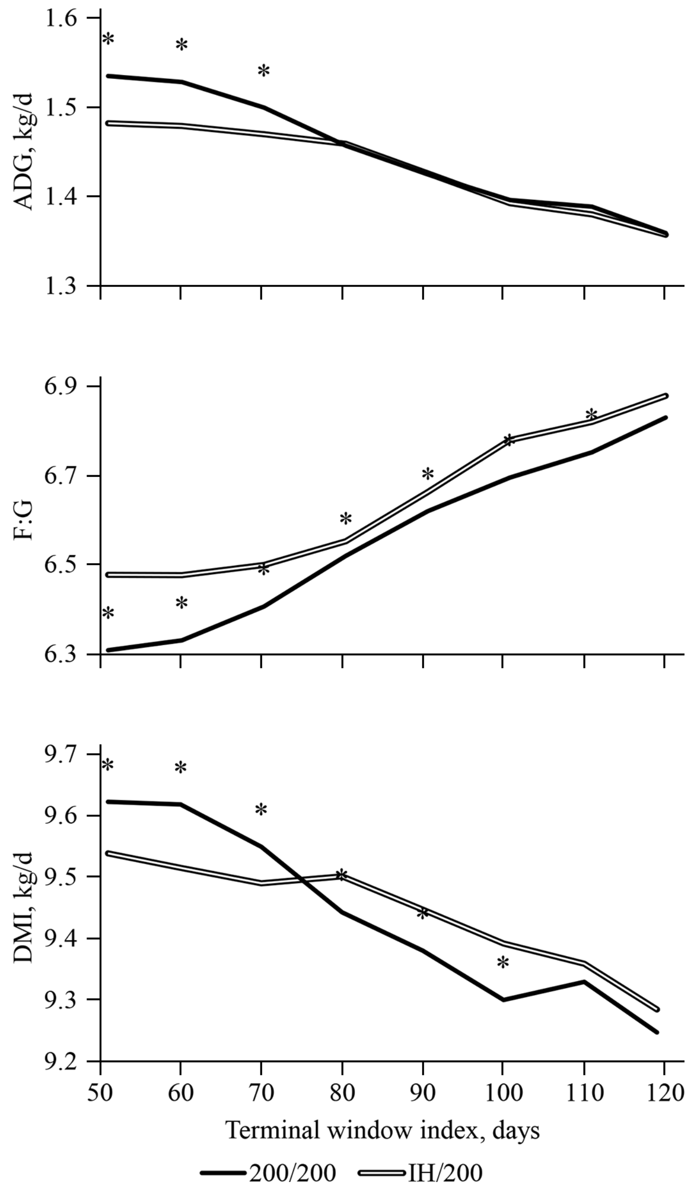

Figure 2. Effects of implant program and terminal window index on ADG (above), feed conversion ratio (F:G, middle), and DMI (below) in heifers. 200/200 = a total dose of 400 mg of trenbolone acetate (TBA) and 40 to 56 mg of estradiol or estradiol benzoate; IH/200 = total of 280 mg of TBA and 28 mg of estradiol. Significance of variation explained by the model was $P < 0.001$, and the implant program × terminal window index interaction was $P < 0.001$ for all variables. Pooled root mean squared errors for ADG, F:G, and DMI, respectively, were 0.33, 0.46, and 1.59. Values containing * within a figure panel are different ($P < 0.05$) within terminal window index. Figure not presented on a 0-axis basis.

between the TW index day immediately before and after. Every index day was different ($P < 0.05$) from its proceeding day for steers given 200/200. Therefore, a reduction in ADG would be expected for every incremental increase in TW. Furthermore, the reduction in ADG decreased at an increasing rate once the TW exceeded 69 d (Table 5). Steers given IS/200 also displayed a decrease in ADG at a decreasing rate beyond the model breakpoint (67 d). Furthermore, the IS/200 seemed to be less affected by TW, because reductions were only detectable ($P < 0.05$) from d 70 through 110. Steers given XS exhibited a reduction in ADG that did not require a broken-slope model. The pre- and postbreak slopes were equal, and therefore, the

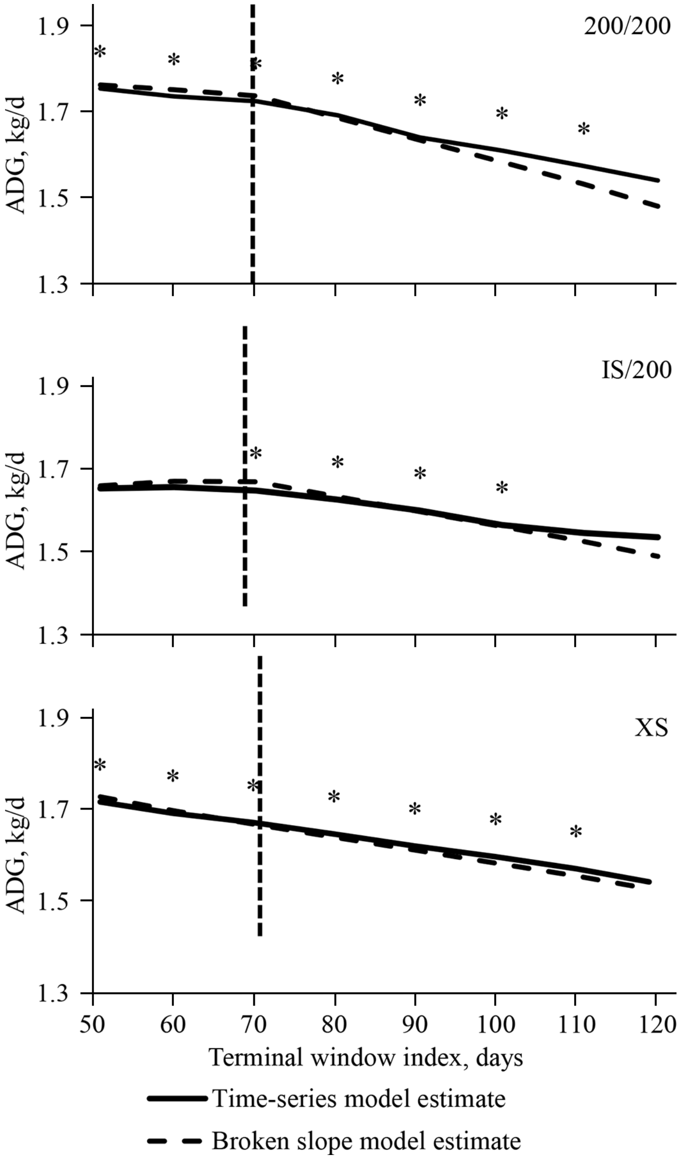

Figure 3. Time-series and broken-slope model estimates of ADG for steers in the 200/200 (above), IS/200 (middle), and XS (below) implant programs. 200/200 = a total dose of 400 mg of trenbolone acetate (TBA) and 40 to 56 mg of estradiol or estradiol benzoate; IS/200 = total of 280 mg of TBA and 36 mg of estradiol; and XS = 200 mg of TBA and 40 mg of estradiol. Values that have an * above them are different ($P < 0.05$) from the proceeding terminal window index day based on the time-series model ($P < 0.001$). Pooled root mean squared error for ADG was 0.35. The vertical dashed line represents the break point of the broken-slope model. Figure not presented on a 0-axis basis.

reduction is truly linear. However, similar to the 200/200 program, all TW indexes were different than their proceeding value.

In the F:G model (Figure 4), the 200/200 was the only implant program where the prebreak slope was greater than the postbreak slope. This seems to be driven primarily by the values on TW index d 60, which were greater ($P < 0.05$) than those on d 50. However, there did not appear to be a consistent effect of TW on F:G until d 80, at which point all proceeding days were greater ($P < 0.05$). The F:G by steers given IS/200 was relatively unaffected by TW duration until d 70 (break point = 73.5, d), at which point it increased ($P < 0.05$) through d 120. Similarly, XS displayed F:G values that were unaffected by TW until d 70 (break point = 75, d), where F:G increased ($P < 0.05$) through d 120.

Table 5. Terminal window broken-slope model components for steers (Exp. 3)

Trait and model component	Implant program[1] 200/200	IS/200	XS
ADG			
Intercept	1.82	1.61	1.88
Prebreak slope	−0.001	0.001	−0.003
Break point	69.3	67.4	70.0
Postbreak slope	−0.005	−0.004	−0.003
F:G			
Intercept	5.57	6.07	6.22
Prebreak slope	0.007	0.001	0.001
Break point	53.5	73.5	75.0
Postbreak slope	0.005	0.008	0.005
DMI			
Intercept	9.95	9.87	11.62
Prebreak slope	0.009	0.004	−0.017
Break point	63.7	65.5	73.0
Postbreak slope	−0.014	−0.004	−0.009

[1]200/200 = a total dose of 400 mg of trenbolone acetate (TBA) and 40 to 56 mg of estradiol or estradiol benzoate; IS/200 = total of 280 mg of TBA and 36 mg of estradiol; and XS = 200 mg of TBA and 40 mg of estradiol.

Feed intake patterns (Figure 5) were more affected by TW index when 200/200 and XS were used compared with IS/200. Steers given 200/200 displayed relatively stable intake from d 50 to 60, at which point DMI was decreased ($P < 0.05$) through d 110. Although the pattern was different than 200/200 steers, XS displayed reduced ($P < 0.05$) DMI from d 50 through 120. Similar to ADG, the DMI response to TW was more linear by XS than 200/200 and IS/200. Furthermore, the broken-slope model did not appear to fit the data as well as ADG or F:G models. The linear response of DMI across TW was minimal for IS/200; however, there was a reduction ($P < 0.05$) in DMI from d 60 through 80.

The relationship between ADG and TW for heifers (Figure 6) was similar to that observed for steers and could be characterized as having a short initial plateau followed by a negative linear response. The break point (Table 6) for 200/200 occurred on d 60, at which point ADG was reduced ($P < 0.05$) through d 100. There was no difference between d 100 and 110; however, 110 was greater ($P < 0.05$) than 120. Similarly, ADG was reduced for IH/200

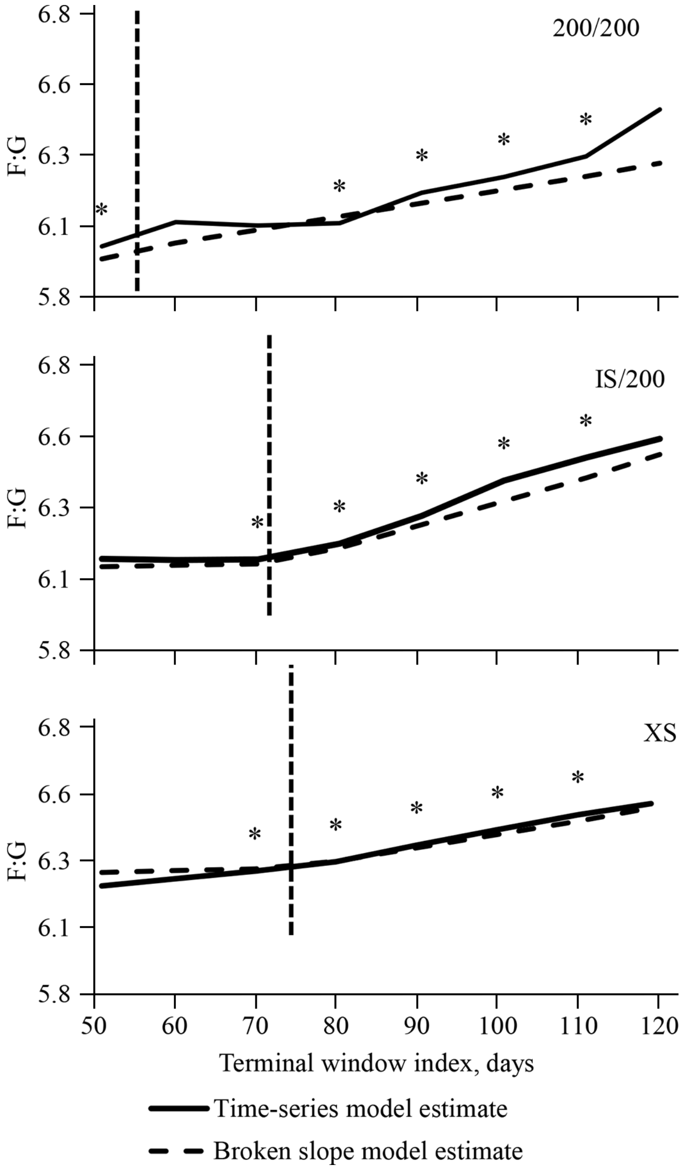

Figure 4. Time-series and broken-slope model estimates of feed conversion ratio (F:G) for steers in the 200/200 (above), IS/200 (middle), and XS (below) implant programs. 200/200 = a total dose of 400 mg of trenbolone acetate (TBA) and 40 to 56 mg of estradiol or estradiol benzoate; IS/200 = total of 280 mg of TBA and 36 mg of estradiol; and XS = 200 mg of TBA and 40 mg of estradiol. Values that have an * above them are different ($P < 0.05$) from the proceeding terminal window index day based on the time-series model ($P < 0.001$). Pooled root mean squared error for F:G was 0.45. The vertical dashed line represents the break point of the broken-slope model. Figure not presented on a 0-axis basis.

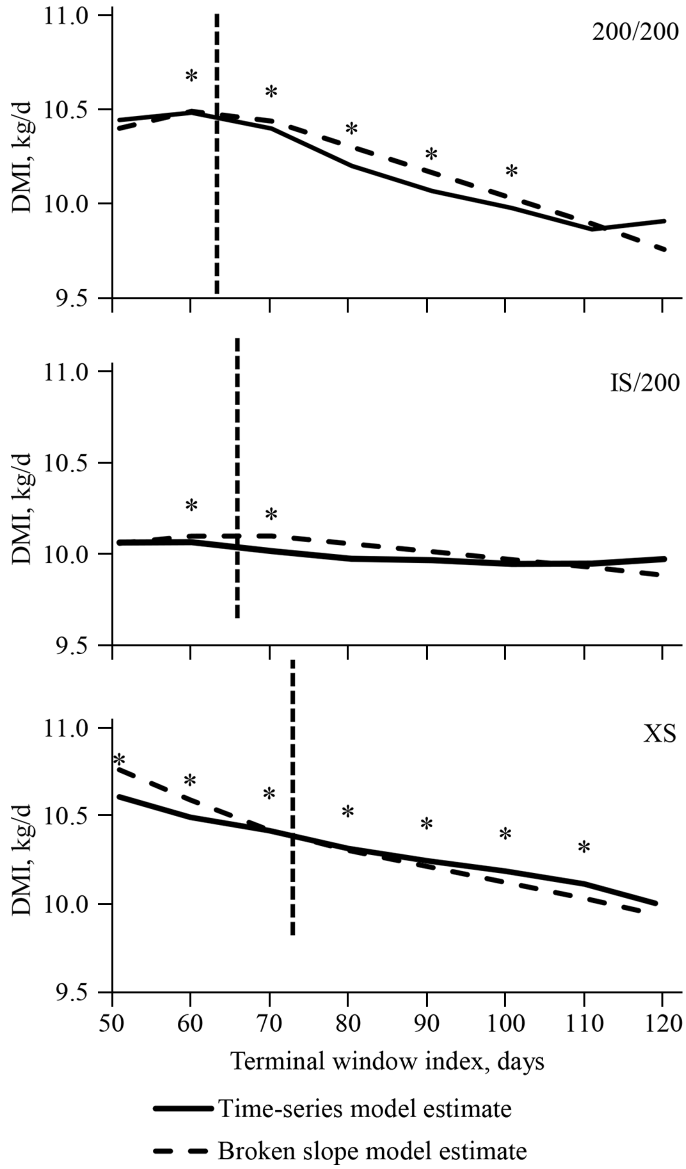

Figure 5. Time-series and broken-slope model estimates of DMI for steers in the 200/200 (above), IS/200 (middle), and XS (below) implant programs. 200/200 = a total dose of 400 mg of trenbolone acetate (TBA) and 40 to 56 mg of estradiol or estradiol benzoate; IS/200 = total of 280 mg of TBA and 36 mg of estradiol; and XS = 200 mg of TBA and 40 mg of estradiol. Values that have an * above them are different ($P < 0.05$) from the proceeding terminal window index time point based on the time-series model ($P < 0.001$). Pooled root mean squared error for DMI was 1.64. The vertical dashed line represents the break point of the broken-slope model. Figure not presented on a 0-axis basis.

from d 60 through 120, although the break point occurred on d 67.

Feed conversion patterns were inversely affected by TW index, although the break points were similar (Figure 7). Both 200/200 and IH/200 exhibited increased ($P < 0.05$) F:G from d 60 through 120. The model break points for 200/200 and IH/200 were 58 and 67 d, respectively. The broken-slope heifer DMI model (Figure 8) does not appear to fit as well as ADG or F:G, as was observed for steers. Heifers given 200/200 displayed a reduction ($P < 0.05$) in DMI from d 60 through 100. The IH/200 had reduced ($P < 0.05$) DMI from d 80 through 100 and between d 110 and 120.

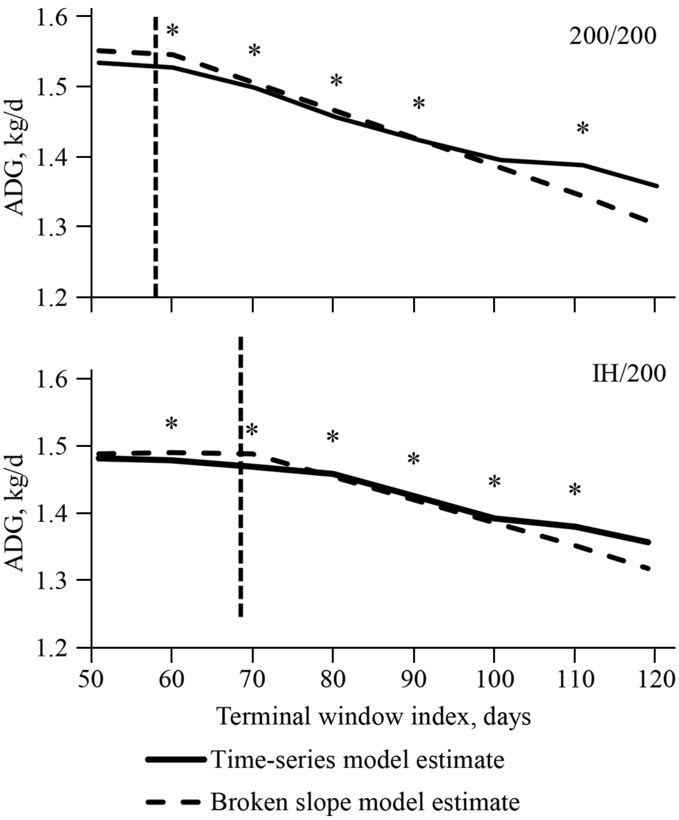

Figure 6. Time-series and broken-slope model estimates of ADG for heifers in the 200/200 (above) and IH/200 (below) implant programs. 200/200 = a total dose of 400 mg of trenbolone acetate (TBA) and 40 to 56 mg of estradiol or estradiol benzoate; IH/200 = total of 280 mg of TBA and 28 mg of estradiol. Values that have an * above them are different ($P < 0.05$) from the proceeding terminal window index time point based on the time-series model ($P < 0.001$). Pooled root mean squared error for ADG was 0.33. The vertical dashed line represents the break point of the broken-slope model. Figure not presented on a 0-axis basis.

Table 6. Terminal window broken-slope model components for heifers (Exp. 3)

Trait and model component	Implant program[1] 200/200	IH/200
ADG		
Intercept	1.57	1.48
Prebreak slope	−0.0004	0.0002
Break point	59.7	69.0
Postbreak slope	−0.004	−0.003
F:G		
Intercept	6.30	6.61
Prebreak slope	0.001	−0.002
Break point	58.4	67.0
Postbreak slope	0.008	0.008
DMI		
Intercept	9.64	9.74
Prebreak slope	−0.0002	−0.0032
Break point	60.9	79.8
Postbreak slope	−0.008	−0.006

[1]200/200 = a total dose of 400 mg of trenbolone acetate (TBA) and 40 to 56 mg of estradiol or estradiol benzoate; IH/200 = total of 280 mg of TBA and 28 mg of estradiol.

DISCUSSION

DOF

Although total weight gain and final BW increased in Exp. 1 as DOF increased, ADG was reduced with increased DOF, suggesting a negative relationship between ADG and DOF. However, there appeared to be no effect on the efficiency of feed use as DOF were extended. Carcass results of Exp. 1 contrast with those of Galyean et al. (1999), who reported that use of a terminal implant could negatively affect carcass quality; however, they used a terminal implant containing less TBA and estradiol than Exp. 1 and also marketed cattle at lighter final BW than in Exp. l. Depenbusch et al. (2018) also observed reduced carcass quality when a terminal implant containing 200 mg of TBA was administered earlier in the feeding period. However, data from Exp. 1 were in agreement with those of Jennings et al. (2015), who reported no negative effects to carcass quality when Component-IH was followed by Component-200 at 60- or 100-d terminal implant windows. These data therefore suggest that a terminal implant of Component-200 can be administered at either 60 or 100 d before slaughter without negative effects on carcass quality and regardless of marketing time of 139, 162, or 183 DOF or 29.0, 30.7, or 31.5% estimated empty body fat, respectively.

Experiment 1 also provides further evidence that, although live performance was reduced as DOF increased, HCW continued to increase. Sissom et al. (2007) similarly reported reduced live performance but increased HCW as DOF increased in heifers. Furthermore, there are multiple reports that have shown this similar effect of DOF on HCW in steers, although with less feed efficiency (Van Koevering et al., 1995; Winterholler et al., 2007). Results of Exp. 1 indicate that situations may exist where increased DOF may be beneficial in heifers sold on a carcass basis despite the negative effects on live ADG and feed efficiency.

Implant Program Dose

Data from Exp. 2 and 3 highlight the effects of overall implant program dose on live performance. In Exp. 2, heifers given 200/200 exhibited increased ADG and improved F:G. These effects were also detected for heifers in Exp. 3, where 200/200 displayed increased ADG initially and improved F:G throughout the TW indices tested. Interestingly, overall dose appeared to affect steer F:G more so

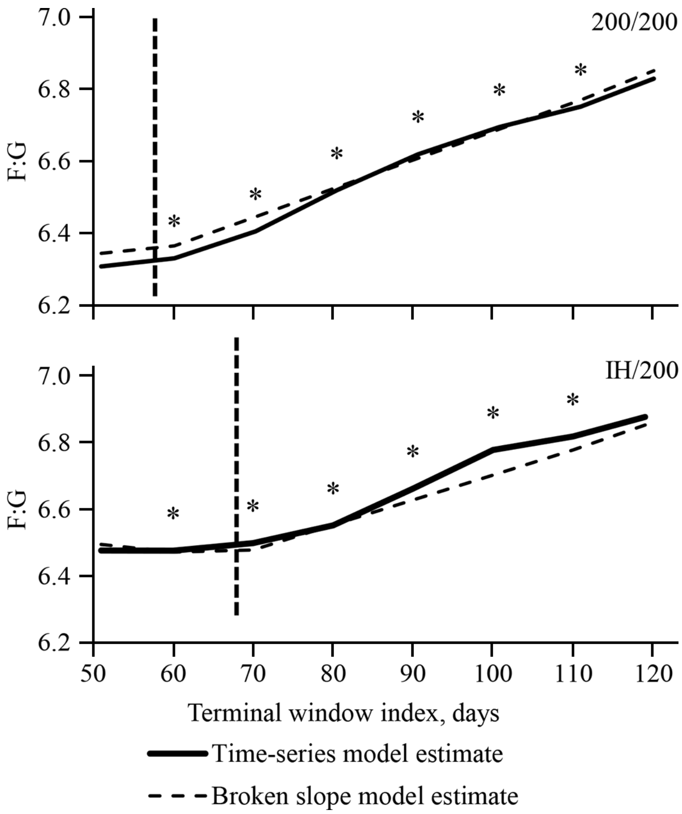

Figure 7. Time-series and broken-slope model estimates of feed conversion ratio (F:G) for heifers in the 200/200 (above) and IH/200 (below) implant programs. 200/200 = a total dose of 400 mg of trenbolone acetate (TBA) and 40 to 56 mg of estradiol or estradiol benzoate; IH/200 = total of 280 mg of TBA and 28 mg of estradiol. Values that have an * above them are different (P < 0.05) from the proceeding terminal window index time point based on the time-series model (P < 0.001). Pooled root mean squared error for F:G was 0.46. The vertical dashed line represents the break point of the broken-slope model. Figure not presented on a 0-axis basis.

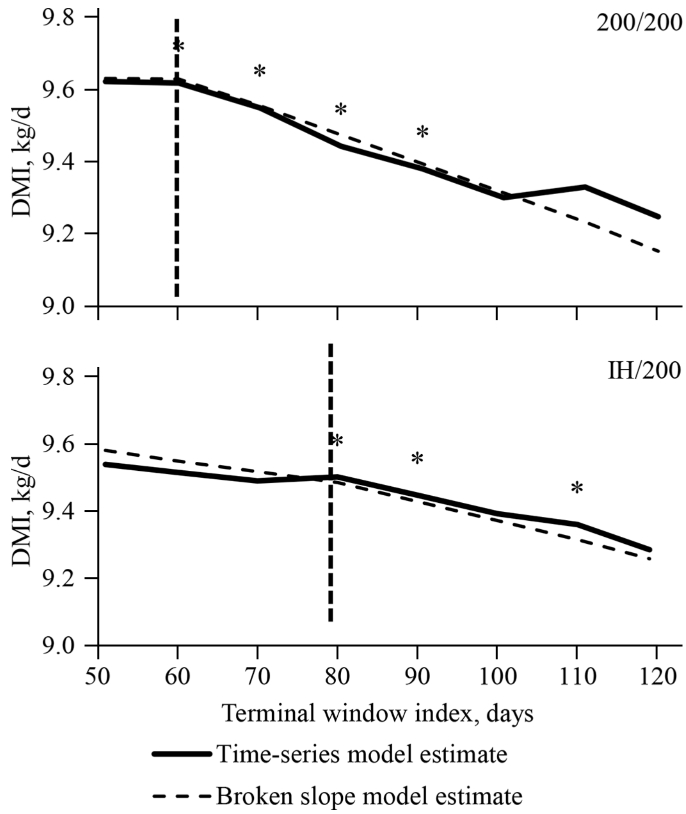

Figure 8. Time-series and broken-slope model estimates of DMI for heifers in the 200/200 (above) and IH/200 (below) implant programs. 200/200 = a total dose of 400 mg of trenbolone acetate (TBA) and 40 to 56 mg of estradiol or estradiol benzoate; IH/200 = total of 280 mg of TBA and 28 mg of estradiol. Values that have an * above them are different (P < 0.05) from the proceeding terminal window index time point based on the time-series model (P < 0.001). Pooled root mean squared error for DMI was 1.59. The vertical dashed line represents the break point of the broken-slope model. Figure not presented on a 0-axis basis.

than ADG. There have been multiple reports (Parr et al., 2011; Reinhardt and Wagner, 2014) where an increased cumulative dose of an implant program has resulted in greater ADG and improved F:G. In contrast, Smith et al. (2019) and Hilscher et al. (2016) reported that increased overall dose did not influence ADG or F:G by either steers or heifers. The ability to detect improvements in performance due to increased cumulative or overall dose may be influenced by DOF and TW, as well as the composition of animals at slaughter. In the observational study, the separation between implant programs converged as TW index increased. Although, in the F:G analysis, the implant programs were generally stratified inversely based on overall dose. Therefore, steers that received a greater overall TBA dose in the program exhibited more favorable F:G.

In Exp. 2, the interaction of TW and DOF on Prime grade is seemingly a minimal inflection point. Relative to the other DOF, heifers fed 183 DOF exhibited reversed Prime percentages, with the 60-d TW being greater than the 100-d TW. The significance of this interaction is most likely a Type I error and an artifact of the factorial treatment arrangement.

In Exp. 2, heifers given 200/200 had increased HCW and reduced estimated body fat, which reduced QG. Hilscher et al. (2016) compared Revalor-IH/200, Revalor H/200, and Revalor 200/200 in heifers fed for 173 d and reported no difference in live performance (carcass adjusted) or HCW, although they observed greater differences in carcass quality between 200/200 and IH/200 than in Exp. 2. In contrast, Schneider et al. (2007) reported no difference in HCW or QG among implant programs of varying initial and terminal concentrations. Consideration must be given to the fact that all heifers in Exp. 2 had the exact same DOF and that when employing an implant program focused on growth such as 200/200, it may be prudent to increase the DOF. In Exp. 2, there was a 0.6-unit difference in average estimated empty body fat between the 200/200 and IH/H implant programs, and based on the results in Exp. 1, the carcass quality differential may be overcome by increasing DOF by 13 d.

TW Analysis

There are few studies that have focused on the effect TW has on animal performance, particularly in steers. Results from Exp. 1 and 2 suggest that TW has a minimal effect on live performance and carcass quality. However, the changes in duration of the initial implant made to accommodate varying TW durations likely blunted the true response of TW. In both experiments, the initial implant duration was increased to make a shorter TW. In Exp. 1, altering TW to 60 d before slaughter tended to affect ADG and total body weight gain in a positive fashion compared with 100 d, but it did not affect HCW. These findings suggest that terminal implant had the greatest effect on ADG in the immediate days following administration, similar to reports by other authors (Duckett et al., 1997; Galyean et al., 1999). However, Jennings et al. (2015) used these same implants and TW as Exp. 1 and did not report an effect on growth performance. Similarly, there were no live performance differences detected between the TW durations in Exp. 2. The serial slaughter aspect of Exp. 1 also provides initial evidence that potentially there is no interaction between DOF and terminal implant window for growth performance variables within an experiment.

In contrast to the aforementioned studies, Ohnoutka et al. (2019) evaluated the effect of TW on animal performance with TW ranging from 40 to 160 d. These authors detected a quadratic relationship between ADG, F:G, and TW; ADG was greater for TW from 80 to120 d compared with 40 or 60 d. Their F:G model was slightly inverted, where F:G was least for the 100-d TW and greatest at 160 d. However, the magnitude of mean separation was less between the shorter TW (40 d = 6.25, 80 d = 6.21, 100 d = 6.17, 120 d = 6.33, and 160 d = 6.45) than the longer TW, suggesting that TW has a greater effect on F:G compared with ADG. Smith et al. (2019) also reported linear reductions in ADG and G:F as TW was increased in multiple experiments with heifers. Furthermore, they reported a linear reduction in DMI in 1 of the 2 reported experiments. Depenbusch et al. (2018) reported that the optimal TW based on growth for heifers implanted with 200 mg of TBA was approximately 90 d. In that study, heifers were fed an average of 181 d; therefore, a shorter TW would have extended the length of time on the initial implant to more than 90 d.

The effects that TW exerts on animal performance is relatively unclear. In some experiments shorter durations appear to improve growth performance, and in others it is of little consequence. One of the challenges with interpreting the results from the available studies is that TW is highly confounded with initial implant window. For example, initial implant window in Exp. 1 ranged from 39 through 83 d, 71 through 111 d in Exp. 2, and 20 through 140 d in Ohnoutka et al. (2019). Another challenge with detecting differences in TW within an experiment could be lack of sample size to determine significance. In the observational study presented, the effects that TW exerts on live performance metrics are clear. This is certainly driven by the much larger sample size within the population database, which comes with its own interpretational challenges. Generally speaking, observational studies have more variation and confounding factors than controlled experiments, but the diversity of animal populations, seasonality, and varying degrees of endpoint body composition are captured.

The results from the observational study highlight the importance of TW on live animal performance. In both steer and heifer populations, there was a significant relationship between ADG, F:G, DMI, and TW. Conveniently for the producer, the break points on the models were relatively similar across implant programs for steers (average = 67.9 d) and heifers (average = 65.8 d), which suggests that the meaningful payout of compressed pellet implants was approximately 70 d. Traditionally, a TW of 65 to 70 d would be considered short by the cattle feeding industry, whose guidance from implant manufacturers has generally been 80 to 120 d to achieve balance between growth and carcass quality based on a large body of experiments. Data from the observational study may suggest that a waning of active ingredient absorption beyond approximately 70 d allows the megacalories to be spared from less protein gain stimulus to support fat gain (Montgomery et al., 2001) to reduce otherwise negative carcass quality effects. However, based on Exp. 1 and 2, any deleterious effects on carcass merit and leanness could also be overcome by increasing overall DOF. Furthermore, these results suggest that there is no optimum TW, rather a threshold at which live growth is affected when exceeded. Even though the results from the observational study are not completely in agreement with previous reports on the surface, they are aligned with animal biology and should assist in the development of implant protocols that maximize growth and feed efficiency of feedyard animals.

APPLICATIONS

Results from this study indicate that increased DOF resulted in poorer live growth performance but increased carcass weight and resulted in generally fatter carcasses. Controlled study data provided evidence that a terminal implant administered 60 d from slaughter does not negatively affect QG, and there was no interaction with DOF. Furthermore, these results supplement previous evidence that HCW continues to increase with increased DOF, even after live growth performance declines. Increased implant program dose improved live growth performance and carcass weight in heifers. Reductions in body fat content due to increased TBA dose could most likely be overcome with increased DOF. The observational TW study highlights the benefit of a population database and the contributions such data can make to the cattle industry. Furthermore, although this analysis does not emphasize an ideal TW, it does indicate that after a period of time on a second implant, live growth performance is no longer optimized. The composition of cattle, length of initial window, and TW duration all require consideration when designing implant programs.

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