

Body Weight and Steroidal Implants Impact Animal Growth Performance, Sera Metabolites, and Pulmonary Arterial Pressure in Feedlot Cattle

Tyler A. Vogel¹, Joseph M. Neary¹, Zachary K. Smith^{2*}, Bradley J. Johnson¹

¹Department of Animal and Food Science, Texas Tech University, Lubbock, TX, USA

²Department of Animal Science, South Dakota State University, Brookings, SD, USA

Email: *zachary.smith@sdstate.edu

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Abstract

The study objective was to evaluate steer growth performance, sera metabolite responses, carcass characteristics, and pulmonary arterial pressure as affected by body weight at time of implantation and steroidal implant administration. Crossbred steers ($n = 20$) were used in a 2×2 factorial arrangement of treatments in a completely randomized design experiment, Factors included: body weight: light (L), or heavy (H) and implant: Non-implanted (NoIMP), or Implanted (IMP) with steer serving as the experimental unit for all analyses. Initial weights for L and H steers were 398 ± 27.6 and 547 ± 25.2 kg, respectively. Implanted steers received a terminal implant (200 mg trenbolone acetate and 20 mg estradiol-17 β ; Revalor-200; Merck Animal Health, Madison, NJ) on d 0. Cattle within treatments were group housed in common pens ($n = 5$ steers/pen). Bodyweight, blood samples, and pulmonary arterial pressure were collected on d 0, 14, 35, 70 and 104. Cattle were fed a common diet once daily to provide *ad libitum* access to feed. The finishing diet contained (DM basis) 13.3% CP, 2.13 Mcal/kg NEm, and 1.45 Mcal/kg NEg. Growth performance (body weight and ADG) and carcass traits were analyzed using the MIXED procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC). Sera metabolites were analyzed as repeated measures over time, with day as the repeated measure. For all analyses, α level < 0.05 determined significance. Heavy steers consumed 2.2 kg more per head of DM daily than L cattle and IMP steers consumed 1.0 kg more DM daily than NoIMP steers. Cumulative ADG did not differ between the L and H steers (1.41 vs. 1.52 ± 0.060 kg; $P = 0.20$). Implanting increased ($P < 0.01$) ADG by 39% (1.22 vs. 1.70 ± 0.060 kg). No differences ($P > 0.05$) in ADG were observed in NoIMP vs. IMP cattle beyond d 70 (1.21 vs. 1.01 ± 0.16 kg; $P = 0.38$). Sera urea-N concentrations were de-

creased ($P < 0.01$) in L cattle subjected to IMP during the study and tended to increase over time for the other treatments. Ribfat, HCW, LM, marbling score, calculated YG, and estimated EBF were greater ($P \leq 0.05$) in H compared to L. Steers from IMP had heavier HCW ($P < 0.01$) but decreased marbling scores ($P = 0.05$) compared to NoIMP. Mean pulmonary arterial pressure was greater ($P < 0.01$) for H compared to L steers which may predispose heavier cattle to right-sided heart failure. The steroid implant had no effect on pulmonary arterial pressure ($P > 0.49$). The study reaffirms the effects of implanting on animal growth performance and carcass characteristics in cattle. In addition, elevated BW leads to increased pulmonary arterial pressures which may increase the risk of right-sided heart failure.

Keywords

Cattle, Estradiol, Pulmonary Pressure, Trenbolone

1. Introduction

Growth enhancing technologies such as implants have been used in the cattle industry since the early 1950's [1]. Steroid implants have been documented to increase ADG by 18%, increase feed intake by 6%, improve feed efficiency by 8%, and increase carcass weight by 5% [1] [2] [3]. Research by [4] has shown both live and carcass weights have continued to increase over the last 50 years. They also reported an increase in mortality in both steers (27.6%) and heifers (30.5%) in the same survey [4]. Neary, Booker, Wildman and Morley [5] observed an increase in mortality due to cardiac failure as cattle weights increased. An ancillary effect of steroids is their ability to affect pulmonary arterial pressure. Estrogens have been documented to reduce pulmonary hypertension in humans [6] [7] [8] although limited information on the effects of estradiol-17 β (E₂) and trenbolone acetate (TBA) on pulmonary pressure have been reported. In addition, with increasing live and carcass weights limited research has been conducted, which looks at the growth performance differences of implants in cattle of differing body weights. Therefore, the objectives of this research were to evaluate BW at time of implant administration and steroidal implant application on animal growth performance, carcass characteristics, sera metabolites responses, and pulmonary arterial pressure in feedlot cattle.

2. Materials and Methods

All experimental procedures involving the use of animals were reviewed and approved by the Texas Tech University Institutional Animal Care and Use Committee (#16064). The experiment was conducted at the Texas Tech University Burnett Center located approximately 10.0 km East of New Deal, TX.

Steer growth performance

Crossbred beef steers (n = 20; 339 kg) were delivered to the Texas Tech Uni-

versity Burnett Center in New Deal, TX during the summer of 2016. Steers were placed in a large group pen and offered a 70% concentrate receiving diet. Steers were fed the 70% concentrate diet for 5 d and subsequently transitioned to an 80% concentrate diet. Upon initiation of the trial, steers were fed a 90% concentrate finishing diet. During arrival processing steers were identified with a unique individual ear tag. All steers were vaccinated for viral respiratory pathogens using Bovishield Gold 5 (Zoetis Animal Health, Parsippany, New Jersey), *clostridial* species using Vision 7 (Merck Animal Health, Madison, NJ), *mycoplasma bovis* using Myco-Bac B (Texas Vet Lab, San Angelo, TX), and treated internal and external parasites using Safeguard (Merck Animal Health) and Ivomec (Merial Animal Health, Duluth, GA). Steers were weighed using a Silencer squeeze chute (Moly Manufacturing, Inc., Lorraine, KS; accuracy + 0.5 kg) on d-14. The steers were then blocked into two BW categories: light (L) or heavy (H), with the 10 lightest steers assigned to the L category and the 10 heaviest steers to the H category. On d-1 cattle were weighed and within each body weight category were sorted by increasing BW and alternately assigned to one of two implant treatments: Non-implant (NoIMP), or Implant (IMP). Steers assigned to the IMP treatment received an implant containing 200 mg TBA and 20 mg of E₂ (Revalor-200, Merck Animal Health, Madison, NJ). On d 0 cattle were weighed again with the average weight of d -1 and d 0 as the initial BW. Initial BW at study initiation for L and H steers were 398 and 547 kg (SEM = 9.7 kg), respectively. Steer served as the experimental unit for all analyses.

All steers within similar BW class and implant treatments were housed in a common pen. Steers were fed once daily with feed mixed and delivered in a drag-type Rotomix feed wagon (2.35 m³; scale readability 0.5 kg; Dodge City, KS). Steers were fed a 90% concentrate ration throughout the study in the morning (0800 to 0900 h). Feed delivery was adjusted to provide *ad libitum* access while reducing wasted feed.

The total mixed ration was sampled weekly throughout the course of the study and split into 2 aliquots as described by [9]. One aliquot of the weekly sample was immediately taken and dried in duplicate in a forced air oven at 100°C for 24 h in order to determine DM content of the diet, which was then utilized to determine total DMI for each week. At the conclusion of the study the second aliquot of the weekly diet samples, were composited by 28 d period for chemical analyses of CP, ADF, NDF, and ash content (DairyOne, Ithaca, NY) using AOAC procedures. Diet composition and chemical analysis of the 90% concentrate diet can be found in **Table 1**.

Orts were collected, weighed and dried in a forced air oven at 100°C for 24 h in order to determine DM content if carryover feed went out of condition, or was present on weigh days. If carryover feed was present on weigh days, the residual feed was removed prior to the collection of BW measurements. The DMI of each pen was adjusted to reflect the total DM delivered to each pen after subtracting the quantity of dry Orts for each interim period.

Table 1. Ingredient formulation and nutrient composition of finishing diet.

Ingredient	% DM
Steam-flaked corn	64.56
Wet corn gluten feed	20.07
Alfalfa hay	7.93
Fat (yellow grease)	3.07
Supplement ¹	1.99
Calcium Carbonate	1.87
Urea	0.51
Nutrient composition ²	% DM ³
Dry Matter, %	78.32
Crude Protein, %	13.27
Neutral Detergent Fiber, %	16.60
Acid Detergent Fiber, %	8.38
Ash, %	4.48
Net Energy Maintenance, Mcal/kg	2.13
Net Energy Gain, Mcal/kg	1.45

¹Supplement composition (DM basis): 67.755% Cottonseed meal, 15.000%, NaCl, 10.000% KCl, 3.760% Urea, 0.986% Zinc sulfate, 0.750% Rumensin-90 (Elanco, Greenfield, IN), 0.506 Tylan-40 (Elanco), 0.500% Endox (Kemin Industries, Des Moines, IA), 0.196% Copper sulfate, 0.167% Manganese oxide, 0.157% vitamin E (500 IU/g), 0.125% selenium premix (0.2% Se), 0.083% iron sulfate, 0.010% vitamin A (1,000,000 IU/g), 0.003% ethylenediamine dihydroiodide, and 0.002% cobalt carbonate. ²Composition from 6 samples that were composited by interim weigh period from weekly diet samples and analyzed at a commercial laboratory (Dairy One Forage Laboratory, Ithaca, NY). Diet DM determined weekly (forced-air oven for 24 h at 100°C). ³All values except for dry matter on a DM basis.

Cattle health was evaluated daily between 0700 and 0900 for signs of illness or injury. Two steers were treated for foot rot (d 14 and d 20) with one steer removed from the L/NoIMP treatment due to lameness. Steer weights, blood samples, and heart pressure measurements were obtained on d 0, 14, 35, 70 and 104 prior to the daily feed delivery.

Sampling procedures

Blood samples were collected and pulmonary arterial pressure was determined for all steers on d 0, 14, 35, 70 and 104. Animal were restrained in a hydraulic squeeze chute for sample collections. Following aseptic preparation of the neck (chlorhexidine solution), a 12-gauge, 8.9-cm needle was inserted into the jugular vein. A flexible, saline-filled polyethylene catheter tubing (external and internal diameter of 17 and 12 mm, respectively) was fed through the needle, down into the right atrium, followed by the right ventricle, and then into the pulmonary artery. A pressure transducer was connected the catheter to an oscilloscope (BM5Vet, Bionet America, Inc. Tustin, CA, U.S.A.). The position of the catheter tip within the vascular system was determined from the pressure waveform on the oscilloscope. Blood was collected using a saline-filled pressure catheter with approximately 15 ml of whole blood collected from the 12-gauge needle in the

jugular vein for harvesting of serum for subsequent sera metabolite analyses. The entire procedure took approximately 4 to 5 minutes per animal. A full description of the equipment, materials and facilities required for pulmonary arterial pressure testing was described by [10]. Final BW was collected on d 104. Seven d later steers were placed in adjacent holding pens, loaded on a truck, and shipped (198 km) to harvest at Tyson Fresh Meats, Inc., Amarillo, TX. Individual carcass measurements included hot carcass weight (HCW), loin muscle area (LMA), ribfat (RF), marbling score, kidney-pelvic-heart fat (KPH), and USDA yield grade were collected by trained West Texas A&M University as described by [11]. Carcass data from one steer in H/IMP treatment group was not collected due to carcass condemnation. Estimated empty body fat percentage (EBF) was calculated using the formula described by [12] [13].

Sera metabolite analyses

Following sampling collection, blood was transferred from the Burnett Research Center to an assay lab at the Texas Tech University Animal and Food Science building. Blood was stored in a refrigerator at 4°C for 24 hours. Blood was subsequently brought to room temperature and spun in a centrifuge at 4000 × g for 20 minutes at 4°C and harvested as sera. Sera samples were divided into 2 ml polystyrene tubes for 17-β trenbolone (17β-TbOH), insulin-like growth factor I (IGF-I), non-esterified fatty acid (NEFA) and sera urea-N (SUN) analyses.

Circulating 17β-TbOH concentration was quantified via liquid chromatography-tandem mass spectrometry (LC-MS/MS) using the same method described by [14] [15]. Blank (n = 3) and spiked (n = 3) matrix (bovine serum, Sigma-Aldrich, St. Louis, MO) samples were analyzed along with 42 unknowns per sample batch (48 extractions in total) in order to monitor extraction method performance. No steroids were observed above the limit of detection in any solvent or matrix blank. The mean matrix spike recovery for sera was 114% ± 9.2%. Solvent blanks and check standards were included every 8 and 16 samples, respectively, in instrument runs for QC purposes. The limit of quantification, as determined by the lowest calibration standard included in sample runs, was 25 pg/mL serum. Values below the limit of quantification were assigned the value for trenbolone-17β of 12.5 pg/mL serum.

Circulating IGF-I concentration was quantified via ELISA procedures (Quantikine Human IGF-I ELISA, R & D Systems, Minneapolis, MN). Samples were assayed according to manufacturer recommendations as described by [16]. Prior to analysis raw sera samples were extracted in order to reduce IGF binding protein interference. The standard curve constructed for the IGF-I assay was between 9.4 and 600.0 ng/mL. For the IGF-I analysis the intra-assay CV was less than 10% and the inter-assay CV was less than 10%. The IGF-I samples were run in duplicate and determinations were considered for re-runs if the coefficient of variation between duplicate determinations was greater than 10%.

The quantification of circulating NEFA concentration was determined using triplicate 5 μL determinations via colorimetric assay using a commercially available kit that involved acyl-CoA synthase, acyl-CoA oxidase, and peroxidase in 96

well microtiter plates (NEFA-HR; Wako Diagnostics, Richmond, VA). Using identical procedures to those described by others [16] [17]. The standard curve constructed for the NEFA assay was between 0 and 1.0 mEq/L. For the NEFA analysis, the intra-assay CV was less than 10% and the inter-assay CV was less than 10%. Samples were considered for re-runs if the coefficient of variation among the absorbance values for triplicate determinations was greater than 5%.

The quantification of circulating serum urea-N (SUN) concentration was determined on a microplate spectrophotometer in triplicate 5 μ L determinations, using diacetylmonoxime via a commercially available kit (STANBIO Urea Nitrogen-0580; STANBIO Laboratory, Boerne, TX). The standard curve constructed for the SUN assay was between 0 and 25.0 mg/dL [16]. For the SUN analysis the intra-assay CV was less than 10% and the inter-assay CV was less than 10%. Samples were considered for re-runs if the coefficient of variation among the absorbance values for triplicate determinations was greater than 5%.

Statistical Analyses

For all analyses, individual steer was considered the experimental unit. Growth performance and carcass data were analyzed as a 2×2 factorial arrangement and included the fixed effects of weight class and implant as well as their interaction using the MIXED procedure of SAS 9.4 (SAS Inst., Inc., Cary, NC). Sera metabolite responses and heart pressure measurements were analyzed as repeated measures appropriate for a 2×2 factorial arrangement using the MIXED procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC). The statistical model included the fixed effects of body weight at implantation time, implant treatment and day as well as all possible interactions; day was included as the repeated variable and steer served as the experimental unit ($n = 5$ steers/simple treatment mean). The covariance structure with the lowest Akaike information criterion (AIC) was used [18]. All results are reported as least-squares means. Data means were separated using the PDIF option of SAS 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 0.051 and 0.10. A significant d 0 effect (relative to implant) was found for IGF-I and SUN. To account for that affect, d 0 was included as a covariate in the model for analysis of those metabolites.

3. Results and Discussion

Cattle within the same treatment were grouped into common pens. Thus, statistical analyses were not conducted for dry matter intake (DMI) and feed conversion (G:F). However, the H cattle consumed numerically 2.2 kg more DM per d during the 104 d study than the L cattle. As the study progressed, the H/IMP treatment group consumed numerically the most DM intake. Implanted steers consumed numerically 1.0 kg more per d than NoIMP steers over the course of the study. Others have reported increased DMI when steers were administered steroidal implants with anabolic activity [9] [11] [16] [19] [20] [21]. The effects of cattle weight and implant status on animal growth performance are shown in **Table 2**.

Table 2. Growth performance responses of light and heavy weight steers given no implant or administered a steroidal implants.^{1,2}

Item	Body Weight (BW)		Implant (Imp)		SEM	P-values		
	Light	Heavy	No Implant	Implant		BW	Imp	BW × Imp
Body weight, kg								
Initial	398	547	474	470	9.7	<0.01	0.78	0.88
d 14	406	566	483	489	9.5	<0.01	0.64	0.56
d 35	454	606	520	540	11.3	<0.01	0.20	0.96
d 70	502	672	560	613	11.5	<0.01	<0.01	0.77
d 104	544	705	601	647	12.7	<0.01	0.02	0.51
Initial to d 14								
ADG, kg	0.61	1.35	0.62	1.34	0.195	0.02	0.02	0.02
DMI, kg	6.10	9.44	7.42	8.13	-	-	-	-
G:F	0.100	0.143	0.083	0.165	-	-	-	-
d 15 to 35								
ADG, kg	2.26	1.93	1.75	2.44	0.182	0.22	0.02	0.21
DMI, kg	8.40	11.22	9.44	10.18	-	-	-	-
G:F	0.268	0.172	0.186	0.239	-	-	-	-
d 36 to 70								
ADG, kg	1.37	1.87	1.16	2.08	0.098	<0.01	<0.01	0.43
DMI, kg	8.31	10.57	8.78	10.09	-	-	-	-
G:F	0.165	0.177	0.132	0.206	-	-	-	-
d 71 to 104								
ADG, kg	1.24	0.98	1.21	1.01	0.161	0.24	0.38	0.36
DMI, kg	7.91	9.31	8.12	9.10	-	-	-	-
G:F	0.157	0.105	0.149	0.111	-	-	-	-
Initial to 104								
ADG, kg	1.41	1.52	1.22	1.70	0.063	0.20	<0.01	0.14
DMI, kg	7.90	10.14	8.52	9.52	-	-	-	-
G:F	0.178	0.150	0.144	0.179	-	-	-	-

¹No shrink was applied to any body weight measures. ²Implanted steers received a 200 mg trenbolone acetate and 20 mg estradiol-17 β implant at study initiation (Revalor-200, Merck Animal Health, Madison, NJ).

There was an interaction ($P < 0.02$) of BW \times IMP detected for ADG from 0 to 14 d. Daily gains were 0.60, 0.62, 0.63 and 2.07 kg/d for steers in L/NoIMP, L/IMP, H/NoIMP, and H/IMP, respectively. Likely the difference in daily gain for steers in the H/IMP treatment was attributable to increased DMI during this period. Beyond d 14, there were no interactions between body weight and implant status ($P > 0.14$) on ADG. Therefore, only the main effects are discussed. At study initiation, steers in the H weight block were 149 kg heavier ($P < 0.01$). This weight difference remained relatively constant for the duration of the study. The H cat-

tle finished the study approximately 161 kg heavier ($P < 0.01$) than L steers. During the entire study, there was no difference in rate of ADG between L and H steers ($P = 0.20$). Cattle in the H groups gained at a faster rate ($P < 0.01$) from d 36 to 70, while during the final 33 d, the L cattle gained numerically faster than H steers ($P = 0.24$). Implanted steers gained faster through the first 70 d compared to NoIMP cattle ($P < 0.02$). Implanted steers gained more than 0.48 kg/d faster than NoIMP steers throughout to course of the experiment. Implanting increased ($P < 0.02$) ADG during days 0 to 14, 15 to 35, and 36 to 70; however, there was no difference ($P = 0.38$) in animal growth performance during the final 33 days on feed. This might suggest the effect of the implant was diminished beyond d 70 since there was not a difference in animal growth performance beyond this time.

The effects of body weight and implant status on carcass characteristics are reported in **Table 3**. Cattle in the H treatment groups had greater HCW than cattle in the L treatment groups ($P < 0.01$). As expected, cattle in the H groups had a larger LMA ($P = 0.04$) and greater RF ($P = 0.04$) than the L steers. Heavier cattle also exhibited greater marbling scores ($P = 0.01$), increased yield grade ($P = 0.03$) and estimated EBF % ($P < 0.01$) compared to the L treatment groups. These differences were expected given the differences in the initial and final weight due to experimental design. Implanted treatment groups had heavier HCW than cattle in the non-implanted treatment groups ($P < 0.01$). This increase in HCW is commonly seen when steroidal implants are administered to feedlot finishing steers [20] [21] [22]. Further, there was no difference between implanted and non-implanted treatment groups with respect to LMA, RF, calculated yield grade and estimated EBF %, which is not consistent to what others have demonstrated [14] [19]. However, implanted cattle exhibited lower marbling scores ($P = 0.05$) compared to the non-implanted treatment groups and this decrease in marbling for cattle harvested at equal days on feed is well noted in the literature [19] [20] [21] [22].

Table 3. Carcass trait responses of light and heavy weight steers given no implant or administered a steroidal implants.¹

Item	Body Weight (BW)		Implant (Imp)		SEM	<i>P</i> -values		
	Light	Heavy	No Implant	Implant		BW	Imp	BW × Imp
HCW, kg	342	445	376	412	8.3	<0.01	<0.01	0.29
Dressing, % ²	62.9	62.3	62.5	62.7	0.60	0.47	0.86	0.97
Loin muscle area, cm ²	88.4	99.1	92.0	95.5	3.41	0.04	0.48	0.18
Ribfat, cm	1.13	1.69	1.38	1.45	0.172	0.04	0.77	0.18
Marbling score ³	421	559	541	439	34.2	0.01	0.05	0.69
Kidney-pelvic-heart fat, %	1.88	1.94	1.88	1.94	0.108	0.69	0.69	0.24
Yield grade	2.47	3.37	2.82	3.03	0.260	0.03	0.57	0.06
Estimated EBF, %	27.5	32.5	30.1	30.0	1.00	<0.01	0.96	0.16

¹Implanted steers received a 200 mg trenbolone acetate and 20 mg estradiol-17 β implant at study initiation (Revalor-200, Merck Animal Health, Madison, NJ). ²HCW/final body weight from d 104. ³marbling score of 400 = small⁰⁰.

Sera levels of 17β -TbOH are illustrated in **Figure 1**. There was an IMP ($P < 0.01$) effect on TBoh concentration however and this is similar to what others have demonstrated post-implantation [14] [16] [17] [19], there was no IMP \times BW interaction ($P = 0.21$) noted in the present experiment. Sera concentrations of 17β -TbOH were greater in L compared to H steers on days 14, 35, and 104 with the lone exception occurring on d 70 when sera concentrations of 17β -TbOH were greater in H steers. Sera concentrations of 17β -TbOH ranged from 0 to 1643 pg/ml for L cattle and 288 to 2527 pg/ml in H cattle on d 70. It is possible the release of TBA from the compressed pellets might have been variable given the erratic numbers found on d 70. Generally speaking, TBA concentrations for the L cattle reached a peak on d 35 and declined thereafter. For the H cattle TBA concentrations did not reach their peak until d 70 and decreased after.

Sera IGF-I concentrations due to BW and implant are shown in **Figure 2**. A d 0 effect ($P < 0.02$) was observed in which IGF-I concentrations were elevated for the L/IMP cattle. To account for this, d 0 was included as a covariate in the model. There was a three-way interaction between BW \times IMP \times Day ($P < 0.02$). Body weight did not affect IGF-I concentration ($P > 0.99$) while implanting increased ($P < 0.01$) IGF-I concentrations and sera IGF-I concentrations decreased with days on feed ($P < 0.01$). It is interesting to note IGF-I levels between IMP and NoIMP separated for H cattle by d 14 while IGF-I concentration in L cattle were similar on d 14 between IMP and NoIMP and then separated on d 35. A hallmark sign of steroidal implant administration in beef cattle in increased sera IGF-I [14] [17].

When evaluating the effects of BW and implant status on sera NEFA concentrations, there was no effect ($P = 0.81$) of BW on sera NEFA concentrations (**Figure 3**). There was no effect of implants on sera NEFA concentrations ($P <$

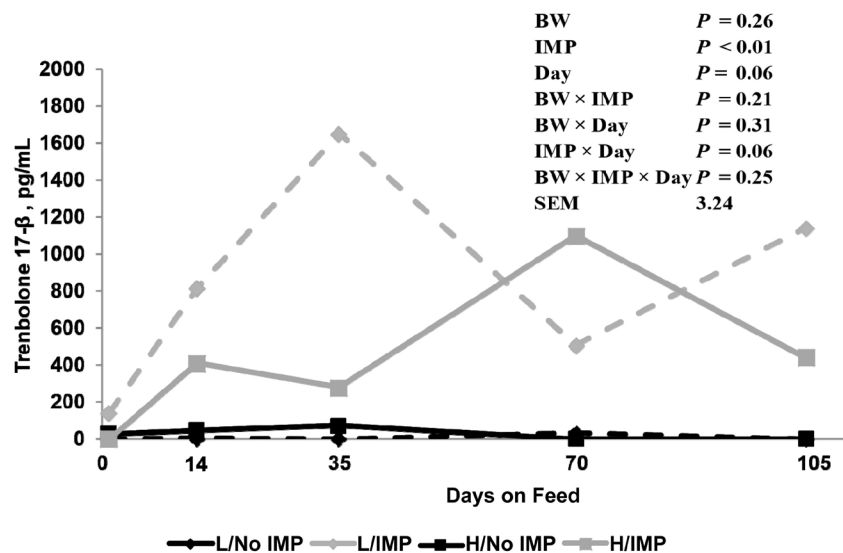


Figure 1. Effect of body weight and implant usage on Trenbolone 17β (TBOH) concentration (L = Light BW; H = Heavy BW; NoIMP = Non-implanted; IMP = Implanted; SEM = 3.24; n = 5 steers/treatment).

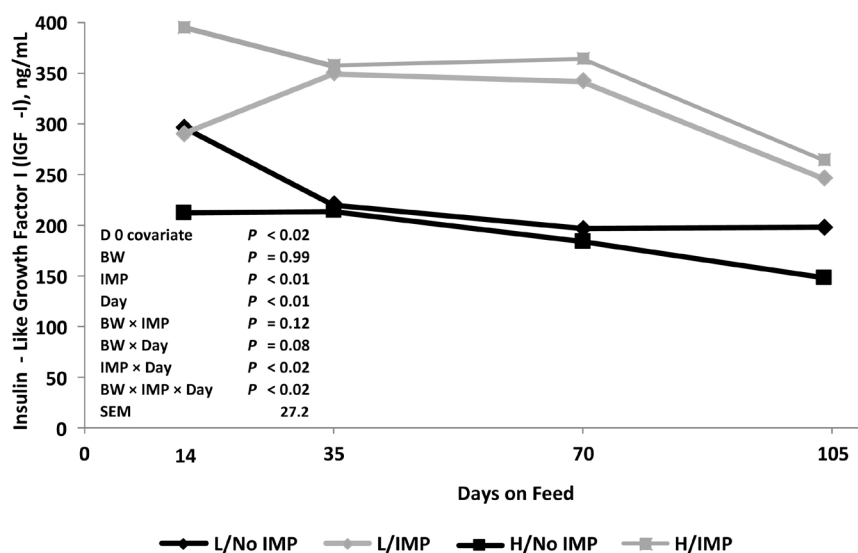


Figure 2. Effect of body weight and implant usage on Insulin-Like Growth Factor I concentration using d 0 values as a covariate (L = Light BW; H = Heavy BW; NoIMP = Nonimplanted; IMP = Implanted; SEM = 27.2; n = 5 steers/treatment).

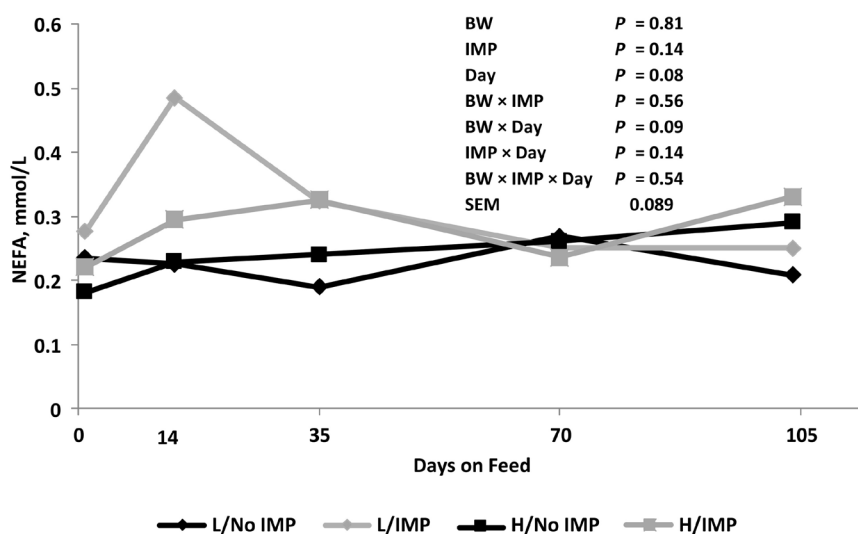


Figure 3. Effect of body weight and implant usage on NEFA concentration (L = Light BW; H = Heavy BW; NoIMP = Non-implanted; IMP = Implanted; SEM = 0.089; n = 5 steers/treatment).

0.14). This response has been confirmed by others previously [16] [17] [23]. Sera NEFA concentrations tended ($P = 0.08$) to be elevated on d 14 in the L/IMP steers indicating that implants resulted in rapid mobilization of fat early in the feeding period. There was a tendency ($P = 0.08$) for NEFA concentration to increase with increasing days on feed. This is not surprising as cattle became heavier with increased adiposity with increasing days on feed.

Sera urea-N concentrations are reported in **Figure 4**. A d 0 effect ($P < 0.02$) was observed due to SUN levels being lower in the L/NoIMP cattle. To account for this, d 0 was included as a covariate in the model. Heavy steers had greater (P

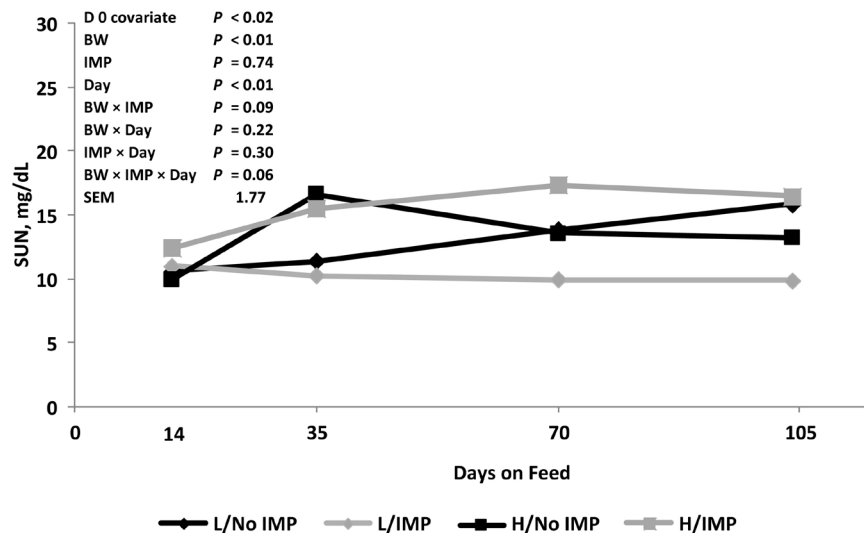


Figure 4. Effect of body weight class and implant usage on serum urea - N using d 0 values as a covariate (L = Light BW; H = Heavy BW; NoIMP = Non-implanted; IMP = Implanted; SEM = 1.77; n = 5 steers/treatment).

< 0.01) SUN concentrations compared to L steers. Implanting steers had no effect ($P = 0.74$) on SUN concentrations across days. Which is not consistent to what others have demonstrated following steroidal implant administration [14] [17]. However, there was a tendency ($P < 0.09$) for a BW by implant interaction. Sera urea-N concentrations increased over time during the 104 d study for both H treatment groups and the L/NoIMP cattle whereas SUN concentrations remained low for the L/IMP cattle for the entire study.

Figures 5-14 show the effects of body weight and days on feed on right atrial and ventricular pressures as well as PAP (mean, systolic and diastolic). To our knowledge this is the first experiment that has evaluated the influence of BW a placement and implant administration on atrial and ventricular pressure in beef cattle. As mentioned previously there was no effect of implant administration ($P > 0.13$) on pulmonary measurements. Therefore, only the effects of BW and days on feed are reported. Right atrial pressure was not affected by BW ($P > 0.24$). There was a tendency ($P = 0.09$) for right ventricular pressure to be affected by BW with ventricular pressure being elevated for the H cattle. In addition, overall pulmonary arterial pressure was affected ($P < 0.01$; **Figure 11**) by BW. The H steers exhibited elevated pulmonary arterial pressure when compared to L steers. In addition, day ($P < 0.01$) was different in almost every parameter measured highlighting differences in pressures measurements with increasing days on feed and increased BW as the duration of days on feed increased. Pulmonary arterial pressure measurements decreased with increasing days on feed. Finally, heart rate was lower ($P = 0.02$) in the H steers. This is because heart rate is inversely related to BW.

4. Conclusion

Steroidal implant administration increased growth performance responses as

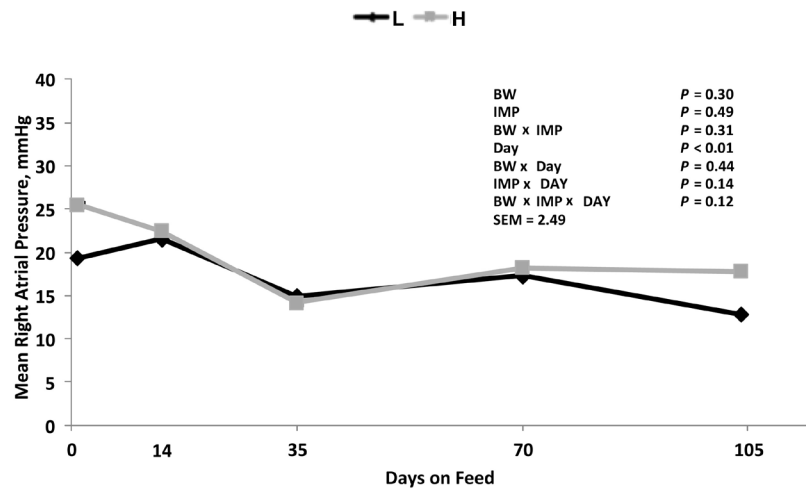


Figure 5. Effect of body weight and days on feed on mean right atrial pressure (L = Light BW; H = Heavy BW; SEM = 2.49; n = 10).

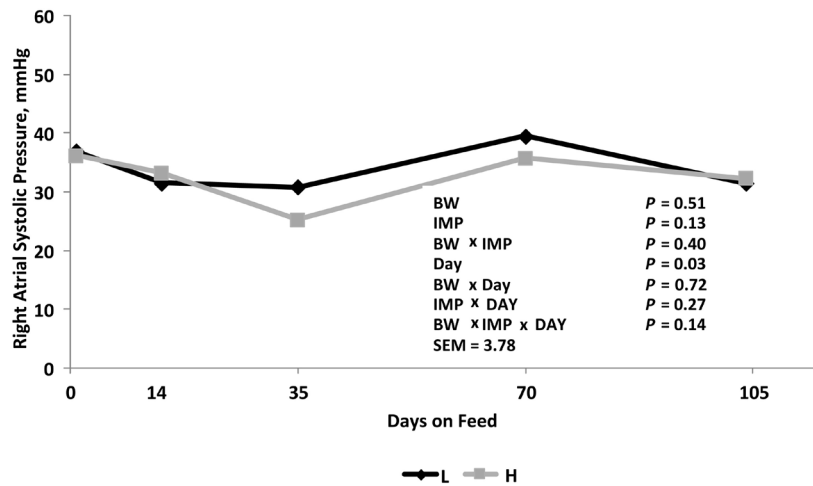


Figure 6. Effect of body weight and days on feed on systolic right atrial pressure (L = Light BW; H = Heavy BW; SEM = 3.78; n = 10).

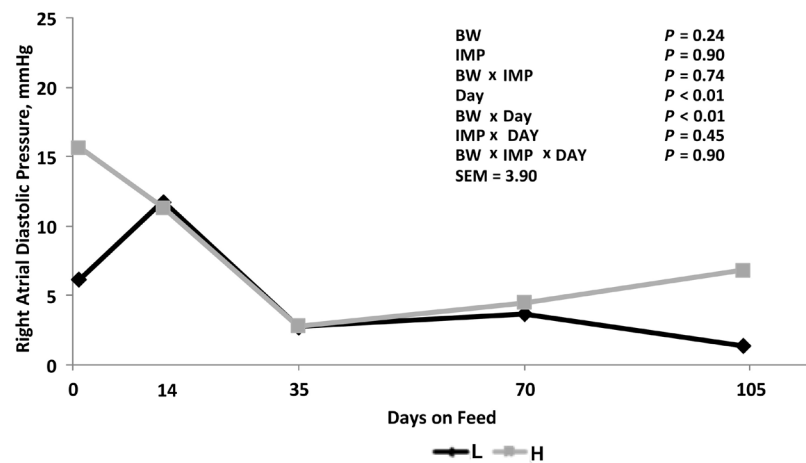


Figure 7. Effect of body weight and days on feed on diastolic right atrial pressure (L = Light BW; H = Heavy BW; SEM = 3.90; n = 10).

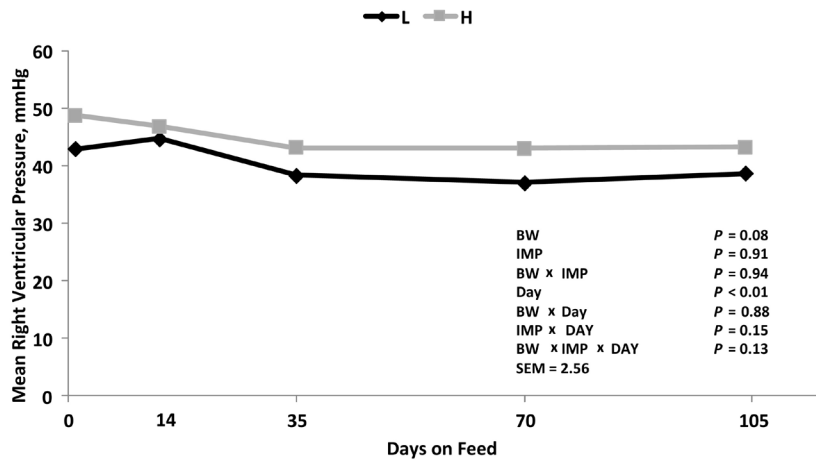


Figure 8. Effect of body weight and days on feed on mean right ventricular mean pressure (L = Light BW; H = Heavy BW; SEM = 2.56; n = 10).

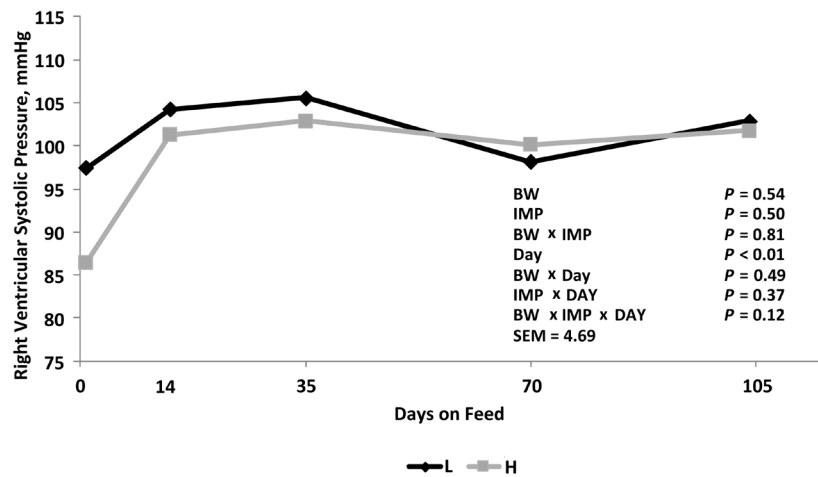


Figure 9. Effect of body weight and days on feed on systolic right ventricular pressure (L = Light BW; H = Heavy BW; SEM = 4.69; n = 10).

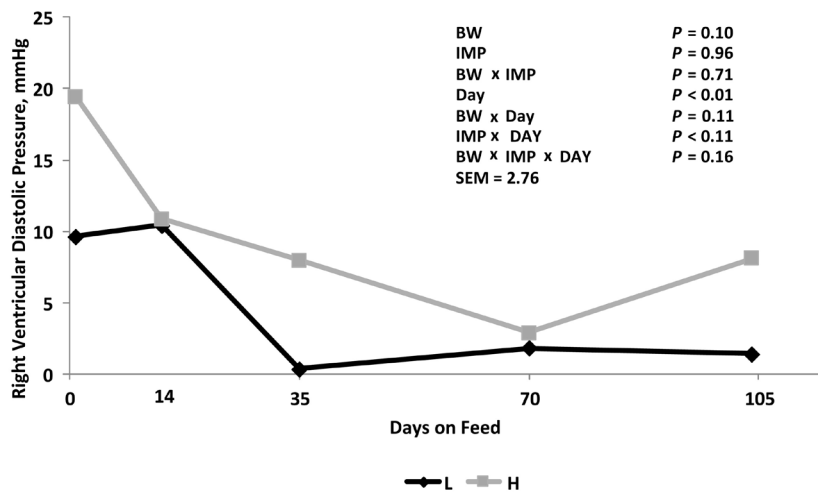


Figure 10. Effect of body weight and days on feed on diastolic right ventricular pressure (L = Light BW; H = Heavy BW; SEM = 2.76; n = 10).

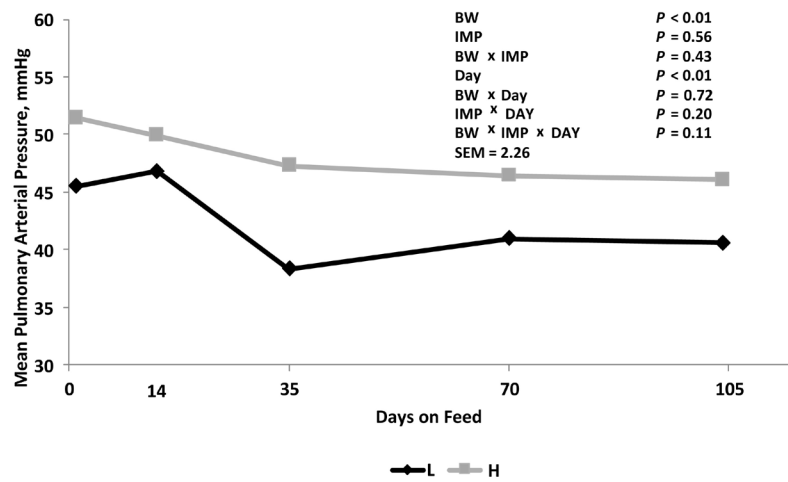


Figure 11. Effect of body weight and days on feed on mean pulmonary arterial pressure (L = Light BW; H = Heavy BW; SEM = 2.26; n = 10).

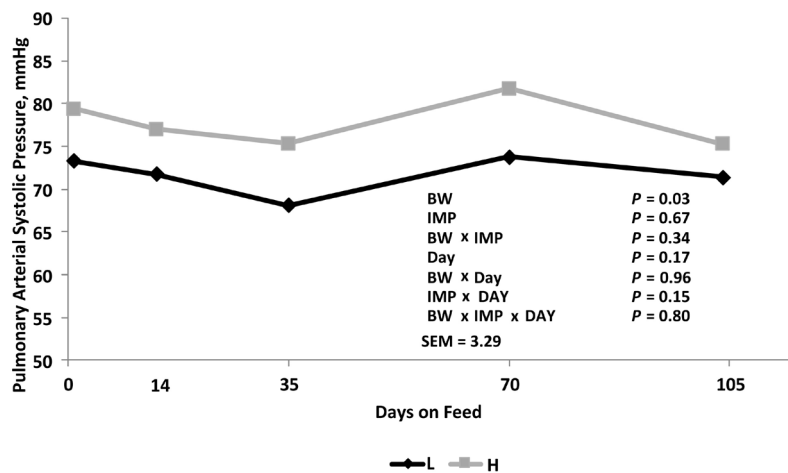


Figure 12. Effect of body weight and days on feed on systolic pulmonary arterial pressure (L = Light BW; H = Heavy BW; SEM = 3.29; n = 10).

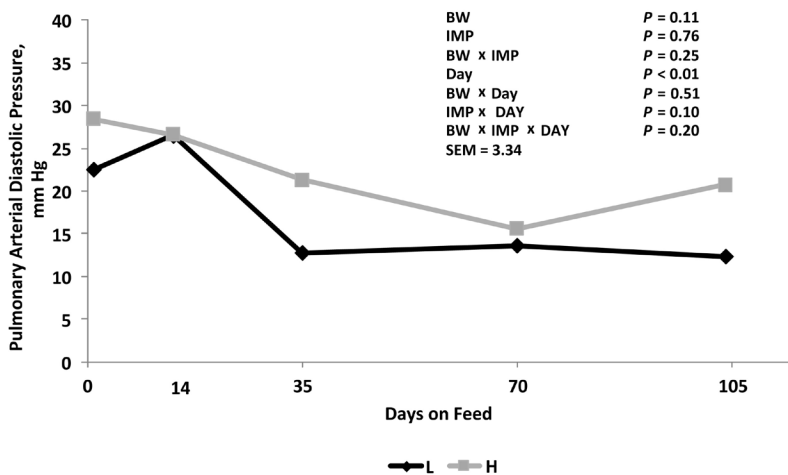


Figure 13. Effect of body weight and days on feed on diastolic pulmonary arterial pressure (L = Light BW; H = Heavy BW; SEM = 3.34; n = 10).

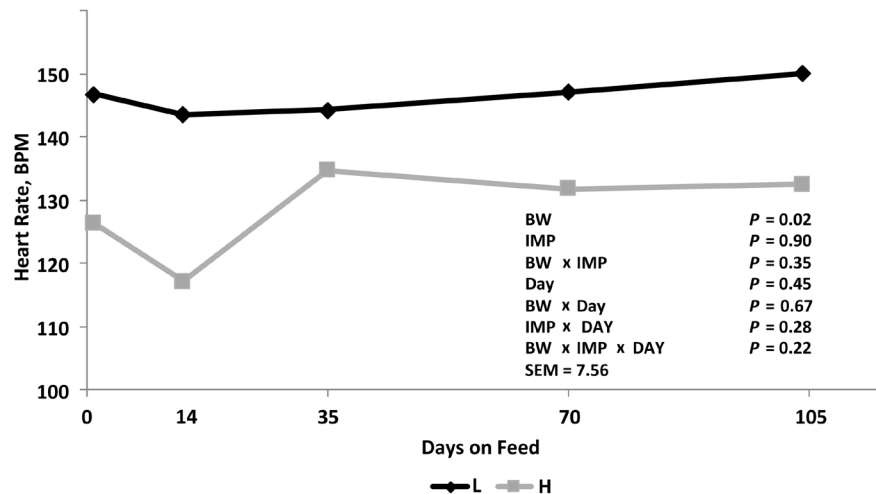


Figure 14. Effect of body weight and days on feed on heart rate (L = Light BW; H = Heavy BW; SEM = 7.56; n = 10).

expected. Regardless of BW at time of implantation, implants increased animal growth performance and carcass characteristics. Cattle of differing size respond to implants differently as evidenced by the changes in NEFA and SUN post-implantation. It is unlikely that steroidal implants with anabolic activity containing E_2 and/or TBA impact pulmonary arterial pressure in feedlot steers under normal conditions. A limitation to this study is that cattle were housed in small pens. In larger pens settings, behavioral modifications and pen based social dynamics might have altered observed outcomes. However, the study highlights the risk of elevated BW on pulmonary arterial pressure.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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