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Evaluation of Growth Performance, Efficiency of Dietary Net Energy Utilization, and Carcass Trait Responses of Heavy Finishing Lambs Administered 12 mg of Zeranol Subcutaneously in the Ear 59 d before Harvest †

Emily R. Nold ‡, Thomas C. Norman ‡, Warren C. Rusche, Rosemarie A. Nold and Zachary K. Smith *

Department of Animal Science, South Dakota State University, Brookings, SD 57007, USA; rosemarie.nold@sdstate.edu (R.A.N.)

* Correspondence: zachary.smith@sdstate.edu

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‡ These authors contributed equally to this work.

Abstract: The objective of this research was to determine the influence of implanting heavy wether lambs with 12 mg of zeranol (1 pellet Ralgro, Merck Animal Health. Madison, NJ, USA) 59 d before harvest. Average daily gain (ADG), feed efficiency, and carcass merit were evaluated. Polypay and crossbred wethers (n = 32) were equally divided into two treatment groups: non-implanted; (CON) or implanted with 12 mg of zeranol (IMP) in a randomized complete block design. Sixteen pens were used, resulting in eight replicate pens per treatment. Wethers were fed a finishing diet consisting of cracked corn, soybean meal, and soybean hulls ad libitum for 59 d. Lambs had access to clean water at all times from water fountains. Lambs were weighed on d -1, 1, 14, and 59. On d 59, 16 lambs (8 lambs/treatment) were harvested in the South Dakota State University Meat Lab. Hot carcass weight (HCW), dressing percent (DP), rib fat, body wall thickness, loin eye area, boneless closely trimmed retail cut percentages, and yield grades were recorded. Final body weight (BW), cumulative ADG, and gain efficiency were greater ($p \leq 0.01$) for implanted lambs by 2.9%, 25.0%, and 35.2%, respectively, while dry matter intake (DMI) was unaffected by implant treatment ($p = 0.18$); thus, the efficiency of dietary net energy utilization was increased for IMP ($p \leq 0.01$). No appreciable differences were noted ($p \geq 0.17$) between treatments for any carcass traits measured. These results indicate that zeranol improves growth performance in heavy finishing lambs without detriment to carcass quality, which implies that producers can improve profitability due to increased gains and efficiency.

Keywords: anabolic; dietary energy utilization; growth; sheep

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1. Introduction

The use of the growth-promoting anabolic implant zeranol was approved for use in cattle and sheep in 1969 by the U.S. Food and Drug Administration [1,2]. Zeranol originates from the mycotoxin zearalenone, which is a product of a *Fusarium* fungus. The anabolic agent has weak estrogenic activity, which improves performance by stimulating the pituitary gland, resulting in the synthesis of growth hormones. Increases in growth hormone secretion can result in extended bone growth and consequently increase lean muscle growth [2]. Zeranol implants have been shown to improve the performance of sheep, as evidenced by increased ADG and feed efficiency [3–6]. However, the use of zeranol in sheep feedlot settings is much more limited than the extensive use of growth-promotant technologies in cattle production.

While the effects of zeranol on performance are well documented, its effects on carcass characteristics are less understood. Ideally, carcasses should be heavy, have minimal fat deposition, a large loin eye area, and a high percentage of boneless, closely trimmed retail cuts. Zeranol effects on carcass data have been inconsistent and these studies have primarily evaluated the use of zeranol in lambs harvested at a lighter final BW (<66 kg) [5–8]. Eckerman et al. [7] reported no appreciable difference in HCW, fat depth, body wall thickness, loin eye area, flank streaking, quality grade, yield grade, boneless, closely trimmed retail cuts, or DP. Likewise, [6] found that 12 mg zeranol had a positive impact on performance but did not affect carcass characteristics. In contrast, Stultz (2000) observed that implanted lambs possessed a larger loin eye and heavier HCW. Absolute growth performance responses are greater in cattle implanted at a heavier weight than in cattle implanted at lighter BW, primarily due to greater DMI in heavier-weight cattle and the fact that maintenance requirements are not linearly related to BW, hence, there is more feed intake available for gain in addition to changes in composition of gain [9]. Thus, the objective of this study was to further investigate the impact of 12 mg zeranol on growth performance, feed efficiency, and carcass merit of heavy wether lambs.

2. Materials and Methods

2.1. Institutional Animal Care and Use Approval

This study was conducted at the South Dakota State University Sheep Unit Research Feedlot (SU) in Brookings, SD between September and November of 2022. The animal care and handling procedures used in this study were approved by the South Dakota State University Animal Care and Use Committee (2208-045).

2.2. Wether Management and Treatments

Polypay (replicates 1 to 7) and Hampshire × Polypay (replicate 8) crossbred wethers (initial BW = 61.9 ± 6.6 kg) were used in a 59-day finishing study. Wethers were procured from the South Dakota State University Sheep Unit. Initial processing was conducted approximately 60 d before the initiation of the present experiment and included vaccination against enterotoxemia and treatment for internal and external parasites. All wethers had a unique identification tag and were weighed individually (scale readability 0.454 kg) on d -1, 1, 14, and 59.

Wethers were assigned to one of sixteen uncovered pens (3.1 m × 3.1 m earthen surface pens with a 1.0 m covered poly-feeder; eight pens/treatment; two wethers per pen) in a randomized complete block design (blocked by initial BW). Each pen was randomly assigned to one of two treatments: a control group receiving no steroidal implant (CON) or a group administered 12 mg of zeranol (Merck Animal Health, Madison, NJ, USA) subcutaneously in the middle third of the ear 59 d before harvest (IMP).

2.3. Dietary Management

If carryover feed was present on weigh days, the residual feed was removed prior to the collection of BW measurements. Carryover feed and feed that was spoiled (e.g., rained on) were collected, weighed, and dried in a forced air oven at 100 °C for 24 h to determine DM content. The dry matter intake (DMI) of each pen was adjusted to reflect the total DM delivered to each pen after subtracting the number of dry orts for each interim period. Actual diet formulation and actual tabular composition (Table 1) were based on monthly DM analyses (drying at 60 °C until no weight change; n = 2 samples/ingredient) of each ingredient, tabular nutrient values [10], and feed batching records.

Table 1. Finishing diet formulation, nutrient composition, and energy values [1].

Item	Finishing Diet
Cracked Corn, %	59.46
Pelleted Supplement, %	22.80
Soybean Hulls, %	15.20
Soybean Meal, %	2.54
Dry matter (DM), %	88.89
Crude protein [2], %	15.14
Neutral detergent fiber [2], %	17.06
Net energy for maintenance [2], Mcal/kg	1.83
Net energy for gain [2], Mcal/kg	1.23

[1] All values except for Dry Matter are on a Dry Matter basis. [2] Calculated using tabular nutrient values according to [9].

2.4. Growth Performance Calculations

Wethers were individually weighed prior to study initiation (d -1) to normalize pen allotments. Wethers were also individually weighed on d 1, d 14, and d 59 (the final day of the experiment). Cumulative daily weight gain was based upon initial (d -1 and 1 body weight average) shrunk body weight (SBW; 4% shrink) and final shrunk BW (4% shrink). Shrunk body weight accounts for feed and water intake. Average daily gain (ADG) was calculated by subtracting the final shrunk BW from the initial shrunk BW and dividing by days on feed. The gain to feed ratio (G:F) was calculated by dividing ADG by DMI.

2.5. Dietary NE Utilization Calculations

Observed dietary net energy (NE) was calculated from daily energy gain (EG; Mcal/d) according to $0.255 \times \text{ADG} \times \text{SBW}^{0.75}$, assuming a mature ram weight of 125 kg for Polypay [11]. Maintenance energy required (EM; Mcal/d) was calculated by the following equation: EM, Mcal/d = $0.056\text{SBW}^{0.75}$ where SBW was the average of the initial shrunk BW and final shrunk BW [11]. Using the estimates required for maintenance and gain, the observed dietary net energy for maintenance (NE_m) and net energy for gain (NE_g) values of the diet were generated using the quadratic formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2c}$$

where x = NE_m, Mcal/kg; a = -0.41 EM; b = 0.877 EM + 0.41 DMI + EG; c = -0.877 DMI; and NE_g was determined from $0.877\ \text{NE}_\text{m} - 0.41$ [12,13]. The ratio of observed/expected NE ratio was determined from the observed dietary NE for maintenance or gain divided by the tabular NE for maintenance or gain. This ratio was used to evaluate the amount of energy that went towards maintenance needs, and the amount of energy that resulted in weight gain. A greater ratio value than 1 indicates a greater amount of utilized energy than expected.

For the estimation of the expected DMI, the equation was used as follows: DMI (kg) = FFM + FFG. Feed for maintenance (FFM; kg) was the EM divided by the tabular NE_m value. Feed for gain (FFG; kg) was the EG divided by the tabular NE_g value. The ratio of observed/expected DMI was determined from the observed DMI divided by the expected DMI. For this calculation, a lower ratio value is more desirable as it indicates less feed intake for equal weight gain.

2.6. Harvest and Carcass Data Collection

To obtain carcass trait information, one wether was randomly selected from each pen allotment (a total of sixteen); thus, carcass data was collected from eight CON and eight IMP wethers at the South Dakota State University Meat Lab on day 59. Once harvested, HCW was recorded immediately, then carcasses were chilled at 2 °C for 5 days. On the sixth day carcasses were evaluated for rib fat thickness, body wall depth, and loin eye area. Percent boneless closely trimmed retail cuts were also calculated at this time.

2.7. Statistical Analysis

Data were analyzed using analysis of variance appropriate for a randomized complete block design experiment using the GLIMMIX procedures of SAS 9.4 (SAS Inst. Inc. Cary, NC, USA). Implant treatment was included as a fixed effect, and the block was considered a random factor; the pen served as the experimental unit for all analyses. Least squares means were generated using the LSMEANS statement and treatment effects were analyzed using the pairwise comparisons PDIFF and LINES option. An α of 0.05 determined significance and an α of 0.06 to 0.10 was considered a tendency.

3. Results and Discussion

Growth performance and carcass data are located in Table 2. As planned, the initial BW was not significantly different between treatments (p = 0.14). Final BW, cumulative ADG, and gain efficiency were greater ($p \leq 0.01$) for IMP by 2.9%, 25.0%, and 35.2%, respectively, while DMI was not appreciably influenced by implant treatment (p = 0.18); thus, the observed dietary NE_m value was increased by 18.9% and NE_g by 25.9% for IMP compared to CON ($p \leq 0.01$). The ratio of observed/expected NE_m and NE_g were greater for IMP as compared to CON ($p \leq 0.01$; 0.95 vs. 1.13 $\pm$ 0.044), meaning that a greater amount of consumed energy was put towards maintenance and weight gain in CON lambs. The ratio of 0.95 for the CON group can be expected because in the late phase of finishing (and high slaughter weight), the energy utilization is less in this phase, and the 5% reduction is perfectly explicable. Future research should evaluate the suitability of current estimates for retained energy and/or estimates for basal metabolic rate in heavy-weight finishing lambs. The ratio of observed/expected DMI was less for IMP compared to CON ($p \leq 0.01$). These ratios together indicate more efficient utilization of nutrients. The application of 12 mg of zeranol did not appreciably ($p \leq 0.17$) influence any carcass traits measured.

The growth responses observed in the current study from implanting lambs with zeranol agree with results from prior experiments [4–6,8] where all reported increased ADG. Sluiter et al. [6] looked at the effects of three different implants in growing lambs. Seventy-five lambs were implanted with 12 mg zeranol (Ralgro) and then compared against a control group and two other implant treatments (Synovex C and Component E-C) both containing 10 mg of estradiol benzoate and 100 mg of progesterone. These researchers reported that lambs with zeranol had a higher ADG than the control lambs, but did not gain as rapidly as those implanted with Synovex-C or Component E-C. Stultz [5] used 146 lambs in a similar trial with a control group and a zeranol-implanted group. Weights were recorded on days 0, 28, 56, 84, and 105, and then average daily gains were computed for each of the time increments. In that experiment, ADG increased between days 0 to 28, 29 to 56, and 57 to 84; however, there was not a significant difference between the groups from day 85 to 105. The final body weights of the implanted lambs were still heavier. Jones et al. [4] reported increased ADG by 19% over the entire feeding period, with the greatest response between days 56 and 69 where ADG was increased by 32%. Our observed 25% increase in ADG aligns with these previous findings. Jones et al. [4] recorded a 14.4% improved feed efficiency of implanted lambs along with others [14]. Hutcheson et al. [8] indicated increased ADG by 26% and DMI by 12.4%, resulting in a 12% improvement in feed conversion efficiency. This is comparable to our 26% observed increase in feed efficiency, but in the present study, heavy-weight finishing sheep implanted with 12 mg of zeranol had greater gain, similar DMI, and improved feed efficiency.

The greater utilization of energy as shown by the higher observed to expected NE ratios for implanted wethers is a reflection of the non-nutritional action of implants. These actions affect the composition of gain by enhancing net protein retention and result in leaner-than-expected tissue growth for the specified live weight and rate of gain [11].

Additionally, the lower, more desirable observed to expected DMI ratio is also a reflection of the more efficient use of energy by IMP wethers.

Table 2. Cumulative growth performance and carcass trait responses following 59 d of implantation [1].

Item	Treatment [2]		SEM [3]	*p*-Value
	CON	IMP		
No. of Wethers (carcasses)	16 (8)	15 (8)	-	-
No. of Pens (carcass data)	8 (8)	8 (8)	-	-
Initial body weight (BW), kg	61.82	61.32	0.305	0.14
Cumulative live growth				
Final BW, kg	72.62	74.75	0.612	0.01
Average daily gain (ADG), kg	0.181	0.227	0.0113	0.01
Dry matter intake (DMI), kg	1.74	1.62	0.085	0.18
ADG/DMI	0.105	0.142	0.0096	0.01
DMI/ADG	9.52	7.04	-	-
Observed diet net energy (NE), Mcal/kg				
Maintenance	1.74	2.07	0.080	0.01
Gain	1.12	1.41	0.071	0.01
Observed to expected				
Maintenance (NE_m)	0.95	1.13	0.044	0.01
Gain (NE_g)	0.91	1.14	0.040	0.01
DMI	1.10	0.89	0.053	0.01
Carcass traits				
Hot carcass weight (HCW), kg	43.82	43.91	0.953	0.95
Dressing percentage, %	60.50	58.70	1.179	0.17
Ribfat, cm	1.37	1.14	0.032	0.27
Body wall, cm	4.14	4.16	0.017	0.78
Loin eye area, cm^2	17.03	17.16	0.023	0.87
Boneless, closely trimmed retail cuts, %	40.11	40.52	0.676	0.55
Yield grade	5.9	4.9	0.81	0.27

[1] A 4% pencil shrink was applied to all BW measures to account for digestive tract fill. [2] Treatments included a control group receiving no steroidal implant (CON) or a group administered 12 mg of zeranol (Merck Animal Health, Madison, NJ) subcutaneously in the middle third of the ear 59 d before harvest (IMP). [3] Pooled standard error of the mean.

Past results of the effect of zeranol on carcass traits have been inconsistent. We observed no significant differences between CON and IMP wethers. Hutcheson et al. [8] noted greater HCW by 12.4% when wether lambs (slaughter BW < 54 kg) were implanted with 12 mg of zeranol. However, other studies [4,5] found no appreciable differences in carcass characteristics between implanted and control lambs (slaughter weight < 57 kg). In contrast, [15] found a slight increase in the loin eye area and less body fat in the implanted vs. control lambs. Inconsistent findings related to carcass trait outcomes in finishing lambs administered 12 mg of zeranol are likely related to differences in slaughter BW.

4. Conclusions

Implanting heavy-weight finishing lambs with 12 mg of zeranol increased daily gain and enhanced the efficiency of energy capture from the diet without detriment to carcass quality. This is critical as the use of zeranol can aid in increasing the pounds of meat produced without altering the number of sheep or the amount of feed required. Such implications provide promise for the United States to become more sustainable in terms of lamb production, as the United States currently does not harvest enough lamb to meet domestic demand.

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Institutional Review Board Statement: This study was conducted at the South Dakota State University Sheep Unit Research Feedlot (SU) in Brookings, SD, between September and November of 2022. The animal care and handling procedures used in this study were approved by the South Dakota State University Animal Care and Use Committee (2208-045).

Informed Consent Statement: Not applicable.

Data Availability Statement: Data can be made available upon reasonable request to Z.K.S.

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