Effects of maternal metabolizable protein supplementation during the last 50 days of gestation on ewe and offspring performance and carcass characteristics[1]

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The objectives of this trial were to determine the effects of maternal metabolizable protein supplementation in ewes during the last 50 days of gestation on offspring performance and carcass characteristics.

SUMMARY

Supplementation of energy and/or protein to ruminants during gestation has become vital in programming the fetus for increased growth and performance throughout life. Therefore, we hypothesized that ewes on the restricted metabolizable protein (MP) diets would have reduced performance during the last 50 days of gestation, and therefore would have smaller lambs at birth. Secondly, we hypothesized that the lambs from ewes maintained on the restricted MP diets would have reduced feedlot performance and carcass characteristics. Two hundred ninety-five multiparous ewes were stratified by weight, body condition score, and expected lambing date into one of three dietary treatments: CON: 100% of the MP requirement, MED: 80% of CON, and LOW: 60% of CON (NRC, 2007) during the last 50 days of gestation. Ewe initial BW, final BW pre-partum, change in BCS during gestation, and BW change at lambing were not different ($P \geq 0.26$) between dietary treatments. Ewes maintained on the CON and MED diets had a greater ($P < 0.0001$) increase in BW change compared with the ewes maintained on the LOW diet. At lambing, the LOW and MED ewes had a greater ($P = 0.007$) reduction in change in BCS compared with the CON ewes. Three hour milk production and lamb weaning weight were not affected ($P \geq 0.65$) by ewe maternal MP supplementation. Maternal dietary treatment did not affect ($P \geq 0.13$) initial BW, final BW, ADG, feed efficiency, carcass weight, dressing percentage, LM area, back fat thickness, body wall thickness, leg score, conformation score, flank streaking, quality grade, and yield grade of wethers in the feedlot. Wethers from ewes on the LOW treatment had increased ($P = 0.01$) DMI compared with wethers from ewe on the MED treatment. The wethers from ewes supplemented with CON tended ($P = 0.10$) to have decreased days on feed in the feedlot compared with wethers from ewes supplemented with MED. Percent boneless, closely trimmed, retail cuts was increased ($P = 0.04$) in wethers from ewes maintained on the CON diet compared with wethers from ewes fed the LOW and MED diets. The tendency for wethers from the CON fed ewes to have reduced days on feed as

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well as the increased percentage of retail cuts suggests that those wethers were programmed in utero to have increased performance and carcass characteristics. These data suggest that ewes fed at 60% of MP requirements can still maintain pregnancy by becoming more efficient in partitioning nutrients to the fetus and mobilizing body reserves.

INTRODUCTION

Crude protein is supplemented during late gestation to cows and ewes to maintain body condition in dams as well as dam body weight (Martin et al., 2007; Swanson et al., 2008). By maintaining body weight and body condition the dam has more nutrient reserves to be utilized in maintaining pregnancy and growth of the fetus. However, very little research has evaluated supplementation of metabolizable protein (MP) during late gestation. Gestation length has also been shown to be reduced in cows fed severely restricted diets during early gestation compared with cows supplemented with adequate energy and CP (Long et al., 2010).

In many studies, birth weight was found not to be affected by dam supplementation or nutrient restriction (Anthony et al., 1986; Long et al., 2010; Martin et al., 2007; and Stalker et al., 2006). However, Swanson et al. (2008) observed that ewes fed diets meeting 60 and 140% of requirements of the early gestational ewe gave birth to heavier lambs than those ewes fed a diet meeting 100% of requirements of the early gestational ewe. Although birth and weaning BW was not significant due to maternal dietary restriction, those steers from cows fed a restricted diet had increased BW at the beginning and end of the feedlot phase (Long et al., 2010). However, these increased BW did not carry over into the carcass characteristics (Long et al., 2010). However, Ford et al. (2007) observed an increase in ultrasonography back fat in lambs from ewes fed a restricted diet during early to mid-gestation, once again yielding conflicting results on the effect of maternal supplementation during late gestation on progeny performance.

Therefore, we hypothesized that ewes on a restricted MP diets would have reduced performance during the last 50 days of gestation, and therefore would have smaller lambs at birth. We also hypothesized that the lambs from ewes maintained on the restricted MP diets would have reduced feedlot performance and carcass characteristics.

PROCEDURES

Ewes. Two hundred ninety-five multiparous ewes were stratified by weight, body condition score, and expected lambing date into one of three dietary treatments (Table 1): LOW: 60% of CON; MED: 80% of CON; and CON: 100% of the MP requirements of a ewe baring twins during the last 4 weeks gestation (NRC, 2007). Ewes were moved into a total confinement barn with a total of 21 pens (7 pens/dietary treatment) and acclimated to the CON diet for 7 d prior to starting dietary treatments. Ewes were supplemented with their respective treatment once daily at 0800 h. Supplementation was determined by the average body weight of the pen and fed according to NRC (2007) requirements. Ewes were given two hours to consume the supplement then low-quality forage (2.92% CP and 60.00% TDN; fescue hay) was offered. Ewes were weighed and body condition scored on two consecutive days at the beginning (d 0 and 1) and end (lambing) and once every 14 d during the treatment period. Supplement intake was adjusted for increases or decreases in body weight at every weigh day. Once ewes had lambed, the ewes and lambs were maintained in a common group on a lactation ration until weaning.

Lambs. Lambs were weighed and tagged within 24 h of birth, as well as gender, lambing difficulty, and lamb vigor recorded. Milk production was evaluated (Benson et al., 1999) utilizing ewes bearing singletons (LOW: n = 15 and MED and CON: n = 16) at an average 23 d of age. Lambs were removed from their ewes for three hours. After the three hour withdrawl, lambs were allowed to suckle until they quit suckling. Once done suckling, lambs were removed from the ewes for another three hours. Lambs were then weighed prior to being allowed to suckle again. Then lambs were allowed to suckle until they were done suckling. Once done suckling the lambs were weighed.

Lambs were weaned at an average of 69 ± 5 d of age. At weaning all lambs were placed into a common pen for a period of 20 d to acclimate to a feedlot diet. Following adaptation, wethers were allotted randomly by maternal dietary treatment and blocked by weight into a heavy or light weight pen per treatment (2 pens/treatment and 6 pens total). Wethers were weighed on two consecutive days at the beginning (d 0 and 1) and end of the feedlot period (d 109 and 110 and d 143 and 144). The d 109 and 110 wethers included all wethers meeting or exceeding at least 69 kg BW and the d 143 and 144 wethers included the remaining wethers. Once every 28 d during the feedlot period wethers were weighed. Wethers were fed ad libitum (85% corn, 15% commercial market lamb pellet; Table 2) via bulk feeders and had access to fresh water. At the end of the feedlot period, lambs were transported to Iowa Lamb Corporation in Hawarden, IA or the Department of Animal Science Meat Lab at North Dakota State University in Fargo, ND for harvest and carcass data collection.

Statistical analysis. Ewe performance, lamb weigh-suckle-weigh, and wether feedlot performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). The model included the main effects of treatment, ewe pen, and the interaction between the two. If the interaction was found to be clearly not significant ($P > 0.30$), it was removed from the model. The data are presented as least squares means (LSmeans) ± SEM. Significance was set at $P \leq 0.05$ and tendencies at $P \leq 0.10$.

RESULTS AND DISCUSSION

Ewe performance. Initial BW, initial BCS, and final BW pre-partum were not different ($P \geq 0.26$, Table 3) among dietary treatments. This was expected due to the randomized allotment. However, Swanson et al. (2008) observed a reduction in final post-partum BW of ewes fed a restricted diet of 60% of NRC (1985) energy requirements during the last 50 day of gestation compared with ewes fed 100 or 140% of energy requirements. Similar to the results observed by Swanson et al. (2008), Ford et al. (2007) observed an increase in pre-partum BW of ewes fed at 100% of NRC (1985) energy requirements for the early gestational ewe compared with those ewes restricted to 50% of requirements for the early gestational ewe during early to mid-gestation. Change in body condition score during the last 50 days of gestation was not affected ($P = 0.59$) by maternal MP supplementation. Although BW was not affected by dietary treatment, ewes maintained on the CON and MED diets had a greater ($P < 0.001$) increase in BW compared with the ewes maintained on the LOW diet. Stalker et al. (2006) observed similar results with cows supplemented during gestation maintaining BW compared with cows receiving no supplement during gestation. Cows supplemented with CP during the last trimester of gestation maintained BW and BCS compared with cows not supplemented (Martin et al., 2007). The reduction in BW in the LOW ewes may indicate that those ewes had to utilize body reserves to maintain pregnancy on a restricted diet and therefore lost more weight during gestation due to the lack of nutrients being fed. There were no difference ($P = 0.35$) in BW change at lambing because of maternal MP supplementation. Cows restricted to 81% of CP requirements had decreased BW and BCS within 24 h post-calving compared with cows fed 141% of CP requirements (Anthony et al., 1986). The final pre-partum BCS tended ($P = 0.09$) to be increased in the MED ewes compared with the LOW ewes. At lambing, the LOW and MED ewes had reduced ($P = 0.001$) BCS compared with CON ewes. The LOW and MED ewes had a greater ($P = 0.007$) reduction in change in BCS compared with the CON ewes. This would be explained by the reduced BCS at lambing for the restricted (LOW and MED) ewes. Increased BCS change in the restricted (LOW and MED) ewes may be indicative of using body reserves to maintain pregnancy during the last 50 days of gestation. The LOW ewes gained less weight and had increased loss in body condition during the last 50 days of gestation, which suggests that those ewes may have mobilized more body reserves to maintain pregnancy.

Offspring. Milk production and lamb weaning weight was not affected ($P \geq 0.65$, Table 4) by

ewe dietary treatment. Calves from cows supplemented with CP during gestation had increased weaning weights and ADG from birth to weaning compared with calves from non-supplemented cows (Stalker et al., 2006). There was a maternal dietary treatment by birth type interaction for birth weight ($P < 0.001$). As litter size increased the CON ewes gave birth to heavier lambs than those ewes fed the MED diet. In contrast, birth weights of lambs from ewes maintained on 60 and 140% of NRC (1985) energy requirements for the early gestational ewe were reduced compared with lambs from ewes maintained on 100% of NRC energy requirements for the early gestational ewe (Swanson et al., 2008). However, birth weights of calves born to cows supplemented with CP during gestation were not different compared with calves born to non-supplemented cows (Anthony et al., 1986; Stalker et al., 2006; Martin et al., 2007). Heifers from cows receiving CP supplementation during the last trimester tended to have increased weaning weights and 205 d adjusted weaning weights (Martin et al., 2007). The increased birth weight of lambs born to ewes on the LOW diet may also indicate a mobilization of body reserves or the ewes becoming more efficient in partitioning nutrients between themselves and the fetus during the last 50 days of gestation to maintain pregnancy.

Maternal dietary treatment did not affect ($P \geq 0.13$, Table 4) initial and final BW, ADG, feed efficiency, carcass weight, dressing percentage, LM area, back fat thickness, body wall thickness, leg score, conformation score, flank streaking, quality grade, and yield grade of wethers during the finishing phase. Back fat thickness measured via real-time ultrasonography was increased in lambs from ewes restricted to 50% of NRC (1985) energy requirements for the early gestational ewe compared with lambs from ewes maintained on 100%

Table 1. Ingredients and nutrient composition of diets fed to ewes from d 100 of gestation until lambing

	Diet[1]		
Item	LOW	MED	CON
Ingredient, %			
Corn	18.50	15.00	5.00
Dried Distiller's Grains	7.00	20.00	30.00
Soyhulls	9.50	—	—
Trace Mineral	0.49	0.49	0.49
Fescue Hay	64.51	64.51	64.51
Nutrient Composition			
DM, %	88.75	89.34	89.68
CP, % of DM	13.16	20.21	25.13
NDF, % of DM	31.03	30.73	39.79
ADF, % of DM	15.69	7.45	10.49

[1]Maternal dietary treatment: LOW: 60% of CON, MED: 80% of CON, and CON: 100% of the metabolizable protein requirement met during the last 50 days of gestation.

Table 2. Ingredient and nutrient composition of diets fed to wethers[1] during the feedlot phase

Item	Ingredient
Ingredient, %	
Whole Corn	85.0
Commercial Market Lamb Pellet[2]	15.0
Nutrient Composition	
DM	89.06
NDF, % of DM	15.54
ADF, % of DM	3.76
CP, % of DM	15.19

[1]Wethers born to ewes fed: LOW: 60% of CON, MED: 80% of CON, and CON: 100% of the metabolizable protein requirement met during the last 50 days of gestation.

[2]Commercial Market Lamb Pellet contained: 200 g/ton Chlortetracycline; 38.0% CP; 3.75-4.75% Ca; 0.6% P; 3.0-4.0% salt; 1.2 ppm Se; 24,000 IU/lb Vitamin A; 2,400 IU/lb Vitamin D; and 95 IU/lb Vitamin E.

Table 3. Effects of metabolizable protein level during the last 50 days of gestation on ewe performance

	Maternal Dietary Treatment[1]				
Item	LOW	MED	CON	SEM[2]	*P*-Value[3]
Initial BW, lb	143	143	144	2.4	0.98
Final BW pre-partum, lb	159	162	165	2.9	0.26
Weight Change, lb					
Gestation	15[b]	20[a]	21[a]	0.9	<0.001
Lambing	-28	-25	- 26	1.3	0.35
BCS					
Initial	2.9	2.9	2.9	0.03	0.64
Final pre-partum	2.9	3.0	2.9	0.03	0.09
Lambing	2.7[b]	2.8[b]	2.9[a]	0.04	0.001
BCS change					
Gestation	-0.01	0.03	0.03	0.04	0.59
Lambing	-0.18[a]	-0.20[a]	0.02[b]	0.04	0.007

[1]Maternal dietary treatment: LOW: 60% of CON, MED: 80% CON, and CON: 100% of the metabolizable protein requirement met during the last 50 days of gestation.
[2]Greatest SEM presented (n = 99 for LOW, n = 98 for MED and CON).
[3]*P* - value for the F test of the mean.
[a,b]Means within a row that lack a common superscript differ ($P \leq 0.05$; LSmeans).

of NRC requirements for the early gestational ewe (Ford et al., 2007). Supplementation of CP during gestation to cows did not affect ADG, DMI, feed efficiency, or carcass characteristics in steer calves in the feedlot (Stalker et al., 2006). However, in the current study, wethers from ewes on the LOW treatment had increased ($P = 0.01$) DMI compared with wethers from ewe on the MED treatment. In contrast to the current study, Martin et al. (2007) observed an increase in DMI in heifers from cows supplemented with CP during late gestation and fed hay during early lactation compared with cows that were pasture grazed during early lactation. The wethers from ewes supplemented with CON tended ($P = 0.10$) to have decreased days on feed in the feedlot compared with wethers from ewes supplemented with MED. Long et al. (2010) observed that calves from restricted fed cows had increased 425 days of age and both beginning and ending finishing BW compared with calves from cows fed adequately. However, the feedlot performance did not carry over to all of the carcass characteristics. Percent boneless, closely trimmed retail cuts was increased ($P = 0.04$) in wethers from ewes maintained on the CON diet compared with wethers from ewes fed the LOW and MED diets.

IMPLICATIONS

The data from the current study suggest that ewes can be fed at 60% of MP requirements (but adequate in CP and energy) and maintain pregnancy by becoming more efficient in partitioning nutrients to the fetus and mobilizing body reserves. The lambs from the ewes fed restricted MP diets may be programmed to be more efficient in partitioning nutrients for growth as well. However, this efficiency does not carry over to the majority of carcass characteristics of the lambs.

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Table 4. Effects of metabolizable protein level fed to ewes during the last 50 days of gestation on lamb performance

	Maternal Dietary Treatment[1]				
Item	LOW	MED	CON	SEM[2]	*P*-Value[3]
Birth Weight[4], lb	9.4	8.3	9.2	0.4	0.03
3 h milk production, lb	0.3	0.3	0.3	0.1	0.65
Weaning weight, lb	39.6	38.6	38.0	3.9	0.94

[1]Maternal dietary treatment: LOW: 60% of CON, MED: 80% of CON, and CON: 100% of the metabolizable protein requirement met during the last 50 days of gestation.
[2]Greatest SEM presented.
[3]*P* - value for the F test of the mean.
[4]Maternal dietary treatment x Birth Type of $P < 0.001$.
[a,b]Means within a row that lack a common superscript differ ($P \leq 0.05$; LSmeans).

Table 5. Effects of maternal metabolizable protein supplementation on feedlot performance and carcass characteristics of wethers

	Maternal Dietary Treatment[1]				
Item	LOW	MED	CON	SEM[2]	*P* - value[3]
Initial Weight, lb	65	60	67	4	0.31
Final Weight, lb	154	150	147	3	0.17
Average Daily Gain, lb/d	0.7	0.7	0.7	0.03	0.20
Days on Feed, d	127	133	123	4	0.10
G:F, lb gain: lb DMI	0.2	0.2	0.2	0.01	0.46
Dry matter intake, lb/hd/d	3.3[a]	3.2[b]	3.3[ab]	0.04	0.01
Carcass Weight, lb	79.8	76.9	75.6	1.6	0.14
Dressing Percentage, %	51.8	51.2	51.4	0.4	0.53
LM area, in^2	2.8	2.7	2.7	0.1	0.94
Back fat thickness, in	0.3	0.3	0.3	0.02	0.27
Body wall thickness, in	1.1	1.1	1.1	0.04	0.72
Leg score[4]	12	12	12	0.2	0.83
Conformation Score[4]	12	12	12	0.2	0.64
Flank Streaking[5]	362	365	395	13.5	0.13
Quality Grade[4]	12	12	12	0.1	0.29
Yield Grade	3.3	3.5	3.2	0.3	0.54
BCTRC, %[6]	44.8[b]	44.9[b]	48.3[a]	1.1	0.04

[1]Maternal dietary treatment: LOW: 60% of CON, MED: 80% of CON, and CON: 100% of the metabolizable protein requirement met during the last 50 days of gestation.
[2]Greatest SEM presented (n = 31 for LOW, n = 33 for MED, and n = 24 for CON).
[3]*P* - value for the F test of the mean.
[4]Leg score, conformation score, and quality grade: 1 = cull to 15 = $Prime^+$.
[5]Flank streaking: 100-199 = practically devoid; 200-299 = traces; 300-399 = slight; 400-499 = small; 500-599 = modest.
[6]Percent boneless, closely trimmed, retail cuts (% BCTRC) = [49.936 – (0.0848 × 2.204 × Hot Carcass Weight, kg) – (4.376 × 0.393 × 12^{th} rib fat thickness, cm) – (3.53 × 0.393 × body wall thickness, cm) + (2.456 × 0.155 × LM area, cm^2)].
[a,b]Means within a row that lack a common superscript differ ($P \leq 0.05$; LSmeans).

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