Effects of rumen-protected arginine supplementation during gestation in ewes on postnatal offspring performance[1]

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Maternal under nutrition can have serious negative effects on fetal development and postnatal outcomes, and is relatively common in grazing ewes (Wu et al., 2006). For this reason, we supplemented pregnant multiparous ewes that were restricted in nutrition with a rumen-protected arginine supplement in an attempt to mitigate negative consequences of compromised maternal nutrition during gestation. We found that lambs from restricted ewes had reduced birth weights and that providing a rumen-protected arginine supplement to ewes during gestation recovered lamb body weight by 19 days of age. Additional research is needed to determine if arginine supplementation could be a means for producers to enhance postnatal lamb performance.

INTRODUCTION

Death losses in the United States sheep industry are notably higher in lambs than adult sheep. Most lamb death losses occur before reaching the age of being marked, docked, or branded (USDA, 2012). Neonatal lamb death is an economic issue and methods to enhance lamb growth, development, and health from a young age with a focus on reducing lamb morbidities and mortalities while simultaneously improving performance should yield benefits for producers.

Studies have shown that the body weights and gain potential of lambs may be heavily influenced by maternal nutrition (Wu et al., 2006, Meyer et al., 2010, Neville et al., 2010). Because most ewes maintain their pregnancies throughout late fall and winter, availability of high quality forages may be compromised and maternal under nutrition can result. In fact, it is estimated that grazing ewes in the western U.S. often don't meet even 50% of National Research Council (NRC) recommendations; clearly supplementation is critical in these instances (Wu et al., 2006). If maternal under nutrition occurs throughout pregnancy, fetal growth and postnatal outcomes can be compromised. Developing offspring from undernourished ewes often are at higher risk of

several animal health complications including respiratory diseases, which are implicated as one of the highest non-predator causes of lamb death loss in the U.S. (Wu et al., 2006, USDA, 2012).

Arginine, an amino acid, is a potential supplement that may help to circumvent under nutrition of grazing ewes. Arginine, among numerous other functions, serves as a precursor to nitric oxide and polyamines (Wu and Morris, 1998, Kwon, 2003). Nitric oxide is a known vasodilator which serves to increase blood flow to the fetus, and in turn transports more nutrients to the placenta for fetal development (Martin et al., 2001). Polyamines play various roles in placental health and development, most notably in regulation of angiogenesis, or the formation of new blood vessels. Similarly to nitric oxide, these polyamines may stimulate blood flow and consequently increase nutrient supply to the placenta throughout gestation (Kwon, 2003). We hypothesize that ewes supplemented with arginine throughout pregnancy will have a greater amount of nutrients available to the fetus during development, and their lambs will show more advanced development evidenced by increased weight gain.

PROCEDURES

Ewes. Thirty-two multiparous western white-face ewes were obtained from Hettinger Research Extension Center in Hettinger, North Dakota. The ewes were confirmed pregnant via ultrasound, and randomly assigned to three treatments: control (**CON**), restricted (**RES**), and restricted with an arginine supplement (**RES-ARG**). Ewes were fed a pelleted diet containing 34% dehydrated alfalfa meal, 27% dehydrated beet pulp, 25% wheat middlings, 9% ground corn, 5% soybean meal, and a tracemineral premix exchanged for ground corn at the rate of 12 pounds per ton on an as fed basis. Control ewes were fed at 100% NRC requirements, while restricted ewes were fed 60% of NRC requirements, and the arginine supplemented group received a granular rumen-protected arginine supplement at 180 mg/kg BW daily. Rumen protected arginine supplements were mixed into 0.11 pounds of corn and fed once a day at 8:00 am. Dietary treatments were implemented at day 54 of pregnancy (standard deviation of start date was 3.89 days). Ewes were housed in individual pens in a temperature-controlled facility.

Lambing. A 24-hour ewe watch procedure was implemented during lambing. Lambs were tagged, weighed, and a blood sample collected immediately following birth. They received C, D, & Tetanus toxoid and vitamins A, D, and E injections post birth. These lambs were not permitted to nurse from their mothers, so artificial colostrum was administered according to requirements of the lamb indicated by weight (Lifeline Rescue Colostrum, APC, Ankeny, IA). Lambs were given 19.1 mL/kg BW colostrum at intervals of 0 and 2 hours post birth, and 25.5 mL/kg BW at intervals of 4, 8, 12, 16, and 20 hours post birth to achieve a total of 10.64g IgG/kg body weight.

Lambs. After 24 hours, lambs were gradually weaned off of bottles to teat buckets filled with milk replacer (Super Lamb Milk Replacer, Merrick's Inc., Middleton, WI). This milk replacer, along with water, was available to them ad libitum. In addition to the milk replacer, a mixture of alfalfa hay and creep feed (Form-A-Feed 20% Lamb Pre-Starter, Form-A-Feed Inc. Stewart, MN) was also available ad libitum. Curved crown rump and girth measurements were taken post birth, and at 19 and 54 days of age. Lambs were weighed at birth, 24 hours, 3, 7, 14 ± 3, 19 ± 3, 33 ± 3, 40 ± 3, 47 ± 3, and 54 ± 3 days of age. Weighing procedures and scales remained constant throughout the project.

RESULTS AND DISCUSSION

Body weights of lambs from CON ewes were greater ($P < 0.05$) than lambs from RES ewes at days 0 ($P = 0.04$), 3 ($P = 0.003$), 7 ($P = 0.03$), 14 ($P = 0.02$), 19 ($P = 0.004$), and 33 ($P = 0.012$). Lambs from RES and RES-ARG ewes had similar body weights at birth ($P = 0.68$), weighing less than lambs from CON ewes (Figure 1). Lambs from RES-ARG ewes tended to weigh less than lambs from CON ewes at birth and on day 7 ($P = 0.10$, $P = 0.08$, respectively), and weighed significantly less on day 3 ($P = 0.02$). However, by day 19 lambs from RES-ARG ewes weighed more than lambs from RES ewes ($P = 0.04$), and were more similar to weights of lambs from CON ewes ($P = 0.41$). At day 19, lambs from CON ewes weighed 26.40 pounds, lambs from RES ewes weighed 22.65 pounds, and lambs from RES-ARG ewes weighed 25.35 pounds (Figure 1). Although birth weights of lambs from RES and RES-ARG ewes were similar, the lambs from RES-ARG ewes caught up to the lambs from CON ewes over time (Figure 1).

Average daily gains are shown in Fig. 2. Compared to lambs from RES ewes, lambs from RES-ARG ewes had greater ADG on day 19 ($P = 0.04$) and numerically had higher ADG for each time period during this trial. At day 19, lambs from CON ewes were gaining 0.783 pounds per day, lambs from RES ewes were gaining 0.676 pounds per day, and lambs from RES-ARG ewes were gaining 0.780 pounds per day (Figure 2).

Table 1 shows differences in curved crown rump and girth measurements. Lambs from RES-ARG ewes were not different than lambs from CON ewes in girth ($P > 0.05$), and, were different from lambs from RES ewes on day 19 ($P = 0.02$) . Girth measurements on day 19 showed lambs from CON ewes were 21.81 inches, lambs from RES ewes were 20.20 inches, and lambs from RES-ARG ewes were 21.50 inches (Table 1). The only difference observed for curved crown rump measurements was on day 54; lambs from RES-ARG ewes had greater curved crown rump than lambs from RES ewes ($P = 0.003$). Curved crown rump measurements on day 54 were 37.91 inches for lambs from CON ewes, 36.97 inches for lambs from RES ewes, and 39.31 inches for lambs from RES-ARG ewes (Table 1).

IMPLICATIONS

These results imply that supplementing ewes with arginine during pregnancy may circumvent the effects of under nutrition. By avoiding these deleterious consequences of poor weight gains, producers could expect to have more vigorous lambs and lower lamb mortality rates. This would ultimately translate in to higher profitability for producers.

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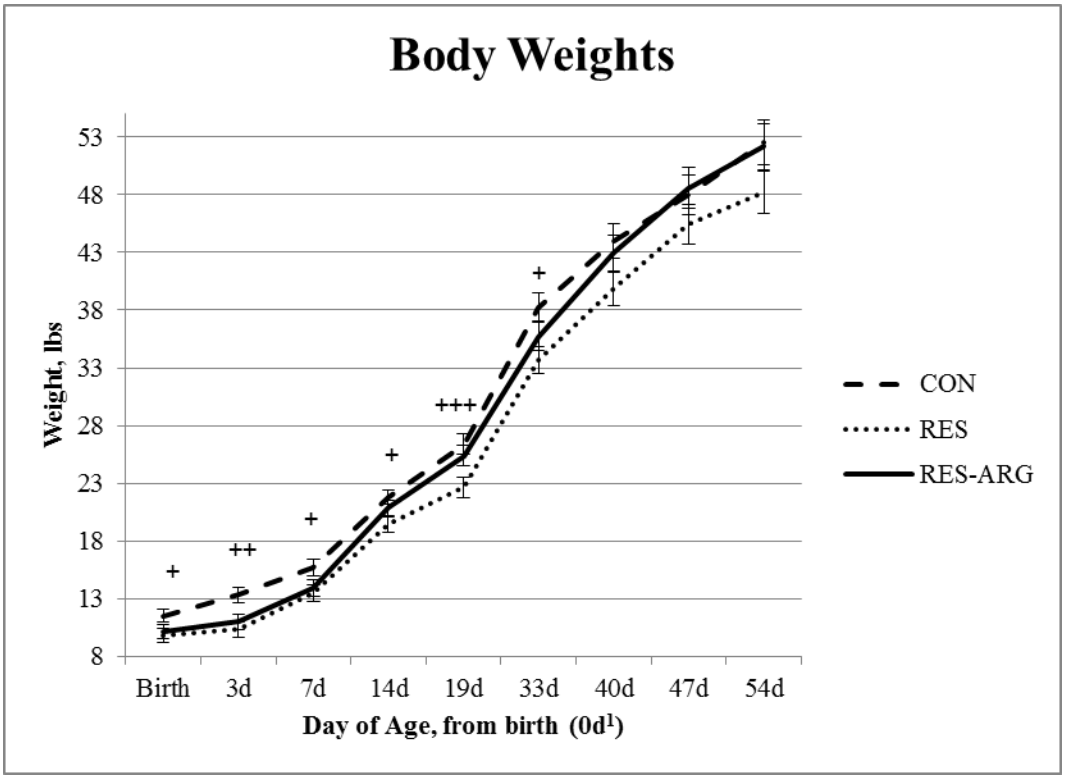
Table 1. Influence of nutrient restriction and rumen-protected arginine supplementation to ewes on offspring girth and curved crown rump measurements over time

Item	CON	RES	RES-ARG	SEM	*P*-value
Girth (in.)					
Birth (0d[1])	16.61[b]	15.19[a]	15.50[ab]	0.449	0.08
19d	21.81[b]	20.20[a]	21.50[b]	0.384	0.01
54d	27.89[b]	26.38[a]	27.43[ab]	0.486	0.10
CCR[c] (in.)					
Birth (0d[1])	21.62	20.71	21.69	0.585	0.43
19d	29.03	27.33	28.70	0.731	0.21
54d	37.91[ab]	36.97[a]	39.31[b]	0.502	0.01

[a,b] Means within a row with different superscripts differ ($P < 0.05$).
[c] CCR abbreviates curved crown rump.
[1] d abbreviates day.

Fig. 1. Influence of nutrient restriction and arginine supplementation of ewes on offspring body weights over time.



CON abbreviates control diet, RES abbreviates restricted diet, RES-ARG abbreviates restricted supplemented with arginine diet

$^{+, ++, +++}$ Means within a day with different symbols differ

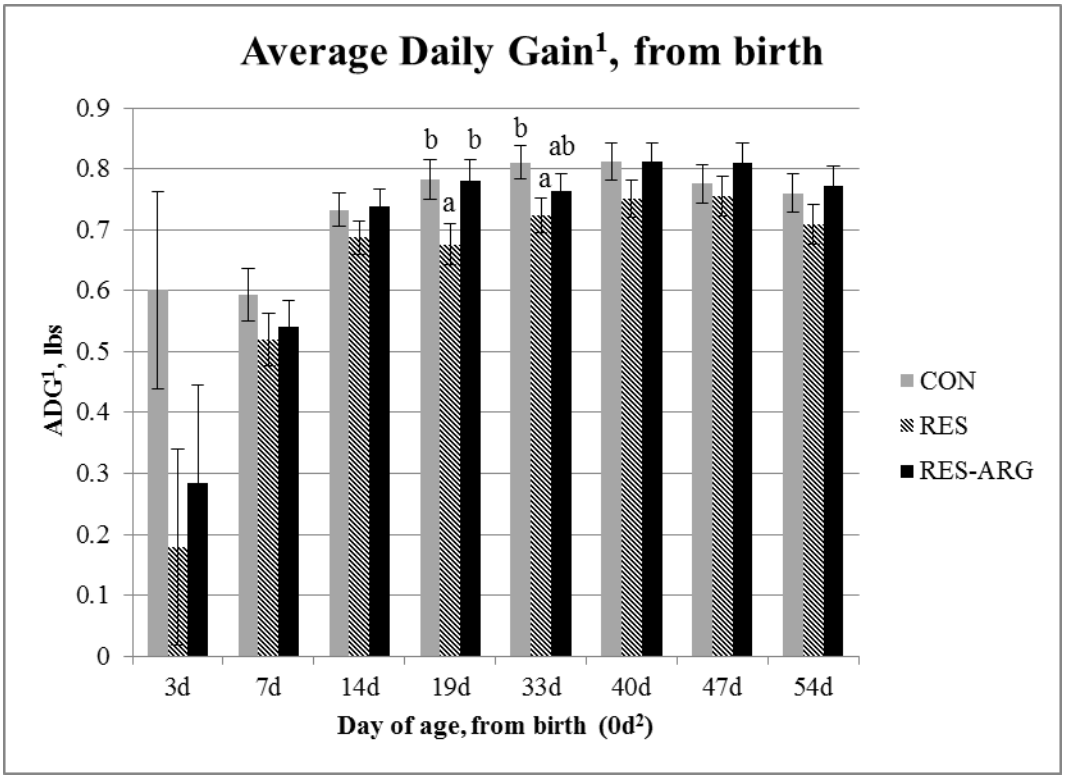
$^{+}$ = CON is significantly different from RES, RES-ARG is similar to both ($P < 0.05$)

$^{++}$ = RES is similar to RES-ARG, and significantly different from CON ($P < 0.05$)

$^{+++}$ = CON and RES-ARG are similar, and significantly different from RES ($P < 0.05$)

[1] d abbreviates day

Fig. 2. Influence of nutrient restriction and arginine supplementation to ewes on offspring average daily gains over time.



CON abbreviates control diet, RES abbreviates restricted diet, RES-ARG abbreviates restricted supplemented with arginine diet

[a,b] Means within a day with different superscripts differ ($P < 0.05$)

[1] ADG abbreviates Average Daily Gain

[2] d abbreviates day