Sheep Research Report

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Using ultrasound measurements for live carcass evaluation can be used as an effective tool for selection of carcass merit improvement. It has been used very little on sheep; however the technology has been available to North Dakota youth participating in the sheep project.

Introduction
The use of ultrasound has been around for research purposes but not used as often in performance measurements for live evaluation until the last decade. In sheep it is used even less, but offers the same amount of accuracy as other species. Combining carcass traits with economic traits of importance such as growth, maternal traits, pedigree, and reproduction can make flock selection decisions for genetic improvement easier. The points evaluated for decision making purposes are ribeye area (REA), fat thickness, and body wall thickness (BWT). These carcass traits are highly heritable and can be useful in determining extremes.

REA is measured in square inches between the 12-13th rib. It is positively correlated with carcass cutability, giving a good indicator of total muscling. REA reflects the differences in the proportion of muscle-to-bone within the carcass, and usually measures between 1.5-4.0 square inches. Fat thickness or backfat is measured over the center of the ribeye at the 12-13th rib. The fat usually ranges from 0.1-0.5 inches. Fat thickness is the most important measurement that helps determine carcass cutability. As fat thickness increases, the percent BCTRC will decrease. Body wall thickness is a measurement across the lean, bone, and fat of the loser rib. This area can accumulate excess fat and thus, serves as an indicator of lean meat yield. BWT usually ranges from 0.5-1.2 inches.

Procedures
In the youth lamb project, the market lamb portion is one that allows smaller youth to get involved at a young age because the size of the animal may fit the size of the child, however that doesn’t limit the knowledge of the participants. This project was started to allow youth that do not traditionally get to evaluate their carcasses a live glimpse at them. This can also help them to make their own decisions regarding technology such as ultrasound. This report marks the beginning of an ongoing project known as the North Dakota Live Lamb Carcass Contest. In the sheep project for 4-H, FFA, or Junior sheep members, youth can enter their live market sheep for ultrasound measurements, weight measurements, and then combine that for an index of percent boneless closely trimmed retail cuts (%BCTRC=49.936-
(0.0848 X HCW)-(4.376 X FT)-(3.530 X BW)+(2.456 X REA). This contest was offered at the North Dakota State Fair and was open to those youth members. Weights were taken and then ultrasound measurements from 119 lambs entered our database.

**Results and Discussion**

After the calculations for % BCTRC were determined the top 20 in the contest received awards from the North Dakota Lamb and Wool Producers Association. The top lamb % BCTRC was 50.95, had a 4.22 in. REA, and 0.2 in FT. The range for all of the competitors was 2.18 - 4.22, BWT ranged from 0.54 - 0.67, FT ranged from 0.18 - 0.39, and the % BCTRC ranged from 49.01 - 50.95.

**Implications**

With this ongoing project, we will be able to evaluate the progress of the youth market lamb project and how selection can affect carcass traits.
The objective of this research was to evaluate the influence of thiamin supplementation on feedlot performance and carcass characteristics of lambs fed a 60% dried distillers grain plus solubles finishing ration. Level of thiamin supplementation may influence performance and dry matter intake; however thiamin supplementation did not have an effect on the incidence of PEM in feedlot lambs. Feeding dried distillers grains plus solubles at 60% of dietary dry matter provided acceptable lamb performance and carcass composition.

Introduction
Recent research indicates sheep can be fed higher levels of dried distillers grains plus solubles (DDGS) than previously considered optimal without affecting carcass characteristics (Schauer et al., 2008). This provides an opportunity for increase utilization of dried distillers grains plus solubles in lamb finishing rations, potentially resulting in cheaper feed costs for lamb finishers. One potential problem with feeding increased levels of dried distillers grains plus solubles is the high dietary sulfur levels which result. These can potentially lead to neurological problems (polioencephalomalacia; PEM) in ruminants. Polioencephalomalacia is thought to result from a thiamin deficiency induced by the conversion of sulfate to sulfite in the rumen. To avoid problems with PEM, supplementation of 100-500mg/d thiamin (McDowell, 2000) in diets containing more than 0.4% S in high concentrate diets and 0.5% S in higher roughage diets (NRC, 2005) has been adopted. However, no research has examined if level of thiamin in these diets will affect feedlot performance, carcass characteristics, and incidence of PEM in feedlot lambs. Therefore, our objective was to determine the influence of thiamin level on feedlot performance, carcass characteristics, and incidence of PEM in lambs fed 60% dried distillers grains plus solubles.

Procedures
The objective of this study was to determine the influence of thiamin level on feedlot performance, carcass characteristics, dry matter intake, and incidence of PEM. Two-hundred forty western white-face lambs (wethers and ewes) were utilized in a randomized complete design to evaluate the influence of level of thiamin supplementation in lamb finishing diets containing 60% dried distillers grains plus solubles. Lambs were assigned to one of sixteen pens and each pen assigned to one of four treatment diets (4 pens per treatment). The final finishing diet was balanced to contain 60% dried distillers grains plus solubles (DM basis), which resulted in a dietary S concentration of 0.72%. The NRC maximum tolerable level of S is 0.40% S (preliminary analysis of these diets are presented in Table 1). Treatments diets differed in the amount of supplemental thiamin supplied; these levels were: 1) CON (no supplemental thiamin), 2) LOW
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(15.8 mg/hd/d thiamin), 3) **MED** (48.4 mg/hd/d thiamin), or 4) **HIGH** (53.0 mg/hd/d thiamin). Rations were mixed in a grinder-mixer and provided ad libitum via bulk feeders. Content of feeders (feed refusals) were collected and weighed at the end of the study. Lambs were weighed on days 0, 27, 56, 84, and 110. Initial and final weights were the average of two-day weights. Following the 110 d finishing period, lambs were transported for harvest and subsequent carcass data collection to Iowa Lamb Corp, Hawarden, IA. One hundred eighty five lambs of the original 240 (77.08%) were shipped. Lambs with a live weight less than 110lbs 28d prior to slaughter were not shipped. Treatment distributions were as follows; 49 head of the CON treatment, 48 head of the LOW treatment, 44 head of the MED treatment, and 44 head of the HIGH treatment. Feedlot performance and carcass trait data were analyzed as a randomized complete design using the GLM procedures of SAS (SAS Inst. Inc., Cary, NY) with pen serving as the experimental unit. Carcass data was analyzed similarly, with missing data points from underweight lambs not included in the data set, but with pen still serving as experimental unit. The model included treatment. Linear, quadratic, and cubic contrasts for increase level of thiamin supplementation were evaluated.

### Results
Based on preliminary analysis of feedstuffs and dry matter intake calculated daily intake of thiamin were 1.6, 15.8, 48.4, and 53.0 mg/hd/d for CON, LOW, MED, and HIGH respectively. Results for feedlot lamb performance and carcass quality were reported in Table 2. There was a tendency for quadratic increases in final BW; specifically the CON, LOW, and MED treatment lambs finished heavier than the group fed the HIGH level of thiamin. Average daily gain exhibited a similar response, although cubic (P = 0.08) in nature with the CON, LOW, and MED treatment groups gaining weight at a faster rate than the HIGH treatment group.

### Table 1. Ingredient and nutritional composition of diets fed to feedlot lambs.

<table>
<thead>
<tr>
<th>Item</th>
<th>CON</th>
<th>LOW</th>
<th>MED</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Diets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ingredient</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa Hay, %</td>
<td>15.00</td>
<td>15.00</td>
<td>15.00</td>
<td>15.00</td>
</tr>
<tr>
<td>Corn, %</td>
<td>21.38</td>
<td>21.38</td>
<td>21.38</td>
<td>21.38</td>
</tr>
<tr>
<td>DDGS, %</td>
<td>60.00</td>
<td>60.00</td>
<td>60.00</td>
<td>60.00</td>
</tr>
<tr>
<td>Ammonium Chloride, %</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Limestone, %</td>
<td>2.25</td>
<td>2.25</td>
<td>2.25</td>
<td>2.25</td>
</tr>
<tr>
<td>Bovetec, %</td>
<td>0.085</td>
<td>0.085</td>
<td>0.085</td>
<td>0.085</td>
</tr>
<tr>
<td>TM package², %</td>
<td>0.78</td>
<td>0.78</td>
<td>0.78</td>
<td>0.78</td>
</tr>
<tr>
<td>Copper Sulfate, %</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
</tr>
<tr>
<td>Thiamin, %</td>
<td>0.00</td>
<td>0.004</td>
<td>0.007</td>
<td>0.011</td>
</tr>
<tr>
<td>Nutrient composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP, %</td>
<td>23.70</td>
<td>23.30</td>
<td>23.40</td>
<td>23.60</td>
</tr>
<tr>
<td>TDN, %</td>
<td>84.50</td>
<td>84.40</td>
<td>84.50</td>
<td>85.10</td>
</tr>
<tr>
<td>NEm, Mcal/lb</td>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
<td>0.93</td>
</tr>
<tr>
<td>NEg, Mcal/lb</td>
<td>0.61</td>
<td>0.61</td>
<td>0.61</td>
<td>0.62</td>
</tr>
<tr>
<td>Crude Fat, %</td>
<td>7.41</td>
<td>7.38</td>
<td>7.51</td>
<td>7.71</td>
</tr>
<tr>
<td>Acid Detergent Fiber, %</td>
<td>10.50</td>
<td>10.50</td>
<td>10.90</td>
<td>11.10</td>
</tr>
<tr>
<td>Sulfur, %</td>
<td>0.74</td>
<td>0.69</td>
<td>0.71</td>
<td>0.72</td>
</tr>
<tr>
<td>Calcium, %</td>
<td>1.33</td>
<td>1.59</td>
<td>1.17</td>
<td>1.08</td>
</tr>
<tr>
<td>Phosphorus, %</td>
<td>0.68</td>
<td>0.69</td>
<td>0.70</td>
<td>0.72</td>
</tr>
<tr>
<td>Copper, ppm</td>
<td>11.00</td>
<td>12.00</td>
<td>9.00</td>
<td>11.00</td>
</tr>
<tr>
<td>Zinc, ppm</td>
<td>71.00</td>
<td>67.00</td>
<td>63.00</td>
<td>59.00</td>
</tr>
<tr>
<td>Thiamin, ppm³</td>
<td>0.90</td>
<td>8.88</td>
<td>24.42</td>
<td>30.46</td>
</tr>
</tbody>
</table>

1 Treatments abbreviations CON (no supplemental thiamin) LOW (15.8 mg/hd/d thiamin), MED (48.4 mg/hd/d thiamin), and HIGH (53.0 mg/hd/d thiamin).

2 TM package contained: 11.7%Ca, 10.0% P, 14% salt, 0.1% K, 0.1% Mg, 20ppm Co, 100ppm I, 2,450ppm Mn, 50ppm Se, 2,700ppm Zn, 30,000 IU/lb Vitamin A, 30,000 IU/lb Vitamin D₃, and 600 IU/lb Vitamin E.

3 Thiamin supplementation calculated based on laboratory analysis of premixed supplement multiplied by %composition of supplement in diet.
Feed dry matter intake (DMI) as well as F:G or G:F were also affected cubically ($P<0.03$) by level of thiamin supplementation. Mortality was not affected ($P = 0.43$) by level of supplemental thiamin. Hot carcass weight (HCW) decreased quadratically ($P = 0.05$), while leg score had a quadratic tendency ($P = 0.06$) for a lower score with increased thiamin supplementation. Fat depth, body wall thickness, ribeye area, flank streaking, quality grade, yield grade, and percent boneless closely trimmed retail cuts (%BCTRC) were all unaffected ($P > 0.16$) by level of supplemental thiamin. However, there was a cubic tendency ($P = 0.10$) for differences in conformation score.

Table 2. Influence of thiamin supplementation on feedlot lamb performance and carcass characteristics

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment¹</th>
<th>CON</th>
<th>LOW</th>
<th>MED</th>
<th>HIGH</th>
<th>SEM²</th>
<th>P-value</th>
<th>Linear</th>
<th>Quad</th>
<th>Cubic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Wt, lbs</td>
<td></td>
<td>71.76</td>
<td>71.60</td>
<td>71.45</td>
<td>71.63</td>
<td>0.34</td>
<td>0.94</td>
<td>0.73</td>
<td>0.63</td>
<td>0.83</td>
</tr>
<tr>
<td>Final Wt, lbs</td>
<td></td>
<td>137.07</td>
<td>138.22</td>
<td>137.44</td>
<td>133.03</td>
<td>1.43</td>
<td>0.10</td>
<td>0.07</td>
<td>0.08</td>
<td>0.79</td>
</tr>
<tr>
<td>ADG, lbs/d</td>
<td></td>
<td>0.59</td>
<td>0.61</td>
<td>0.60</td>
<td>0.56</td>
<td>0.01</td>
<td>0.08</td>
<td>0.09</td>
<td>0.04</td>
<td>0.08</td>
</tr>
<tr>
<td>Intake, lbs/hd/d</td>
<td></td>
<td>3.90</td>
<td>3.92</td>
<td>4.36</td>
<td>3.83</td>
<td>0.08</td>
<td>0.001</td>
<td>0.49</td>
<td>0.004</td>
<td>0.002</td>
</tr>
<tr>
<td>F:G, lbs DMI: lbs gain</td>
<td></td>
<td>6.60</td>
<td>6.48</td>
<td>7.29</td>
<td>6.86</td>
<td>0.19</td>
<td>0.05</td>
<td>0.09</td>
<td>0.45</td>
<td>0.03</td>
</tr>
<tr>
<td>G:F, lbs gain; lbs DMI</td>
<td></td>
<td>0.15</td>
<td>0.15</td>
<td>0.14</td>
<td>0.15</td>
<td>0.004</td>
<td>0.05</td>
<td>0.08</td>
<td>0.57</td>
<td>0.03</td>
</tr>
<tr>
<td>Mortality, %</td>
<td></td>
<td>1.67</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.83</td>
<td>0.43</td>
<td>0.20</td>
<td>0.34</td>
<td>0.66</td>
</tr>
<tr>
<td>HCW, lbs</td>
<td></td>
<td>68.98</td>
<td>70.66</td>
<td>69.84</td>
<td>68.06</td>
<td>0.81</td>
<td>0.18</td>
<td>0.35</td>
<td>0.05</td>
<td>0.68</td>
</tr>
<tr>
<td>Leg Score⁴</td>
<td></td>
<td>11.32</td>
<td>11.48</td>
<td>11.60</td>
<td>11.05</td>
<td>0.17</td>
<td>0.16</td>
<td>0.36</td>
<td>0.06</td>
<td>0.41</td>
</tr>
<tr>
<td>Conformation score</td>
<td></td>
<td>11.50</td>
<td>11.42</td>
<td>11.57</td>
<td>11.23</td>
<td>0.09</td>
<td>0.09</td>
<td>0.12</td>
<td>0.17</td>
<td>0.10</td>
</tr>
<tr>
<td>Fat Depth, in⁵</td>
<td></td>
<td>0.31</td>
<td>0.34</td>
<td>0.30</td>
<td>0.33</td>
<td>0.02</td>
<td>0.59</td>
<td>0.96</td>
<td>0.96</td>
<td>0.18</td>
</tr>
<tr>
<td>Body Wall Thick, in</td>
<td></td>
<td>1.07</td>
<td>1.10</td>
<td>1.00</td>
<td>1.05</td>
<td>0.04</td>
<td>0.32</td>
<td>0.39</td>
<td>0.83</td>
<td>0.11</td>
</tr>
<tr>
<td>Ribeye Area, in²</td>
<td></td>
<td>2.42</td>
<td>2.40</td>
<td>2.43</td>
<td>2.43</td>
<td>0.06</td>
<td>0.98</td>
<td>0.77</td>
<td>0.92</td>
<td>0.81</td>
</tr>
<tr>
<td>Flank Streaking⁶</td>
<td></td>
<td>336.92</td>
<td>340.25</td>
<td>353.33</td>
<td>336.36</td>
<td>6.74</td>
<td>0.29</td>
<td>0.71</td>
<td>0.16</td>
<td>0.21</td>
</tr>
<tr>
<td>Quality Grade</td>
<td></td>
<td>11.34</td>
<td>11.33</td>
<td>11.47</td>
<td>11.18</td>
<td>0.08</td>
<td>0.17</td>
<td>0.36</td>
<td>0.13</td>
<td>0.15</td>
</tr>
<tr>
<td>Yield Grade⁷</td>
<td></td>
<td>3.48</td>
<td>3.75</td>
<td>3.42</td>
<td>3.66</td>
<td>0.18</td>
<td>0.55</td>
<td>0.82</td>
<td>0.94</td>
<td>0.17</td>
</tr>
<tr>
<td>%BCTRC⁸</td>
<td></td>
<td>44.66</td>
<td>44.33</td>
<td>45.01</td>
<td>46.81</td>
<td>0.21</td>
<td>0.18</td>
<td>0.24</td>
<td>0.75</td>
<td>0.06</td>
</tr>
</tbody>
</table>

¹Treatments abbreviations CON (no supplemental thiamin) LOW (15.8 mg/hd/d thiamin), MED (48.4 mg/hd/d thiamin), and HIGH (53.0 mg/hd/d thiamin).
²Standard Error of Mean; n = 4.
³P-value for linear, quadratic, and cubic effects of increasing level of thiamin supplementation.
⁴Leg score, conformation score, and quality grade: 1 = cull to 15 = high prime.
⁵Adjusted fat depth and yield grades.
⁶Flank streaking: 100-199 = practically devoid; 200-299 = traces; 300-399 = slight; 400-499 = small; 500-599 = modest.
⁷Yield Grade = 0.4 + (10 x adjusted fat depth).
⁸% Boneless closely trimmed retail cuts (49.936 - (0.0848 x Hot Carcass Weight, in.) - (4.376 x Fat Depth, in.) - (3.53 x BW, in.) + (2.456 x Ribeye Area, in²)).
Discussion
The tendency for quadratic decrease in final weight with increasing level of thiamin was an unexpected result. Given that excess thiamin is cleared by the kidneys (McDowell, 2000), and that intake of upwards of 1000 times requirement are thought to be safe (NRC, 1987) it is difficult to attribute the decreased performance to thiamin toxicity at the levels fed in the present study. Further, it is unclear if the differences in performance are due to a negative effect of the 53 mg/hd/d thiamin intake or if the optimal level of supplementation is closer to 15.8 mg/hd/d. Palatability could be another possible cause for the differences in intake. Carcass characteristics with the exception of leg score and hot carcass weight were unaffected by treatment. The data from the present study as well as that of (Schauer et al., 2008) are largely comparable. Differences in HCW and leg score are more than likely driven by the similar differences observed in final BW.

As previously stated no differences (P = 0.43) in mortality were observed due to level of thiamin supplementation. During the course of this study one lamb did die; however the cause of death, as determined by a veterinarian, was chronic respiratory illness. Of further interest is that no (0) cases of polioencephalomalacia were observed during the entire 110 d feeding period; even with dietary S levels (0.72% S DM basis) nearly twice the maximum tolerable level of sulfur 0.4% for high concentrate diets reported by the NRC (2005). Contrary to the present study Krasicka et al. (1999) reported that all lambs fed a low fiber-high starch diet containing 0.72% S died from PEM after 12 weeks. Loneragan et al., (2005) hypothesized that the therapeutic effects of thiamin in PEM-affected animals is either due to an increased requirement for thiamin or a beneficial effect of thiamin on impaired brains. The present research discounts the proposed increased requirement; at least in feedlot lambs fed distillers grains as the sulfur source. In fact, our data suggests that thiamin was not required to prevent PEM. However, we cannot support or dismiss the second theory, relating to the beneficial effect of thiamin on impaired brains, as no cases of PEM occurred in our study.

Further links between sulfur induced PEM and ruminal pH change have been explored (Gould, 1998). Gould (1998) concluded that in diets with levels of sulfur exceeding 0.3 percent the combination of dietary sulfur, ruminal sulfide production, and increased thiaminase production may increase incidence of PEM. Alves de Oliveira et al. (1996) reported that decreasing ruminal pH did not decrease microbial production of thiamin; however, the decrease in rumen pH has been found to favor thiaminase producing bacteria (Morgan and Lawson, 1974; Boyd and Walton, 1977; Thomas et al., 1987). In the present study lambs were previously adapted to high concentrate diets prior to receiving the 60% dried distillers grains plus solubles diet which contained presumed toxic levels of sulfur. This along with the fact that no measurements of ruminal sulfide or thiaminase were conducted does not allow for a comparison of the present study to the previous data. However, in a second portion of this study (unpublished data) lambs which were individually fed the same diets presented here were adapted from a medium concentrate diet to a high concentrate diet while increasing the amount of dried distillers grains plus solubles and thus sulfur content of the diet. While this portion of the study is on-going no incidences of PEM have occurred even with the suspected increased susceptibility to PEM during diet adaptation.

A review of literature reporting the amount of S fed to ruminants in corn by-product based rations further demonstrates the inconsistencies in the amount of sulfur required to cause neurological problems, such as PEM. Similar to the present study (Schauer et al., 2008) fed lambs a finishing diet which contained 0, 20, 40, or 60% dried distillers grains plus solubles. In this study no differences in animal performance were reported; further, the 60% dried distillers grains plus solubles diet which contained 0.55% S (DM basis) did not cause any incidence of PEM. Contrary to the present study, (Niles et al., 2002)
reported that 10 of 14 calves fed a corn gluten feed based diet exhibited PEM; those calves affected were fed diets that contained either 0.554 or 0.701% S (DM basis). Both authors reported water sulfate values; the water consumed by the lambs (Schauer et al., 2008) contained 141 ppm S, while the water consumed by the steers (Niles et al., 2002) contained 56ppm S. Unfortunately, Niles et al, (2002) did not report how much, if any, supplemental thiamin was provided to the steers in their study; however, Schauer et al, (2008) did report that their lambs did receive 142 mg/hd/d of supplemental thiamin. Huls et al. (2008) fed 50 percent modified dry distillers grains plus solubles while supplementing 150 mg/hd/d thiamin without affecting performance when compared to steers fed control diets. Contrary to these results Buckner et al. (2007) discontinued a 50 percent dried distillers grains plus solubles when multiple steers exhibited polioencephalomalacia while receiving 150 mg/hd/d thiamin. Sulfur from water has also been implicated as a cause of PEM in ruminants. Ward and Paterson (2004) evaluated thiamin supplementation as a method of preventing PEM in steers consuming high sulfate (4000 ppm) water. Two steers on high sulfate water and one steer from high sulfate water supplemented with 1g/hd/d thiamin died; however, only one case from the unsupplemented group was confirmed to have died from PEM. Although no incidences of PEM occurred, (Loneragan et al, 2001) reported that steers consuming water of increasing sulfate concentrations negatively impacted performance and carcase characteristics. However, this decrease in performance was not observed in lambs fed dried distillers grains diets containing increasing amount of sulfur (Schauer et al, 2008). The fact that the lambs fed 60% dried distillers grains plus solubles from (Schauer et al., 2008) as well as the lambs fed 60% dried distillers grains plus solubles in the present study did not develop PEM, even when not given supplemental thiamin, demonstrates repeatability of our results. Further, this data appears to indicate that either the NRC maximum tolerable level of S, or the need for supplemental thiamin, is in question. At a minimum Schauer et al. (2008) and the present study illustrate the need for additional research to further determine the interactive affects of sulfur, thiamin supplementation, and dietary grain concentration in finishing rations, and the effect they collectively have on the incidence of polioencephalomalacia.

Implications
The current research as well as previous work has demonstrated that dried distillers grains plus solubles can be included in lamb finishing rations at levels up to 60% of dietary dry matter in limited situations. Feeding dried distillers grains plus solubles at 60% of dietary dry matter does not appear to increase the incidence of polioencephalomalacia in lambs when water with low sulfur (141 ppm sulfate) is available. Further, the use of thiamin as a dietary additive to aide in the prevention of polioencephalomalacia does not appear to be necessary in feeding environments with similar sulfur present in the feed and water as observed in the present study. However, the authors still strongly advise producers to have feed samples as well as water samples tested before determining their livestock’s risk to developing PEM due to sulfur toxicity.

Literature Cited


The objective of the current study was to determine if supplementation with the amino acid arginine enhances ovarian function and reproductive performance in sheep. Since prenatal mortality represents a large portion of economic loss in the sheep enterprise appropriate strategies need to be developed for reducing lamb losses before birth. Arginine supplementation is proving to be an effective strategy to improve the number of lambs born per ewe.

Introduction
Reproductive performance is the largest determinant of income in the livestock enterprise. In sheep embryonic and fetal deaths during pregnancy account for 25 to 50% of the total number of fertilized ova (Inskeep et al., 2003; Dixon et al., 2007), and can lead to complete pregnancy losses or decreases in dam productivity. Even if prenatal losses do not occur, improper growth and development before birth can decrease immediate survival after birth (Moulet et al., 1956), alter feed efficiency (Greenwood et al., 2003), decrease carcass yield (Greenwood et al., 2001), and impair reproductive performance during later life (Da Silva et al., 2001; Martin et al., 2007). Clearly, the development of strategies for enhancing prenatal growth and survival in sheep could have a major economic impact.

The amino acid L-arginine is important for the synthesis of polyamines and nitric oxide, both of which are essential for proper development of the embryo and placenta.

It is reasonable to hypothesize that supplementation with arginine would have beneficial impacts on prenatal growth and survival ruminant livestock. Gestating sows supplemented with arginine achieved a 22% increase in live piglets born when compared to non-supplemented sows (11.4 vs. 9.4, P < 0.03, respectively) (Mateo et al., 2007). In addition to these beneficial effects on prenatal survival, arginine treatment during late pregnancy increases transport of nutrients to the unborn lamb (Thureen et al., 2002) and enhances lamb birth weight (De Boo et al., 2005).

The objective the current study was to determine the effects of arginine supplementation on ovarian function, early reproductive losses and lamb birth weight in Rambouillet ewes.

Procedures
In April of 2008, Rambouillet ewes of a similar BW (68 ± 1.8 kg) and age (4.7 ± 0.32 yr) received a CIDR device for 12 d followed by a single injection of 400 IU PMSG. Thereafter,
ewes were exposed to fertile rams at a ratio of 1 ram:2 ewes. From d 0 (estrus) to d 15 post-estrus ewes received L-arginine HCl (equivalent to 27 mg of L-arginine/kg of BW, ARG, n = 20) or saline (CON, n = 20) i.v. once daily. Daily blood samples were obtained from 5 ewes/group immediately after treatment (0 h) to assess progesterone (P4) concentrations and at -0.5, 0, 0.5, 1, 2, 4, 8, and 24 h on d 12 to determine circulating concentrations of arginine in response to treatment. Ovarian hemodynamics (d 12) and reproductive losses (d 25 and 45) were determined with color-Doppler and B-mode ultrasonography techniques, respectively.

Results

On d 12 of pregnancy, serum concentrations of arginine (nmol/ml) were elevated in ARG vs. CON ewes at 0 ($P < 0.001$), 0.5 ($P < 0.001$), 1 ($P < 0.001$), 2 ($P < 0.005$), and 4 h ($P < 0.05$), but were similar ($P > 0.05$) at -0.5, 8 and 24 h (Figure 1). Resistance index in the ovarian artery was reduced ($P < 0.05$) on d 12 at approximately 4 h after treatment in ARG vs. CON ewes (Figure 2). Despite similarities in the number of corpora lutea in those ewes that were blood sampled (ARG, 1.8 ± 0.20 and CON, 1.8 ± 0.20 CL/ewe; $P > 0.05$), ARG ewes had greater ($P < 0.004$) P4 concentrations throughout treatment compared to CON ewes (Figure 3).

Treatment with L-arginine did not influence pregnancy rate (ARG, 55% and CON, 60%; $P > 0.05$) or the number of corpora lutea among all ewes studied (ARG, 1.8 ± 0.12 and CON, 1.8 ± 0.199; $P > 0.05$). However, ARG ewes had more ($P < 0.05$) embryos per ewe (Figure 4) and less CL not represented by embryos (0.18 ± 0.122 vs. 0.58 ± 0.155, $P < 0.05$) compared to CON ewes at d 25 of pregnancy. As pregnancy progressed to d 45, ARG ewes continued to have more ($P < 0.03$) embryos present compared to CON ewes (Figure 4), and the difference in the number of CL not represented by embryos was even greater ($P < 0.03$) in CON (0.75 ± 0.227) vs. ARG ewes (0.18 ± 0.122). The overall proportion of ewes conceiving, but then exhibiting embryonic loss by d 45 of pregnancy was reduced in ARG vs. CON ewes (18 vs. 58%, respectively, $P < 0.05$).

Ewes treated with L-arginine gave birth to more lambs when compared to control ewes (ARG, 1.6 ± 0.16 vs. CON, 1.1 ± 0.16 lambs born per ewe), but average lamb birth weights were not affected (ARG, 10.9 ± 0.32 and CON, 10.7 ± 0.18 lbs.).

Discussion

This is the first study to demonstrate that reproductive losses can actually be prevented with supplementation of the amino acid arginine during early pregnancy. Ewes receiving arginine from the time of standing estrus to d 12 of pregnancy lost fewer embryos during early pregnancy and ultimately gave birth to more lambs per ewe. Mateo et al. (2007) observed similar results when gestating sows were supplemented with arginine. Sows supplemented with arginine achieved a 22% increase in live piglets born when compared to non-supplemented sows (11.4 vs. 9.4, $P < 0.03$, respectively). The latter results may be due to an increase in nutrient delivery to the developing embryo/fetus.

In the current study, it would appear that treatment with arginine enhanced the early uterine environment making it more ideal for embryonic survival. Ewes treated with arginine had higher concentrations of progesterone, a hormone necessary for maintaining pregnancy. Several studies have shown that low levels of progesterone can lead to a greater incidence of embryonic loss in sheep and ultimately result in decreases in ewe productivity. Progesterone is necessary for the secretion of histotroph by uterine glands during early pregnancy (Spencer et al., 2001), which is important for early embryonic growth and development. Increases in progesterone production may have resulted from greater ovarian function in ewes supplemented with the amino acid arginine. Arginine is important for many biological functions, including the synthesis of nitric oxide, a chemical important for dilating blood vessels and increasing tissue blood flow. Increases in ovarian blood flow and/or vascular perfusion of the corpus luteum (structure responsible for...
progesterone production during early pregnancy in sheep) probably resulted in higher concentrations of progesterone in ewes treated with arginine. In summary, early reproductive losses can be prevented, at least in part, by treatment with arginine. Decreased ovarian vascular resistance and increased concentrations of progesterone may result in a more ideal environment for early embryonic survival.

**Implications**
Although a more suitable delivery method must be developed, the current results imply that embryonic survival in sheep can be enhanced when L-arginine is supplemented during early pregnancy. We are currently evaluating a rumen protected source of arginine for enhancing embryonic survival and ultimately ewe productivity. In the near future it may be possible to include a rumen protected source of arginine in your breeding ewe ration at a relatively low cost.

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**Figure 1.** Serum arginine concentrations relative to injection (0 h) in ARG and CON ewes on d 12. Data are means ± S.E.

**Figure 2.** Resistance index (RI) in the ovarian artery 4 h after injection in ARG and CON ewes on d 12. Data are means ± S.E.

**Figure 3.** Serum progesterone (P4) concentrations throughout the treatment period in ARG and CON ewes. Data are means ± S.E.

**Figure 4.** Number of corpora lutea and embryos (d25 and 45) present ARG and CON ewes. Data are means ± S.E.
Ovine Progressive Pneumonia
N W Dyer, DVM

Introduction
Ovine progressive pneumonia (OPP), called maedi-visna in Europe, is a slow viral disease of sheep which causes chronic, debilitating pneumonia and wasting. It is related to a similar virus in goats called caprine arthritis and encephalitis virus. This progressive emaciation is sometimes referred to as “thin ewe syndrome”, however the infection may also cause respiratory disease, mastitis (“hard bag”), neurologic problems, and arthritis. The arthritis typically appears in the knee and hock joints causing thickening and mineralization of the joint capsule as well as deterioration of the cartilage and bone. Adults of any age can be affected, but it is typically seen in 2 to 3 year old sheep. Affected animals may continue to eat, but show signs of exercise intolerance, rapid and/or open mouth breathing, and coughing. Those ewes that do lamb often have small, weak offspring. Transmission of the virus occurs through ingestion of colostrum by lambs, nose to nose contact between animals, and, rarely, via the uterine circulation in pregnant ewes. All breeds of sheep are susceptible. Death after prolonged disease is the usual outcome.

Diagnosis and Testing
It is important to differentiate this disease from Mannheimia pneumonia, lungworms, Corynebacterium pseudotuberculosis infection (caseous lymphadenitis), and adenomatosis. The NDSU Veterinary Diagnostic Laboratory can help diagnose this condition in the individual animal (necropsy) or the flock (serology). In a live animal, the best samples to submit for a respiratory workup include a nasal swab, a whole blood sample and a serum sample. The nasal swab will help identify bacteria and/or viruses that may be contributing to the problem, the whole blood sample can be used for virus isolation, and the serum sample can be used to look for antibody to an infectious agent. If an animal has died, then tissue samples can increase the chances of identifying the problem. Post mortem samples from the respiratory tract should include lung tissue, trachea, and tracheobronchial lymph node. Representative samples should be submitted fresh and chilled as well as fixed in formalin. Contact your

1Veterinary Diagnostic Laboratory, NDSU, Fargo, ND
veterinarian or call the Veterinary Diagnostic Laboratory for assistance with this process. Two types of serologic test are generally available. The agar gel immunodiffusion test (AGID), and the enzyme-linked immunosorbent assay (ELISA). The AGID is simple and cheap; however the ELISA is more sensitive and able to detect animals with the infection earlier. Currently, there is not a commercial OPP ELISA available; therefore laboratories that offer this assay have developed and validated their own test. Commercial AGID tests are available and widely used. The AGID test detects antibodies to the virus, but usually not before the infection has been in place at least 6 months. In lambs, any antibody acquired from the ewe in colostrum should be out of the blood by the time the lamb is 6 months old, therefore a positive test in a lamb less than 6 months old should be regarded as inconclusive. The lamb should be retested again after it reaches six months of age. A negative AGID either means no infection, or that the antibody in the blood has dropped to undetectable levels. Negative tests should be repeated in a few months to insure that an animal maintains its negative status. A positive AGID indicates infection, but gives no information on the status of active disease in the animal. A positive test will have more meaning in an animal with clinical signs of respiratory disease, but it is not conclusive evidence that the cause is the OPP virus. Animals will test positive approximately one month after exposure to the virus. Not all sheep testing positive for OPP antibody will develop clinical disease, therefore it becomes difficult to know when to cull animals. However, because an infected animal can shed the virus into the environment, it is best to remove any antibody positive animals from the herd.

**Treatment and Control**

Antibiotics can be used to treat secondary infections but there is no effective treatment or vaccine available for OPP infections. While it is impossible to completely avoid the possibility of infection, particularly if you show sheep, there are some things that can be done to minimize risk. Use your own buckets and tubs to feed and water your stock. Minimize nose-to-nose contact between your stock and other sheep. When possible, transport your own animals to and from shows and sales. Accurate health papers and animal identification are important. When mouthing sheep it might, in some situations, be a good idea to disinfect hands between animals.

Control is managed through two general methods. Producers may test for antibody and cull any positive reactors from the herd. Retesting is recommended on an annual or semi-annual basis to insure that animals which seroconvert later do not infect the herd. Alternatively, lambs may be removed from ewes before they nurse and be reared using colostrum from seronegative sheep or heat-treated sheep colostrum, and then raised on milk replacer, milk from seronegative ewes or heat-treated sheep milk. OPP is a persistent, progressive viral infection in sheep that must be managed as there is no effective treatment or vaccine available to the producer.

**Literature Cited**


FLOCK CALENDAR OUTLINE

The following guidelines are neither inclusive nor intended to fit every sheep operation. Each operation is different, therefore, each “calendar event” should be tailored to each flock’s needs.

PRIOR TO BREEDING

1. Bag and mouth ewes and cull those that are not sound.
2. Replace culled ewes with top-end yearlings or ewe lambs.
3. Keep replacement ewe lambs on growing rations.
4. Evaluate sires:
   A. Be sure they are vigorous, healthy and in good breeding condition.
   B. Rams should be conditioned at least a month before the breeding season. Flush rams in poor condition.
   C. Allow at least two mature rams (preferably three) or four buck lambs per 100 ewes.
   D. Utilize production records to evaluate anticipated breeding ability.
5. Flush Ewes:
   A. One pound grain/day two to five weeks before breeding (usually 17 days).
   B. If ewes are over-conditioned, the effect of flushing will be lessened.
6. Vaccinate ewes for vibriosis and enzootic abortion (EAE).
7. Identify all ewes and rams with ear tags, paint brands or tattoos.

BREEDING

1. The ovulation rate of a ewe tends to be lower at the first part of the breeding season. Vasectomized or teaser rams run with ewes through the first heat period tend to stimulate then and increase the ovulation rate at the second heat period.
2. Use a ram marking harness or painted brisket to monitor breeding. Soft gun grease with a paint pigment mixed in works well for painting the brisket. A color sequence of orange, red and black is recommended with colors being changed every 17 days.
3. Leave rams in NO LONGER than 51 days (35 days is more desirable).
   A. An exception may be with ewe lambs. Allowing them four heat cycles or 68 days may be beneficial.
4. Remove rams from ewes after the season (don’t winter rams with ewes).

PRIOR TO LAMBING– EARLY PREGNANCY (First 15 Weeks)

1. Watch general health of ewes. If possible sort off thin ewes and give them extra feed so they can catch up.
2. Feed the poor quality roughage you have on hand during this period, saving the better for lambing.
3. An exception to the above is feeding pregnant ewe lambs. They should receive good quality roughage and grain (about 20 percent of the ration) during this period.
LAST SIX WEEKS BEFORE LAMBING

1. Trim hooves and treat for internal parasites.
2. Six to four weeks before lambing feed 1/4 to 1/3 pound grain/ewe/day.
3. Shear ewes before lambing (with highly prolific ewes at least a month before is preferred). Keep feeding schedule regular and watch weather conditions immediately after shearing (cold).
4. Vaccinate ewes for enterotoxemia.
5. Control lice and ticks immediately after shearing.
6. Four weeks before lambing increase grain to 1/2 to 3/4 pound/ewe/day (usually done immediately after shearing).
7. Give A-D-E preparations to ewes if pastures and/or roughage are or have been poor quality.
8. Feed selenium-vitamin E or use an injectable product if white muscle is a problem. Caution—do not do both.
9. Check facilities and equipment to be sure everything is ready for lambing.
10. Two weeks before lambing increase grain to 1 pound/ewe/day.

LAMBING

1. Be prepared for the first lamb 142 days after turning the rams in with the ewes, even though the average pregnancy period is 148 days.
2. Watch ewes closely. Extra effort will be repaid with more lambs at weaning time. Saving lambs involves a 24-hour surveillance. Additional help at this time is money well spent.
3. Pet a ewe and lambs in lambing pen (jug) after lambing, not before.
4. Grain feeding the ewe during the first three days after lambing is not necessary.
5. Be available to provide assistance if ewes have trouble.
6. Disinfect lamb’s naval with iodine as soon after birth as possible.
7. Be sure both teats are functional and lambs nurse as soon as possible.
8. Use additional heat sources (heat lamps, etc) in cold weather.
9. Brand ewes and lambs with identical numbers on same sides. Identify lambs with ear tags, tattoos or both.
10. Turn ewes and lambs out of jug as soon as all are doing well (one to three days).
11. Bunch up ewes and lambs in small groups of four to eight ewes and then combine groups until they are a workable size unit.
12. Castrate and dock lambs as soon as they are strong and have a good start (two days to two weeks of age). Use a tetanus toxoid if tetanus has been a problem on the farm (toxoids are not immediate protection. It takes at least ten days for immunity to build).
13. Vaccinate lambs for soremouth at one to two weeks of age if it has been a problem in the flock.
14. Provide a place for orphaned lambs. Make decision on what lambs to orphan as soon after birth as possible for the best success. Few ewes can successfully nurse more than two lambs.
END OF LAMBING TO WEANING

1. Feed ewes according to the number of lambs suckling. Ewes with twins and triplets should receive a higher plane of nutrition.
2. Provide creep feed for lambs (especially those born during the winter and early spring).
3. Vaccinate lambs for overeating at five weeks and seven weeks of age.

WEANING

1. Wean ewes from lambs, not lambs from ewes. If possible, remove ewes from pen out of sight and sound of lambs. If lambs have to be moved to new quarters, leave a couple of ewes with them for a few days to lead the lambs to feed and water locations.
2. Lambs should be weaned between 50 and 60 days of age or when they weigh at least 40 pounds and are eating creep and drinking water. The advantage of early weaning is that the ewe’s milk production drops off to almost nothing after eight weeks of lactation.
3. Grains should be removed from the ewe’s diet at least one week prior to weaning and low quality roughage should be fed. Restriction of hay and water to the ewes following weaning lessens the chance of mastitis to occur. Poorer quality roughage should be fed to ewes for at least 10-14 days following weaning.
4. Handle the ewes as little as possible for about 10 days following weaning. Tight udders bruise easily. If possible, bed the area where the ewes will rest heavily with straw to form a soft bed for the ewes to lay on.

WEANING TO PRE-BREEDING

1. If ewes go to pasture, treat for internal parasites.
2. Feed a maintenance ration to the ewes. Put ewe lambs that lambed back on a growing ration once they have quit milking.
3. Adjust ewes conditions so they can be effectively flushed for next breeding season. Don’t get ewes too fat prior to breeding.
REARING LAMBS ARTIFICIALLY (ORPHANS)—MANAGEMENT TIPS

Within 2 to 4 hours after birth, decide which lambs among those from multiple births you should remove. Look for the weaker, or smaller ones to choose for artificial rearing. It is important to make the decision early. Relatively weak lambs remaining with ewes can experience more stress than those reared artificially. Consider the following tips:

• It is essential that newborn lambs receive colostrums milk. Cow’s colostrums will work if ewe’s milk is not available. Do not dilute with water or warm too quickly if colostrums is frozen.
• Lambs should be removed from sight and hearing distance of ewes.
• Provide a warm, dry, draft-free area to start lambs.
• Use a good milk replacer that is 30% fat and at least 24% protein. Each lamb will require from 15 to 20 pounds of replacer to weaning.
• Use good equipment. Self priming nipple and tube assemblies have been founds to be excellent for starting lambs.
• Lambs may require some assistance the first day or two to teach them to nurse on whatever feeding device is used.
• Start on nurser quickly. Young lambs start easier.
• Self feed cold milk replacer after lambs are started. Milk replacers should be mixed with warm water for best results and then cooled down. Lambs feed cold milk grow well with less problems from sours and other digestive disturbances. Cold milk keeps better too.
• There is a Formaldehyde solution commercially available that retards bacterial growth in milk (1cc/gallon milk).
• Hang a light over the milk replacer feeding device and dry ration feeder.
• Avoid placing young lambs with older lambs, as they may be pushed aside and be able to obtain milk replacer. Remember that lambs nursing ewes drink 25 to 40times per 24 hours. Best results have been obtained when lambs are fed in groups of 3 to 4 initially. After lambs are successfully trained, they can be handled in groups of 25.
• Inject lambs in the first few days with Iron Dextran, Vitamin A-D-E, and Selenium-Vitamin E. At 15 days of age, vaccinate for overeating (Colostridum perfringen type C & D)
• Provide lambs a high-quality creep feed as soon as possible. Provide ample fresh water in front of lambs at all times. Do not feed hat or oats the first three weeks of age as it encour- ages bloat. Caution! Do not feed leafy alfalfa until two weeks after weaning, as it my en- courage bloat.
• Wean lambs abruptly at 21-30 days of age. When to wean depends upon whether lambs are eating creep feed and drinking water. Newly weaned lambs will go backwards for sev- eral days. Don't be alarmed, they will make compensating gains later on.
NOTE: these and other plans are available through county agents or from Extension Agricultural Engineering, NDSU, Fargo, ND. These drawings show construction details and include a materials list for estimating. Due to changes in lumber size, lumber grades, plywood quality and other developments in building materials, some adjustments are required for older plans. (Present charge is shown or $1.00 per sheet.)

CORRALS AND BARN

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<td>3.00</td>
</tr>
<tr>
<td>MW 73113</td>
<td>32’ &amp; 48” wide Pole frame Hay Shed (Interior Poles)</td>
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<tr>
<td>MW 73210</td>
<td>Moveable Grain Storage Walls, 6’ to 12’ High</td>
<td>2.00</td>
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<tr>
<td>MW 73217</td>
<td>20, 45, 170 and 340 Bu. Hoppered Grain Bins</td>
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<tr>
<td>MW 73220</td>
<td>48’ Wide Pole Frames Grain Storage</td>
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<tr>
<td>MW 73250</td>
<td>Grain Storage Buildings 600, 1000, 1200, 1500 or 2000 Bu.</td>
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<td>MW 73293</td>
<td>Grain-Feed Handling Center, Work Tower Across Drive</td>
<td>4.00</td>
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<tr>
<td>MW 73294</td>
<td>Grain-Feed Handling Center, Work Tower Beside Drive</td>
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<tr>
<td>APA</td>
<td>10 Ton Hoppered Feed Bin</td>
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<tr>
<td>APA</td>
<td>4 Compartment Bin for Feed Mill</td>
<td>no charge</td>
</tr>
<tr>
<td>AED-15</td>
<td>Horizontal Bunker Silos, Concrete Tilt-up</td>
<td>no charge</td>
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<tr>
<td>USDA 6090</td>
<td>5500 Bushel Wooden Grain Bin</td>
<td>2.00</td>
</tr>
<tr>
<td>MWPS-13</td>
<td>Planning Grain-Feed Handling Handbook</td>
<td>5.00</td>
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</table>
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