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Effects of Dietary Zinc Concentration during Gestation on Preweaning Progeny Performance

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Abstract

Mastitis is one of the leading reasons for culling ewes from U.S. flocks, and subclinical mastitis indicated by high somatic cell counts (SCC) in milk has also been shown to negatively impact ewe productivity. However, means to reduce subclinical mastitis and consequential effects on lamb production are sparse. A previous study which found deprived zinc levels in ewes with high SCC suggests that ewes supplemented with zinc may exhibit lower SCC and increased lamb performance (Murphy et al, 2018). In this study, yearling ewes (n = 59) were provided zinc above dietary recommendations during gestation and the effects on lamb performance measured by visual scores at birth and by weight gain. Ewes were divided into three treatment groups in which each ewe received one pound of a zinc sulfate fortified supplement containing 40 mg/kg zinc (control), 500 mg/kg, or 1000 mg/kg from approximately day 70 of gestation until parturition. Providing dietary zinc concentration during gestation did not affect lamb vigor scores, lamb weights, nor pounds of lamb weaned per ewe, but did increase lamb survival ($P < 0.05$). Pending serum zinc levels and somatic cell counts, along with data from two concurrent collaborative studies will provide further insight to the significance of this project.

Key words: ewe, lamb, zinc, mastitis, progeny performance

Introduction

Mastitis is inflammation of the mammary gland, predominantly caused by bacterial infection (Erskine). One survey revealed that 6.7% of ewes are culled due to mastitis, and is the fifth greatest reason for removing ewes from production (USDA APHIS, 2011). Mastitis reduces milk production of ewes and consequently decreases their ability to raise lambs, yet the disease is readily identified and selected against by sheep producers.

Subclinical mastitis (SCM) may be of greater importance. SCM affects up to 50% of ewes, and does not present with visual symptoms. Instead, SCM is detected in milk samples by a somatic cell (SCC) count greater than 500,000 cells/mL (Keisler et al., 1992). A recent study found that ewes with SCM wean on average 30lbs less lamb than ewes with a lower SCC (Murphy et al., 2018). The prevalence and impact of SCM on sheep production emphasize the need for additional research on preventive measures.

The study by Murphy et al. (2018) also found greater serum zinc levels ($p = 0.02$) in ewes with a low SCC, and suggests the potential of zinc supplementation to reduce the prevalence of SCM. Zinc is required in general for numerous biological processes, including for proper immune function, growth, and reproduction (ASI, 2002; Prasad, 2008; Hosnedlova et al., 2007). More specifically, zinc may contribute towards udder health in ruminants due to the role of zinc in keratin formation (Davidov et al., 2013; Tomlinson et al., 2004) and a reduction in bacterial adherence to mammary epithelium (Saianda et al., 2007). For adult sheep, the NRC (2007) estimates that a minimum of 20-39 mg Zn/kg dry matter is required to prevent decreased performance.

To investigate the effects of zinc on the prevalence of SCM, yearling ewes (n = 59) were divided into three treatment groups in which each ewe received one pound of a zinc sulfate fortified supplement containing 40 mg/kg zinc (control), 500 mg/kg (ZN500 group), or 1000 mg/kg (ZN1000 group) from approximately day 70 of gestation until parturition. Preweaning progeny performance was gauged by assigning vigor and suckling scores at birth, weight gain, and percent survival. Based on the nearly 20% prevalence of SCM, coupled with higher serum zinc in ewes with low SCC and decreased performance of progeny from afflicted ewes, we predict that ewes supplemented with zinc above dietary recommendations may exhibit increased progeny performance. This prediction is of greater interest given that range ewes are overwintered predominantly on pasture, and that an estimated 77% forage in the U.S. is zinc deficient of marginally deficient (USDA-NAHMS, 1997).

Materials and Methods

Experimental Design and Treatments- Hampshire and Rambouillet ewes (n = 59) born in 2016 were divided into three treatment groups in which each ewe received one pound of a zinc sulfate fortified supplement containing 40 mg/kg zinc (control; n=18), 500 mg/kg (n=22), or 1000 mg/kg (n=19) from approximately day 70 of gestation until parturition. Zinc concentrate was delivered to ewes via a Super SmartFeed™. Ewes were maintained on regrowth hay meadows until one month prior lambing, then moved to dry-lot pens and fed ad lib meadow hay until parturition. All pastures and pens contained automatic watering systems.

Postpartum Management- After lambing, ewes and their lambs were moved into individual pens for two days, during which lambs were scored for vigor, weighed, ear tagged, tails docked, castrated, and vaccinated with CD/T and sore mouth. Any ewes bearing triplets had one lamb removed at 2 days of age, and this lamb was excluded from the study. Ewes and lambs received ad lib 50/50 mixture of meadow hay and 2nd cut alfalfa, and had free-choice access to mineral. Lambs were also provided free-choice 18% protein creep feed.

Progeny Performance- Lamb vigor and suckling scores were adapted from Matheson et al. (2011). Vigor scores were assigned within 45 minutes postpartum, on a scale from one to five (1 = very weak, 5 = extremely active) and suckling scores assigned from one hour to two days postpartum, also on a scale from one to five (1 = assistance required past two days, 5 = nursing within one hour without assistance). Lamb weights were recorded within 24 hours of birth using a fish scale and sling, at approximately 30 days of age, and at weaning at approximately 90 days of age. Weights were adjusted to 30 or 90 days using calculations provided by the Sheep Production Handbook (2002). Percent lamb survival, comparing the number of lambs weaned to the number of lambs born, and pounds of lamb weaned per ewe were also calculated after the 90 day weaning weights.

Statistical Analysis- SAS software (version 9.4) was used to perform statistical analysis. The effect of treatment (40 mg Zn/kg, 500 mg Zn/kg, 1000 mg Zn/kg) on lamb vigor, suckle score, survival, lamb weights at birth, 30 days, at weaning at 90 days, and total pounds lamb per ewe were analyzed using MIXED procedure. Fixed effects in addition to treatment included in the model were breed (Hampshire or Rambouillet), birth type (single or multiple), rearing (single or multiple), and their interactions. Data are reported as least squares means ± SEM. Statistical significance was declared at $P \leq 0.05$.

Results

Lamb vigor scores were assigned on a scale from one to five, with five being optimal. A score of five for vigor indicated that the lamb was quick to stand and had high energy, and a score of five for suckling indicated that the lamb nursed unassisted within one hour of birth. The average lamb vigor and suckle scores were all above a four. No differences were found in lamb vigor between treatment groups (P = 0.49), nor in lamb suckle scores between treatment groups (P = 0.71; Figure 1).

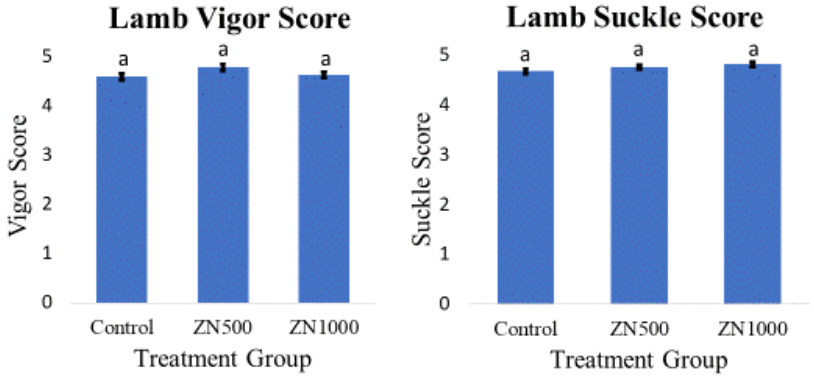

Figure 1. Vigor scores were assigned to lambs from ewes that received 40mg/kg Zinc (control; n = 34), 500mg/kg Zinc (n = 39), or 1000mg/kg Zinc (n = 34) during gestation. The scale ranges from 1-5 with 5 being optimal. Values are least squares means ± SEM. Bars without a common letter (a) differ ($P < 0.05$).

Lamb weights were obtained at birth, and at approximately 30 and 90 days of age at weaning. No differences in lamb weights were observed at birth (P = 0.79) nor at 90 days of age at weaning (P = 0.20; Figure 2). At the 30 day weight, lambs in the control group weighed on average about five pounds heavier (P = 0.004) than lambs from either the ZN500 or ZN1000 groups.

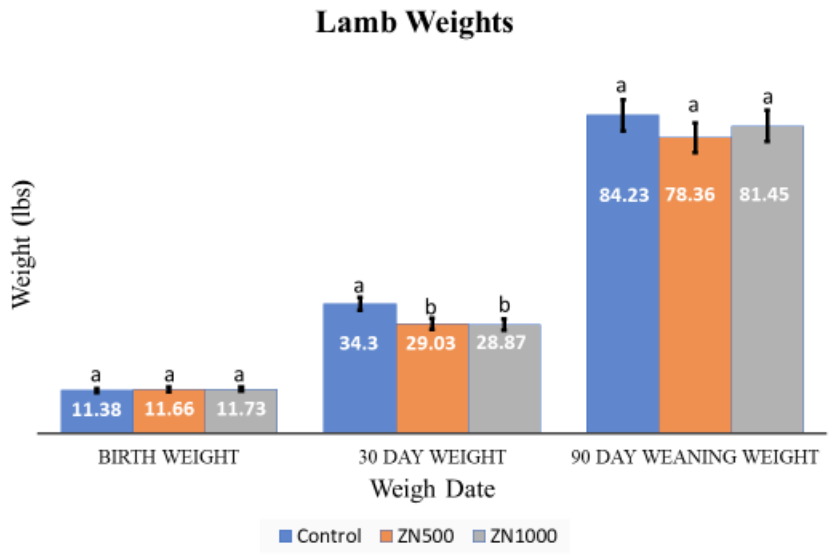

Figure 2. Weight of lambs from ewes that received 40mg/kg Zinc (control; n = 34), 500mg/kg Zinc (n = 39), or 1000mg/kg Zinc (n = 34) during gestation. Lamb weights were obtained at birth, and at approximately one month and three months of age, with weights adjusted to 30 and 90 days of age. Values are least squares means ± SEM. Bars without a common letter (a-b) differ (P < 0.05).

Pounds of lamb weaned per ewe were calculated using lamb weights obtained from the 90 days weaning date. No differences were found in pounds of lambed weaned per ewe between treatment groups (P = 0.78; Figure 3). Lambs reared as singles also weighted more than lambs reared as multiples across treatment groups (<0.0001).

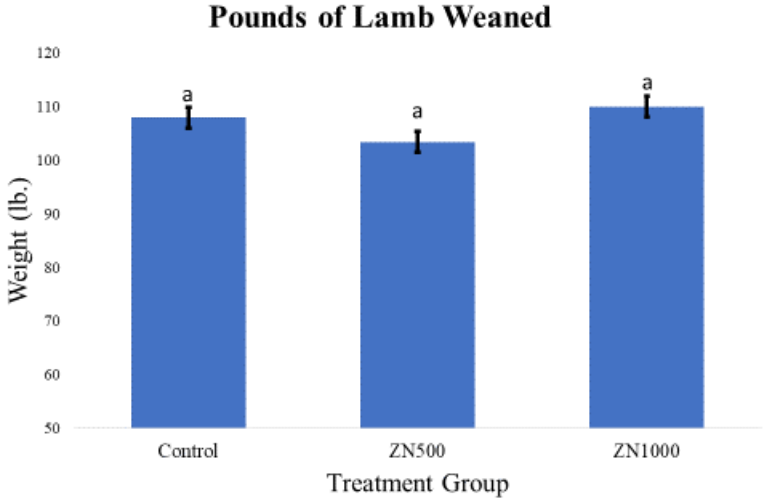

Figure 3. Pounds of lamb weaned was found per ewe that received 40mg/kg Zinc (control; n = 34), 500mg/kg Zinc (n = 39), or 1000mg/kg Zinc (n = 34) during gestation. Calculations used 90 day lamb weaning weights. Values are least squares means ± SEM. Bars without a common letter (a) differ (P < 0.05).

Percent lamb survival represents the ratio of lambs weaned to the total number of lambs born within each treatment group. Lambs from the control group had decreased survival

compared to lambs from the ZN1000 group (P = 0.02). Percent survival in the ZN500 group was intermediate to the control and ZN1000 groups.

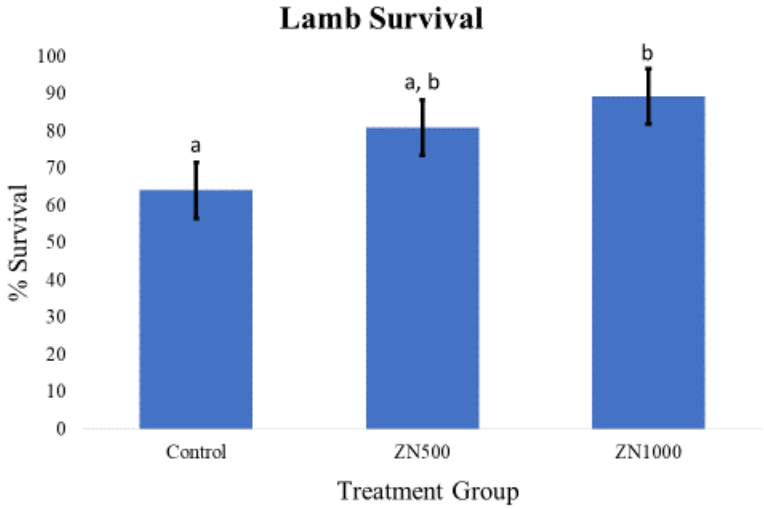

Figure 4. Percent survival was found for lambs from ewes that received 40mg/kg Zinc (control; n = 34), 500mg/kg Zinc (n = 39), or 1000mg/kg Zinc (n = 34) during gestation. Lamb survival was determined at approximately 90 days at weaning. Values are least squares means ± SEM. Bars without a common letter (a-b) differ (P < 0.05).

Discussion

Subclinical mastitis indicated by a SCC above 500,000 cell/mL of milk affects a high proportion of ewes in U.S. flocks, and has been shown to reduce progeny performance. Given that detecting SCM is not feasible in range sheep operations, a means to reduce the prevalence of SCC would be beneficial to both flock health and has economic merit. Studies suggest that supplementing zinc above dietary recommendations may decrease the occurrence of SCM in ewes and increase progeny performance (Davidov et al., 2013; Murphy et al., 2018; Saianda et al., 2007). In this study, yearling ewes were divided into three groups in which each ewe received one pound daily of a zinc fortified diet with either 40mg Zn/kg (control), 500mg Zn/kg, or 1000mg Zn/kg from about day 70 of gestation through parturition. Lamb performance was measured by vigor scores at birth, weight gains, and percent survival.

No differences were observed in lamb vigor or suckle scores between treatment groups. However, average scores for each group were all above a score of four, suggesting that zinc concentrate above dietary recommendations during gestation did not have a negative impact on lamb vigor at birth.

Zinc concentration did not affect lamb weights at birth or weaning, but lambs in the control group weighed more (P = 0.004) than either the ZN500 or ZN1000 groups at 30 days of age. If zinc supplementation reduced somatic cell counts and subsequently increased milk quality or quantity, weights of lambs in the ZN500 and ZN1000 groups may have been greater than weights of lambs in the control group. Lambs in the control group instead weighed slightly heavier at 30 and 90 days of age. The heavier weights of control lambs at 30 days and at weaning could be explained by a compensatory effect from ewes receiving minimal zinc during gestation, then greater amounts of zinc from alfalfa and free-choice mineral postpartum (Turgeon, 1986). Feedlot performance of lambs will be monitored to further observe influence of zinc supplementation on lamb weight gains.

Pounds of lamb weaned per ewe is the single most important metric to determine ewe productivity. We predicted that ewes in ZN500 or ZN1000 groups would wean more pounds of lamb than ewes in the control group, however, no differences were seen between groups. Lambs reared as singles were heavier than lambs reared as multiples (P = <.0001), and may influence observable effects of zinc concentration on lamb performance. More definitive data could be collected if the study were repeated with a larger sample size.

Percent lamb survival was lowest in the control group, intermediate in the ZN500 group, and greatest in the ZN1000 group, and survival between control lambs and ZN1000 lambs was significantly different (P = 0.02). This finding is consistent with our prediction that zinc concentration may increase lamb performance, yet inconsistent with results for pounds of lamb weaned. If lambs in ZN500 or ZN1000 groups have greater survival than control lambs, pounds of lamb weaned per ewe should also be greater for lambs in groups that received higher zinc concentrate. Again, this finding and the previous would have greater merit if repeated with a larger sample size. Increased IgG levels were found in the colostrum of dairy cows provided zinc concentrate (Kinal, 2005), suggesting that testing for immunoglobulin in colostrum could provide insight into the mechanism involved in lamb survival.

Pending data on SCC and serum zinc level are needed before conclusions about effects of zinc concentration on the prevalence of SCM can be made. Concurrent collaborative studies at Montana State University and the U.S. Sheep Experiment Station will provide additional insight, and a greater sample size. Forthcoming data will be used to determine 2018-2019 protocol adaptations, including the possibilities of repeating the study with a larger sample size, detecting for IgG in colostrum, and measuring milk production in context of variations in SSC.

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