## Diseases Causing Abortions

There are many bacterial and viral causes of abortion. Diagnostics should be done to determine causes. The fetus should be submitted and DO NOT FORGET TO SUBMIT THE PLACENTA. Also wear gloves when handling abortive tissues.

## Vaccine Schedules

Vaccine schedules vary by risk of exposure in each flock and their location. Clostridium vaccines should always be given to the lambs and the dams prior to the lambing.

## Other Various Conditions Found in Sheep

Lacerations – suture if found within 6 hours. Minor wounds use tamed iodine or triple antibiotics. If underlying muscle is exposed or swollen give antibiotics. Use fly spray in warm months.

Bloat – sheep is unable to belch to relieve gas and could die due to compression of the lungs. A tube should be passed through the mouth into the rumen. If free gas is present the sheep's rumen will decompress. If it does not decompress then it is frothy bloat and the sheep should be drenched with a product such as Therabloat, which dissolves the froth. The tube should then again be passed and the gas relieved.

Foot Rot/Scald – clinical sign is limping with a deep infection and foul smell in the hoof tissue. Scald is a mild infection between toes. Treatment is trimming off infected tissue and administration of tetracycline, topical formalin. Sheep can also be allowed to stand in foot bath with zinc sulfate or formalin. Prevention is to improve the environment to prevent mud, manure slurry or sharp rocks from damaging and weakening the hoof.

Mastitis – is infection of the udder. The udder becomes swollen with abnormal milk. Treatment consists of banamine, antibiotics, stripping out the quarter with use of oxytocin and intramammary treatment of the quarter (Cattle lactating tube).

Pneumonia – high fever, increased respiratory rate and effort, with nasal discharge, coughing, outstretched head and depression. Treatment consists of antibiotics (ie excenel, nuflor, draaxin), and banamine. Prevention is improvement of ventilation and decrease of crowding. So far vaccination using cattle products has not been shown scientifically to decrease incidence of disease. However it is felt that treatment of sick animals that have mycoplasma will prevent occurrence of pasteurella respiratory disease, which invade after the mycoplasma infection.

Pregnancy toxemia (Fatty Liver) – this is a metabolic disease where thin or overly conditioned ewes with multiple fetuses cannot meet their energy demand and begin to break down body fat. Ewes with twins require 180% more energy and those with triplets 200-259% more energy than normal doing the last 2 months of pregnancy. These animals stop eating, become depressed and recumbent. Ketones can be found in their urine. Treatment consists of correcting the negative energy balance with 100-250 ml of dextrose solution IV, induction of lambing with 20 mgs of dexamethasone or a C-Section. Additional therapies consist of B-vitamins, transfaunation of rumen contents, oral dextrose, calcium, propylene glycol and oral electrolyte solutions containing dextrose.

Rectal prolapse – predisposing factors are length of tail dock, straining due to parasitism, diarrhea, coughing or straining due to urinary stones. Treatment depends on severity. A mild prolapse can be cleaned, replaced and a purse string suture around the anus or injection of counterirritants such as lugols iodine or oxytetracycline around the anus to provide swelling and stricture. More severe prolapses may need to be amputated with a prolapse ring or surgery. These are salvage procedures and generally the animals are sent to market as soon as possible. All animals with prolapses should be given mineral oil orally and enemas if their manure is hard.

Diarrhea –
- E coli <10 days of age – oral electrolytes, SQ fluids, antibiotics
- Rotavirus <3 wks of age – oral electrolytes, SQ fluids
- Cryptosporidium <2 wks – oral electrolytes, SQ fluids (zoonotic)
- Salmonella – any age – very sick, fever, antibiotics and fluids (Zoonotic)
- Giardia – fluids, fenbendazole
- Clostridium perfringes – sick, painful, bloody diarrhea – tx antitoxin orally and SQ, penicillin orally and SQ and banamine
  - Amprolium (Corid) – treatment
  - Sulfa boluses (Albon) – treatment
  - Bovatec – preventative
  - Deccox – preventative
- Internal parasites - older animals – anemia, weight loss, diarrhea, ventral edema – strategic deworming and fecal exams
- Johnes disease – chronic weight loss in older sheep

**UW Preventative Medicine – Ewes**

- 4-6 weeks before lamb – 400 mg/head chlortetracycline/head – chlamydia abortion
- 3-6 wks before lamb – vaccinate clostridium C,D&T
  - (Maiden ewes vaccine twice 1 and 2 months before lambing)
- 4-6 wks before lambing – Deccox in the grain thru lambing and weaning – coccidiosis preventative
- Hooves trimmed prior to pasture and as needed and 5% zinc sulfate footbaths
- Deworming with either (ivomec, panacur, tramisol) 3 times per year
  - Fall after first freeze
  - Pre-lambing shearing
  - Prior to ewes going out to pasture

**UW Preventative Medicine – Lambs**

- Birth – dip navel with 7% iodine and trim, 2 ml oral nutritional drench, spectinomycin
- Colostrum bottle feed or tube feed 8 oz colostrum if not nursing aggressively or if twin or triplet – repeat in 12 hours
- Day 1 – 1 ml BoSe, Dock tail, castration – meloxicam

Day 30 - Vaccines – Sore mouth vaccine if present in the flock
Clostridum C,D,&T with a booster 1 month later
8 weeks - weaned

**Welfare Concerns**

Tail dock length and its association with rectal prolapses
Pain medication and husbandry procedures (Castration and tail docking)
Museling - AVA supports practice with analgesics done by trained personnel
Age of castration and its association with urolithiasis

# THE EFFECT OF SODIUM BICARBONATE SUPPLEMENTATION ON DAIRY EWE PERFORMANCE

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## Introduction

Maximizing profit while minimizing risk are key components to any business, and sheep dairying is no different. In order for a farm to be sustainable, returns need to outweigh costs. Dairies should always be looking for ways to improve milk yield, milk quality, and animal health in order to improve profitability. Like all ruminant animals, sheep get most of their nutrients through fermentation of feed. Microbes in the rumen assist the fermentation process and produce nutrients that the animal can use for maintenance, growth, and production. The microbes present in the rumen require a specific range of pH for optimal utilization of feed and forage.

Sodium bicarbonate ($NaHCO_3$) is classified as a buffer. The addition of sodium bicarbonate to a ruminant diet allows the microflora in the rumen to flourish by keeping rumen pH at a stable point, thus reducing its variability (Marden et al, 2008). The normal pH of the rumen is 6.0, where there is optimal digestion of structural carbohydrates such as those found in corn and forages.

During grain feeding of ewes in the milking parlor at the Spooner ARS, the rapid intake of grain likely causes the pH of the rumen to dip below 6.0. Without a buffer like sodium bicarbonate, this decline can cause the microbial population to produce lipids using an alternative pathway for making volatile fatty acids (VFA). At optimal rumen pH, the VFA acetate is produced. Acetate is a versatile fatty acid as it can be used as an energy source and a carbon source for fatty acids. Acetate is crucial for not only adipose tissue but also in the mammary gland for increased milk fat percentage.

The buffering capacity of sodium bicarbonate allows for increased milk fat as well as protection against several common complications in early lactation. The introduction of a high grain diet at the beginning of lactation can create ruminal acidosis as well as parakeratosis. By providing $NaHCO_3$ in the diet, the animal has a better chance of warding off these complications by keeping the pH at a steady level, thus mediating the negative effects of high concentrate diets.

## Applications

Previous studies have been performed on both dairy cattle and goats in order to provide support for the chemical and nutritional basis of the benefits of feeding a buffer. It has been reported that the greatest benefits of sodium bicarbonate occurs in early lactation, with effects evident 2 to 3 weeks after supplementation has been initiated (Hadjipanayiotou, 1982). In dairy cows, $NaHCO_3$ was shown to increase milk yield by almost 2 kg/day and milk fat by 69 g/day

(Rogers et al, 1985). In a study with dairy goats, sodium bicarbonate supplementation resulted in an increase of 18.6 g of milk fat per day (Hadjipanayiotou, 1982).

## Methods

In order to see the effects of adding sodium bicarbonate to a milking ewe's diet, a two and half week study was initiated this year at the Spooner Agricultural Research Station on 279 ewes. The ewes were randomly assigned to a treatment group, balancing both age and lambing date across groups. Ewes ranged in age from 1 to 9 years old and lambing dates ranged from early January to early March. Of the 279 ewes, 139 were selected to be supplemented free choice $NaHCO_3$ (bicarb) the other 140 ewes served as the control (control). The supplementation period lasted 18 days, from 4/10/15 to 4/28/15. A random sample of 71 ewes were selected for milk testing, 36 in the bicarb group and 35 in the control group. These ewes had their milk tested five times (4/8, 4/15, 4/21, 4/28, 5/5) for fat and protein percentage. All of the ewes in the study had daily milk yields recorded on all five test dates.

The bicarb and the control groups were kept in different pens and were milked separately. Sodium bicarbonate was fed free choice in a mineral feeder. In order to minimize a possible pen effect, the ewes and the sodium bicarbonate feeders switched pens in the middle of the supplementation trial on April 21st. The ewes in the bicarb group consumed a total of 90 pounds of sodium bicarbonate in the two and a half week period, equating to 0.036 lb./head/day (16.3 g/head/day). A similar study was conducted in dairy goats where sodium bicarbonate was fed at a level of 4% of the concentrate or 40 g/head/day (Hadjipanayiotou, 1982).

In order to analyze the effect of sodium bicarbonate supplementation on milk yield and percentage milk components, the following model was implemented in the MIXED procedure of SAS with repeated measures:

$$y_{ijkl} = \mu + C + G_i + T_j + Age_k + Animal_l + \varepsilon_{ijkl}$$

where $\mu$ is the overall mean for the dependent variable, $C$ is the pre-trial record covariate for the appropriate dependent variable, $G_i$ is the fixed effect of trial group, $T_j$ is the fixed effect of test date, $Age_k$ is the fixed effect of ewe age (1, 2, 3, or 4+), $Animal_l$ is the random effect of the $l^{th}$ ewe, and $\varepsilon_{ijkl}$ is the residual error. Fixed two-way interactions were included if significant ($P < 0.10$) and depended on the trait being analyzed. The %Protein model contained no interaction terms, the %Fat model contained the $G_i$ x $T_j$ interaction, and the milk yield model contained the $G_i$ x $T_j$ and $T_j$ x $Age_k$ interactions.

## Results

Table 1 presents the least squares means of the main effects for milk yield, % fat, and % protein. Test date had a significant effect ($P < 0.0001$) on all of the traits. Age of ewe affected ($P < 0.02$) yield but not component traits ($P > 0.45$). Similar to other Spooner studies, daily milk yield peaked at 3 years of age. For all three traits, sodium bicarbonate supplementation had a favorable numerical effect. However, there was only a tendency for significant statistical difference between groups ($P < 0.07$) for % fat.

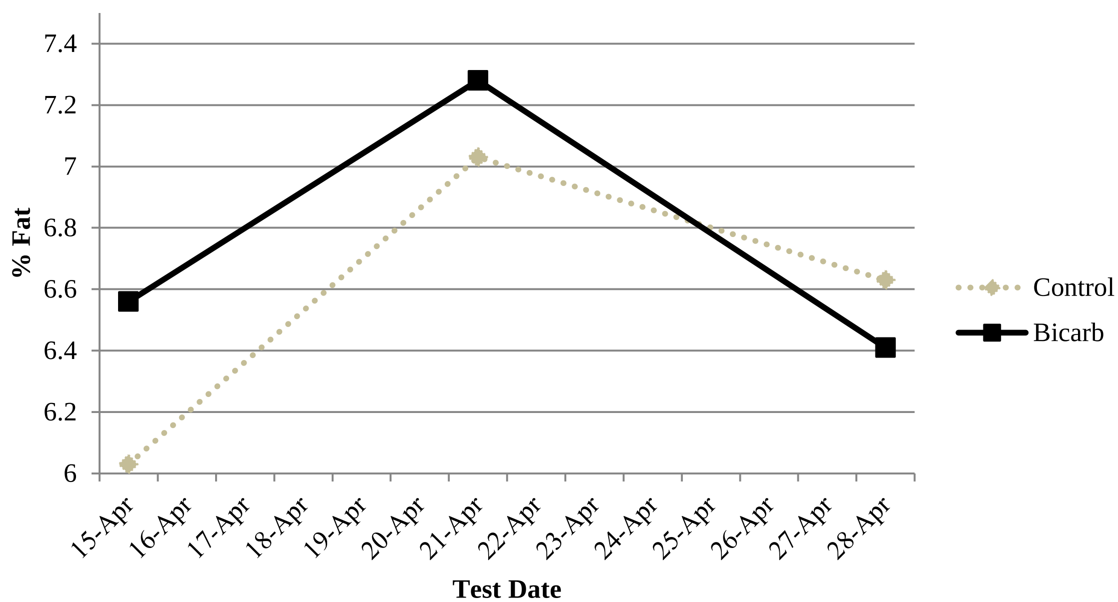
Because the group x test interaction for milk yield and % fat and the group x age interaction for milk yield were highly significant ($P < 0.0001$), it is perhaps more appropriate to examine these interactions before making claims of the main effects of sodium bicarbonate supplementation. Figure 1 displays the least squares means for % fat of the bicarb and control groups for each test day. For this experiment, the favorable effect of sodium bicarbonate supplementation on % fat came within the first week of the trial ($P < 0.003$). On the final two trial dates (4/21 and 4/28) there were no significant differences ($P > 0.45$) between the control and bicarb groups for % fat.

**Table 1.** Least squares means ± standard errors for milk yield (MY), % fat (%F), and % protein (%P) of Spooner ewes.

| | | Trait | | |
|---|---|---|---|---|
| Effect | Level | MY (kg) | %F | %P |
| Test date | 4/15 | $1.95 \pm 0.02^{a}$ | $6.29 \pm 0.07^{a}$ | $4.98 \pm 0.03^{a}$ |
| | 4/21 | $1.67 \pm 0.02^{b}$ | $7.16 \pm 0.07^{b}$ | $4.93 \pm 0.03^{a}$ |
| | 4/28 | $1.77 \pm 0.02^{c}$ | $6.52 \pm 0.07^{c}$ | $4.84 \pm 0.03^{b}$ |
| Age | 1 | $1.76 \pm 0.02^{a}$ | . | . |
| | 2 | $1.78 \pm 0.03^{a}$ | . | . |
| | 3 | $1.89 \pm 0.04^{b}$ | $6.69 \pm 0.09^{a}$ | $4.94 \pm 0.05^{a}$ |
| | 4+ | $1.75 \pm 0.03^{a}$ | $6.63 \pm 0.06^{b}$ | $4.90 \pm 0.03^{a}$ |
| Group | Control | $1.78 \pm 0.02^{a}$ | $6.57 \pm 0.07^{a}$ | $4.89 \pm 0.04^{a}$ |
| | Bicarb | $1.82 \pm 0.02^{a}$ | $6.75 \pm 0.07^{b}$ | $4.95 \pm 0.04^{a}$ |

[a,b,c]Means within a column and an effect without a common superscript are different ($P < 0.10$).

**Figure 1.** % fat by test date for Control and Bicarb groups



## Conclusions

The effect of free-choice supplementation of sodium bicarbonate to dairy ewes is inconclusive from this study. Only one of the three test dates showed good evidence of a positive effect of sodium bicarbonate on milk fat percentage. There also appears to be an unexplained pen effect in these data because the effect of sodium bicarbonate on milk fat changed from numerically positive to negative when the supplemented ewes were moved from the first pen to the second pen.

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## DOES FEEDING DRY HAY AFTER MILKING INCREASE MILK YIELD IN PASTURED DAIRY EWES?

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### Introduction

The increasing trend away from feeding baled hay could ultimately reduce productivity in milking herds and flocks. Rumen health is a key component to a high grossing dairy animal. Fermented feeds such as haylage and silage are more convenient for the producer, but dry hay may be more beneficial for the animal. Another factor producers need to keep in mind is how their feed is utilized. By increasing the animal's feed efficiency, less waste and more profit occur.

Particle size is a large determinate to how the rumen works and digests the food it is presented. Along with particle size, fermentation depends on the diet fermentability and pH. A more finely ground forage such as haylage or even grass from the pasture increases the rate of passage through the rumen. The percent of digestion is a function of two factors, the rate of passage ($k_P$) and the rate of digestion ($k_D$). The formula for percent digestion is shown below.

$$\%Digestion = \frac{k_D}{k_D + k_P}$$

The rate of digestion is fixed for a food source so variability in digestibility percent occurs due to the rate of passage. By having a larger particle size, such as dry hay, $k_P$ will decrease which allows for total digestion to increase. In addition to the slower $k_p$, hay will also increase the acetate to propionate ratio in the Volatile Fatty Acids (VFA) produced by the microbes in the rumen. With this, there may be a boost in milk fat as acetate favors lipid formation.

Several goat studies have been performed on varying roughages and their effect on milk yield. One study found that feeding hay decreased somatic cell counts compared to feeding both good and poor quality silage. The does fed hay had an average SCC of 1.9 x $10^6$ cells/mL while the good and poor silage fed does averaged 2.1 x $10^6$ and 3.3 x $10^6$ cells/mL, respectively (Hussain et al., 1996). Another study was performed on Egyptian Nubian goats to determine the relationship between roughage ratio and milk components. Here, an increase in roughage resulted in an increase in milk fat content with the greatest benefit in mid-late lactation. On average, the higher roughage ration resulted in 0.31% more milk fat (El-Gallad et al., 1988).

### Materials and Methods

In order to investigate the effects of hay on milk yield, a study was performed on a whole flock basis (n = 279 ewes) at the Spooner Agricultural Research Station this year. Alfalfa hay was fed in small square bales in addition to the normal pasture rotation beginning on June 3rd. After each milking, the ewes were allowed to eat hay until 15 minutes after the last group of ewes went through the parlor. After two weeks of feeding hay, another milk test was performed and the ewes were then not supplemented hay for the next two weeks. In total there were two periods of two weeks for both hay and no hay treatments. In addition to individual yields, bulk tank weights were recorded every day after the whole flock had been milked.

This experiment was easily implemented. Since all ewes were in the same treatment group at any given point, extra time and labor to separate groups during milking was not needed. However the ease of implementation presents some challenges when analyzing the data. Ewes were at different stages of lactation, and the effect of hay supplementation on passage rate and pasture utilization could be different at different lactation stages. To account for this, 3 classes of lactation stage were considered: Early (≤ 90 days in milk), Mid (91-120 days in milk), and late (> 120 days in milk). In order to obtain estimates of average flock performance on each test date, the following model was implemented in the MIXED procedure of SAS with repeated measures:

$$(1) \qquad y_{ijkl} = \mu + T_i + Age_j + DIM_k + T_i \; x \; Age_j + Ewe_l + \varepsilon_{ijkl}$$

where $y_{ijk}$ is the milk yield record, $\mu$ is the overall mean milk yield, $T_i$ is the fixed effect of test date, $Age_j$ is the fixed effect of age of ewe (1, 2, 3, or 4+), $DIM_k$ is the fixed effect of lactation stage at the start of the trial (Early, Mid, Late), $T_i$ x $Age_j$ is the fixed interaction of test date and age, $Ewe_l$ is the random effect of the $l^{th}$ ewe, and $\boldsymbol{\varepsilon}_{ijk}$ is the residual.

To understand the effect of hay supplementation on milk yield, it was assumed that ewe milk yield was decreasing at a linear rate throughout the trial. With this assumption, our dependent variable became slope between milk yield test dates, which was calculated as:

$$slope = \frac{yield_j - yield_i}{date_j - date_i}$$

For example, if hay supplementation had a positive effect on milk yield, the slope between test days when hay was supplemented would be smaller (less negative) than the slope during a period when hay was not fed. To analyze the effect of hay supplementation on slope between test dates the following model was implemented in the MIXED procedure of SAS with repeated measures:

$$(2) \qquad y_{ijkl} = \mu + Age_i + Diet_j + DIM_k + Ewe_l + \varepsilon_{ijkl}$$

where $y_{ijkl}$ is the slope between test dates, $\mu$ is the overall mean slope, $Age_i$ is the fixed effect of age of ewe (1, 2, 3, or 4+), $Diet_j$ is the fixed effect of diet in the previous two week period, $DIM_k$ is the fixed effect of lactation stage at the start of the trial (Early, Mid, Late), $Ewe_l$ is the random effect of the $l^{th}$ ewe, and $\boldsymbol{\varepsilon}_{ijkl}$ is the residual.

**Results**

Figure 1 displays the total daily bulk tank yield records corrected for number of ewes milked. The solid black line represents a period of time when ewes were supplemented with hay and dotted gray line is a period when the ewes received no hay. Figure 2 displays the least squares means of milk yield on each test date obtained from model 1. From the graph it appears that the slope of the line from 6/03 to 6/17 is less steep than the slope between 6/17 to 7/01, but the slopes from 7/01 to 7/14 and 7/14 to 7/28 do not appear to be different. Graphically, this seems to suggest that the flock milk yield was decreasing at a slower rate during the first period of hay feeding compared to the other periods.

**Figure 1.** Daily bulk tank milk yield records

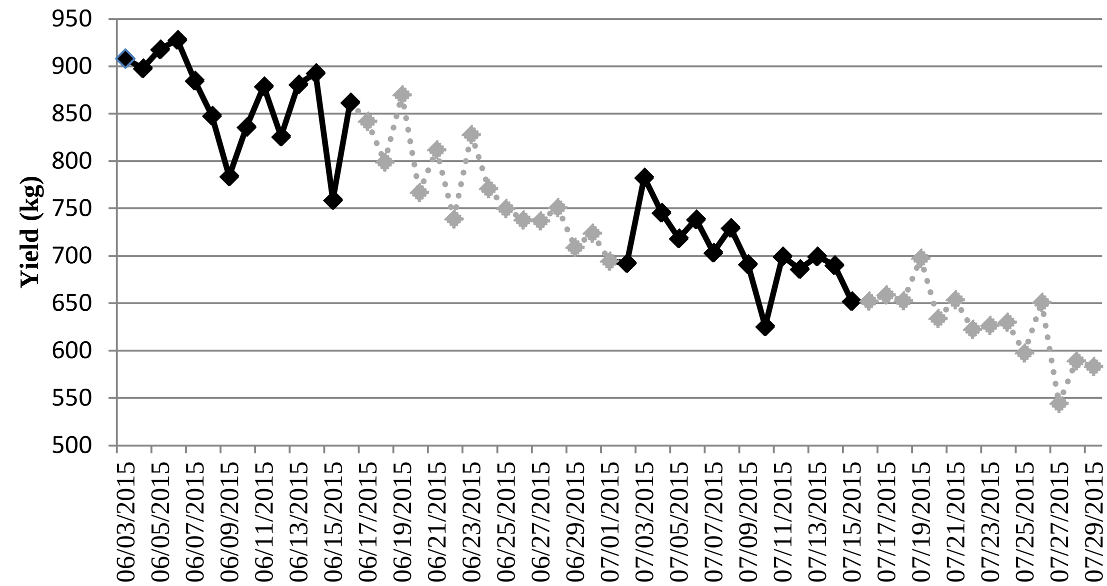
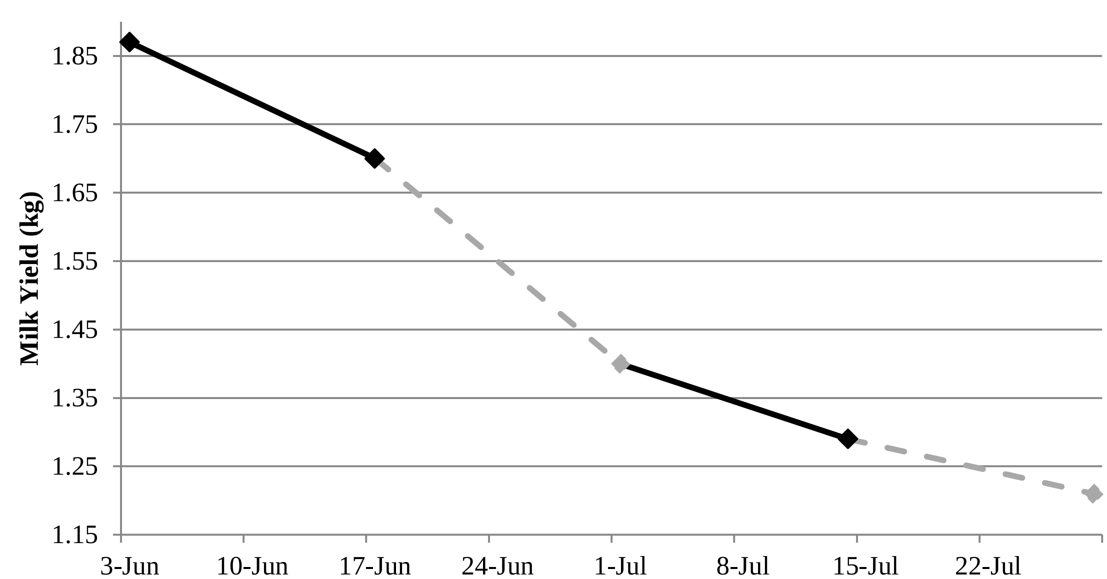



**Figure 2.** Ewe milk yield by test date




The results from model 2 are presented in Table 1. The main effect of ewe age on milk yield slope was significant ($P < 0.04$). Although milk production generally peaks at 3 years of age, daily milk yield for these ewes was also decreasing at the fastest numerical rate ($-0.016$ kg·d$^{-1}$) throughout this period. Numerically, first lactation females were the most persistent, i.e. their milk yield was decreasing at the slowest rate ($-0.009$ kg·d$^{-1}$). There was no difference ($P > 0.28$) between milk yield slopes for ewes at different lactation stages. The main effect of hay supplementation was significant ($P < 0.05$). When ewes were supplemented with dry hay after milking, their daily milk yield was decreasing 0.003 $kg \cdot d^{-1}$ less than when they received no hay.

**Table 1.** Least squares means ± standard errors for milk yield slope between test dates.

| Effect | Level | Slope ($kg \cdot d^{-1}$) |
|---|---|---|
| Age | 1 | $-0.009 \pm 0.001^{a}$ |
| | 2 | $-0.014 \pm 0.002^{a,b}$ |
| | 3 | $-0.016 \pm 0.002^{b}$ |
| | 4+ | $-0.012 \pm 0.002^{a,b}$ |
| Lactation Stage | Early | $-0.015 \pm 0.002^{a}$ |
| | Mid | $-0.012 \pm 0.002^{a}$ |
| | Late | $-0.012 \pm 0.001^{a}$ |
| Diet | No Hay | $-0.014 \pm 0.001^{a}$ |
| | Hay | $-0.011 \pm 0.001^{b}$ |

[a,b]Means within a column and an effect without a common superscript are different ($P < 0.05$).

**Conclusions**

The effect of feeding dry hay on ewe milk yield was analyzed. The thought behind this study was that feeding a small amount of hay before turning ewes out to pasture would slow the passage rate of forages, thus allowing greater digestibility of the grazed pasture forage. It was shown that daily milk yield decreased at a slower rate during at least one period when ewes were supplemented with dry hay than when they were not supplemented. However, this study does not allow us to determine whether the hay supplementation was truly slowing the rate of passage of pasture forage or if it was just providing additional nutrients to the ewes.

The difference between milk yield slopes when ewes were supplemented hay and when they were not was 0.003 $kg \cdot d^{-1}$. With this estimate, a ewe supplemented with hay would produce 0.042 kg (0.093 lb.) more milk over 2 weeks than a ewe that did not receive hay. Hay disappearance averaged 15.1 lb. per head over 2 weeks. Assuming a purchase price of $0.05/lb. for alfalfa hay and a value of $0.95/lb. for milk, the $0.09 increase in milk revenue for a $0.76 increase in feed costs is not economical on a per head basis. Future studies should focus on feeding a low quality (low nutritional value and cheap) hay to a group of ewes throughout the grazing season to determine if a similar positive effect on milk production could be obtained at a lower cost.

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# PREVALENCE OF CASEOUS LYMPHADENITIS AND ITS EFFECT ON PERFORMANCE IN SHEEP AT ARLINGTON AND SPOONER ARS

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## Introduction

Caseous Lymphadenitis (CL) is a disease caused by an infection of *Corynebacterium psuedotuberculosis* that creates abscesses on or near the lymph nodes and occasionally internal organs of sheep. Several other pathogens can create external abscesses on sheep, so visual inspection alone may result in improper diagnosis. A blood sample submitted to a veterinary diagnostic lab and subjected to a synergistic hemolysis-inhibition (SHI) test can detect the concentration of antibodies specific to *C. psuedotuberculosis* (Alves *et al.*, 1986, 1987). However, a positive test result does not necessarily indicate that the animal has an active CL infection; only that the animal was exposed to the infective organism at some time in the past and mounted an immune response.

At present, there is no cure or effective treatment for CL in sheep (Cameron, *et al.*, 1999). There is a vaccination that has shown to be effective, but once an animal is vaccinated, it will always be positive on the SHI test. This makes the assessment of the efficacy of preventative management practices difficult. It has been estimated that CL infection costs the Australian sheep industry 12 million AUD per year from losses in meat and, perhaps, wool production (Baird and Fontaine, 2007). To our knowledge, the effect of CL infection on production traits in dairy sheep and U.S. meat sheep has not been reported.

## Materials and Methods

In July of 2014, blood samples were collected from lactating ewes (n = 247) at Spooner and ewes whose lambs had recently been weaned (n = 102) at Arlington to determine their CL infection status (positive = POS, negative = NEG) by SHI testing. At this time, the Spooner ewes were weighed and their body condition score (BCS) was evaluated. Each ewe's CL infection status was added to her 2014 lambing and milking records at Spooner and to her 2014 lamb weaning weight records at Arlington.

<u>*Spooner Ewes*</u>: To determine the effect of CL infection on mid-lactation BW and BCS of the Spooner ewes, two models were analyzed in the GLM procedure of the Statistical Analysis System (SAS). The final model for both BW and BCS included the main effects of age in years (1, 2, 3, or 4+) and CL infection status (POS or NEG).

Test-day somatic cell count (SCC) records were transformed to test-day somatic cell score (SCS; Ali and Shook, 1980) using the following equation:

$$SCS = 3 + log_2\left(\frac{SCC}{100}\right)$$

where SCC is expressed in units of 1,000 cells/mL.

To determine the effect of CL infection on test-day milk yield (MY) and SCS, models were analyzed in the MIXED procedure of SAS with an auto-regressive type I covariance structure. The model included fixed effects of age, number of lambs born (NLB; 1 or 2+), CL infection status, days in milk class (DIM class; 9 levels - 21 day intervals), and the random effect of ewe (n = 242). Two-way fixed interactions were included if significant ($P < 0.05$). The final SCS model contained the fixed interactions of DIM class x age and DIM class x NLB. The MY model contained these interactions in addition to age x NLB.

*Arlington Lambs*: The model for the 151 lamb 60 day adjusted weaning weight (60d WW) records included the fixed effects of breed (Hampshire or Polypay), age of dam (1, 2, 3, or 4+), sex, rear type (single or multiple), dam CL infection status (POS or NEG), and the random effect of dam (n = 102). The fixed two-way interaction of dam CL status x age of dam was also included in the model.

**Results**

The number and percentage of CL infection cases by age for both Arlington and Spooner ewes is listed in Table 1. At both farms, few 1 and 2 year old ewes tested positive for CL, but this gradually increased with ewe age. The two locations had similar overall infection rates of 18% and 19% at Spooner and Arlington, respectively.

**Table 1.** Number and percent of CL cases by age for Spooner and Arlington ARS ewes.

| | CL Status | |
|---|---|---|
| **Age (yr)** | **NEG (Spooner, Arlington)** | **POS (Spooner, Arlington)** |
| 1 | 74, 35 (96%, 95%) | 3, 2 (4%, 5%) |
| 2 | 49, 34 (91%, 89%) | 5, 4 (9%, 11%) |
| 3 | 30, 12 (83%, 63%) | 6, 7 (17%, 37%) |
| 4+ | 49, 7 (61%, 50%) | 31, 7 (39%, 50%) |
| Overall | 202, 88 (82%, 81%) | 45, 20 (18%, 19%) |

*Spooner Ewes*: Results from the BW and BCS models for the Spooner ewes are presented in Table 2. Not surprisingly, the effect of age was highly significant ($P < 0.0001$) for BW and BCS, both increasing with increasing ewe age as expected. CL status did not have a significant effect on ewe BW ($P > 0.70$) as POS and NEG ewes weighed similar in mid-lactation. CL status tended to have a significant effect ($P < 0.10$) on BCS and, numerically, POS ewes were thinner than NEG ewes which is a common symptom of CL infection. Perhaps with continual testing, a larger data set in future years will enable us to elucidate a bigger difference between POS and NEG ewes in terms of BCS.

Results from the Spooner lactation trait analyses are presented in Table 3. Age ($P < 0.0001$) and NLB ($P < 0.03$) had significant effects on a ewe's daily milk yield. Daily milk yield increased with ewe age and ewes that gave birth to multiple lambs produced more milk. However, there were no significant differences between POS and NEG ewes for daily MY (*P* > 0.69). This is confirmed graphically in Figure 1 as CL positive ewes had very similar daily yields to CL negative ewes. The age of a ewe tended to have a significant (*P* < 0.09) effect on SCS. Ewes that gave birth to a single lamb had statistically lower (*P* < 0.02) SCS than ewes that gave birth to multiple lambs. There was a significant effect (*P* < 0.03) of CL status on SCS; throughout lactation, NEG ewes had lower SCS than POS ewes.

**Table 2.** Least squares means ± standard errors for BW and BCS of Spooner ewes.

| | | Trait | |
|---|---|---|---|
| Effect | Level | BW (kg) | BCS[1] |
| Age | 1 | 66.3 ± 1.21[a] | 2.24 ± 0.10[a] |
| | 2 | 73.5 ± 1.33[b] | 2.39 ± 0.11[a,b] |
| | 3 | 76.9 ± 1.52[b] | 2.94 ± 0.12[c] |
| | 4+ | 82.2 ± 0.98[c] | 2.63 ± 0.08[b,c] |
| CL Status | NEG | 75.0 ± 0.63[a] | 2.65 ± 0.05[a] |
| | POS | 74.5 ± 1.39[a] | 2.44 ± 0.11[a] |

[1]BCS: 1 = very thin, 5 = very fat.
[a,b,c]Means within a column and an effect without a common superscript are different (*P* < 0.05).

**Table 3.** Least squares means ± standard errors for test-day lactation traits of Spooner ewes.

| | | Trait | |
|---|---|---|---|
| Effect | Level | MY (kg) | SCS |
| Age | 1 | 1.30 ± 0.05[a] | 3.61 ± 0.20[a] |
| | 2 | 2.08 ± 0.05[b] | 3.64 ± 0.21[a] |
| | 3 | 1.70 ±0.07[c] | 3.15 ± 0.26[a] |
| | 4+ | 1.72 ±0.04[c] | 3.12 ± 0.16[a] |
| NLB | Single | 1.65 ± 0.04[a] | 3.16 ± 0.17[a] |
| | Multiple | 1.75 ± 0.03[b] | 3.61 ± 0.14[b] |
| CL Status | NEG | 1.71 ± 0.03[a] | 3.12 ± 0.11[a] |
| | POS | 1.69 ±0.05[a] | 3.64 ± 0.22[b] |

[a,b,c]Means within a column and an effect without a common superscript are different (*P* < 0.05).

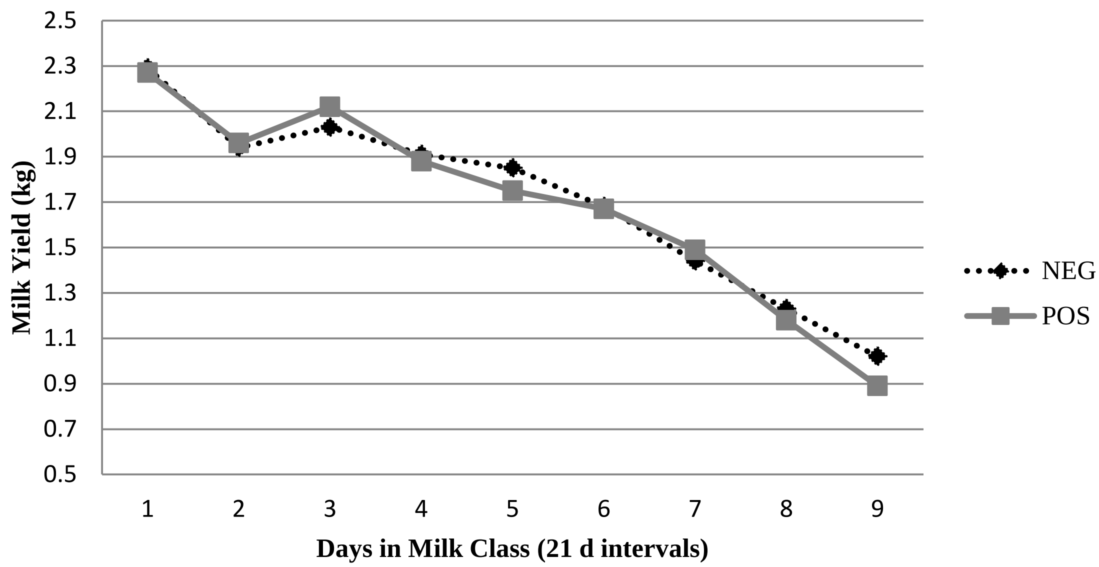



**Figure 1.** Test day milk yield of CL NEG and POS ewes

*Arlington Lambs*: Results from the Arlington data set are presented in Table 4. Breed ($P <$ 0.04), sex of lamb ($P < 0.0001$), and rear type ($P < 0.0001$) all had a significant effect on lamb 60 day adjusted weaning weight. Not surprisingly, Hampshire lambs weighed more than Polypay lambs at weaning, ram lambs weighed more than ewe lambs, and lambs raised as singles weighed more than lambs raised as multiples.

**Table 4.** Least squares means ± standard errors for 60d adjusted weaning weight of Arlington lambs.

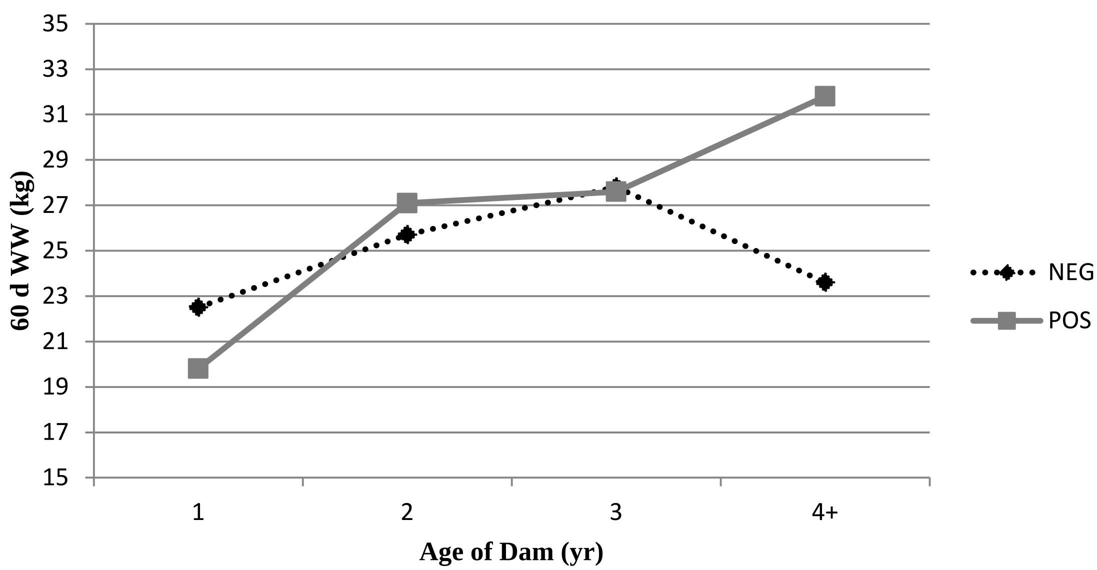
| Effect | Level | 60d WW (kg) |
|---|---|---|
| Dam Age | 1 | 21.2 ± 0.71[a] |
| | 2 | 26.6 ± 1.06[b] |
| | 3 | 27.7 ± 0.96[b] |
| | 4+ | 27.7 ± 1.16[b] |
| Rear Type | Single | 27.7 ± 0.73[a] |
| | Multiple | 23.8 ± 0.70[b] |
| Breed | Hampshire | 26.7 ± 0.71[a] |
| | Polypay | 24.8 ± 0.75[b] |
| Sex | Ewe | 24.2 ± 0.70[a] |
| | Ram | 27.3 ± 0.70[b] |
| Dam CL Status | NEG | 24.9 ± 0.55[a] |
| | POS | 26.6 ± 1.03[b] |

[a,b,c]Means within a column and an effect without a common superscript are different ($P < 0.05$).

CL POS ewes produced lambs with heavier ($P < 0.05$) 60d WW than CL NEG ewes, but the interaction of dam CL status x age of dam was significant ($P < 0.02$), so it is more appropriate to look at differences between CL POS and NEG dams within these age groups as shown in Figure

2. Lamb 60d WW was not different (*P* > 0.98) between NEG and POS 1-, 2-, or 3-year-old dams. However, within lambs raised by ewes 4 years of age and older, those raised by POS ewes were heavier (*P* < 0.02) than lambs that were raised by NEG ewes.

**Figure 2.** Lamb 60d WW by age of dam




## Conclusions

At Spooner ARS, Caseous Lymphadenitis infection was not found to have an effect on test-day milk yield. However, CL infected ewes were numerically thinner and had higher SCS throughout lactation. Perhaps CL infection may be compromising a ewe's immune system at Spooner, which may explain the resulting increase in somatic cells present in milk.

At Arlington ARS, a lamb's dam's CL infection status had varying effects on 60d WW depending on the age of the ewe. Of the lambs raised by 4 year and older ewes, weaning weights of those with CL POS dams were heavier. However, some things need to be addressed before you go off infecting your ewes with *C. psuedotuberculosis* to achieve heavier weaning weights.

Caseous Lymphadenitis infection was determined by the presence of specific antibodies in the blood, not the presence of abscesses on the ewes or other evidence of an active infection. A ewe that tests positive would have encountered the causative bacterium at some point in her life, she combatted this by creating a high level of antibodies, and she may or may not have been able to fight off the infection. In any flock, older ewes have encountered a suite of bacteria in their productive lifetimes, and they'll likely have built up antibodies that enable them to handle many infections that come their way. These older CL POS ewes may just have a better immune system and be generally healthier ewes which enables them to be more productive. It is not to say that CL infection itself gives a ewe higher maternal performance.

Ewes at both Arlington and Spooner will continue to be tested for CL in future years, and the data set may reveal more insight on the effect of CL infection on production traits.

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# ORGANIZING BREEDING GROUPS: AN APPROACH TO MAXIMIZE WHOLE-FLOCK GENETIC GAIN WHILE CONTROLLING FOR INBREEDING

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## Introduction

Raising replacement rams for use within your flock is a way to eliminate the cost of purchasing sires while making use of the genetic improvement being made in your flock. However, the level of inbreeding in the flock will increase at a faster rate with the use of home-bred rams than with the use of outside rams.

Inbreeding is the mating of individuals more closely related than average for the flock (Bourdon, 1997). An animal's level of inbreeding is measured by their inbreeding coefficient. An inbreeding coefficient is calculated as one half of the relationship of an animal's parents, which can be obtained from pedigree information. Inbreeding increases the proportion of deleterious recessive alleles that are in the homozygous state so that they are expressed. This eventually increases the incidence of noticeable genetic defects such as spider lamb syndrome or monkey/parrot mouth. Some producers may be willing to lose a few lambs to such defects as long as the majority of their lambs "look good". But it is the deleterious recessive alleles whose effects we can't easily see that can have major implications on the productivity of a flock.

The decrease in performance traits due to increased inbreeding is known as inbreeding depression. Many studies have shown a negative effect of inbreeding on prolificacy, birth weight, and growth traits in sheep (Norberg and Sorensen, 2007; Lamberson and Thomas, 1984). In order to avoid the detrimental effects of inbreeding, we should organize our breeding groups in a way that avoids mating closely related individuals. However, genetic gain in a flock is maximized by mating the "best" rams to the "best" ewes, and these "best" individuals are often related. Therefore, how can we maximize genetic gain while controlling for inbreeding?

## Procedures

*Effect of individual inbreeding on performance*: Parentage identification is essential in order to obtain inbreeding coefficients of individuals and genetic relationships between potential mates. Individual animal identification along with their sire and dam identification was first used to construct a complete pedigree of the sheep in the Spooner flock (R package: "pedigree"). In order to determine the effect of level of inbreeding on performance traits, each animal's inbreeding coefficient was added to their production records. Inbreeding coefficients were then broken into 4 classes: 0% inbred, 1% to 5% inbred, 6% to 10% inbred, and greater than 10% inbred. As a guide, the mating of a half-brother with his half-sister will result in an individual with an inbreeding coefficient of at least 12.5%.

First, the effect of inbreeding on lamb 30d adjusted weaning weight (30d WW) was modelled. Only lambs that were raised artificially and were 75% or greater dairy breeding (%

East Friesian + % Lacaune) were analyzed for a total of 3,169 observations. The final model in the MIXED procedure of SAS included the main fixed effects of sex, birth type (single or multiple), age of dam (1, 2, 3, or 4 years old and greater) and inbreeding class and the random effects of sire (n = 68), dam (n = 1,022), and year (n = 18). All two-way interactions were fit as fixed effects, but none were significant ($P > 0.10$), and they were left out of the final model.

Next, the effect of inbreeding on ewe 180d adjusted milk yield (180 d MY) and lactation length (LL) was modelled. Each ewe's percentage dairy breeding (% East Friesian + % Lacaune) was broken into three classes: 25% to 50%, 51% to 75%, and greater than 75%. The MIXED procedure of SAS was again used to model the 3,497 observations. The final model included the main fixed effects of dairy breeding, age (1, 2, 3, or 4 years old and greater), number of lambs born (single or multiple), and inbreeding class and the random effects of ewe (n = 1,350) and year (n = 17). The two-way fixed interactions of dairy breeding x age and number of lambs born x inbreeding class were also fit in the 180d MY model. The LL model contained the fixed two-way interactions of dairy breeding x age, age x number of lambs born, and age x inbreeding class.

*Organizing breeding groups*: In order to understand how breeding groups should be organized to avoid inbreeding, ram and ewe pairs were simulated. The estimates of progeny 180d MY breeding value minus the penalty of ram-ewe relationship, $B_{i,j}$, is shown below mathematically (Pryce et al., 2012):

$$B_{i,j} = \frac{1}{2}\left(180d\ MY_{ram_i} + 180d\ MY_{ewe_j}\right) - \lambda \cdot \frac{1}{2}\left(R_{ram_i\,,\,ewe_j}\right)$$

where $180d\ MY_{ram_i}$ and $180d\ MY_{ewe_j}$ are the 180d MY EBVs of $ram_i$ and $ewe_j$, respectively, $R_{ram_i\,,\,ewe_j}$ is the numerator relationship between $ram_i$ and $ewe_j$, and $\lambda$ is a weighting factor placed on $R_{ram_i\,,\,ewe_j}$. For this simulation I used 6 rams and 296 ewes, all of which had progeny in the 2015 lambing season. The selected rams and ewes were all born at Spooner ARS and thus had some genetic relationship to others in the flock.

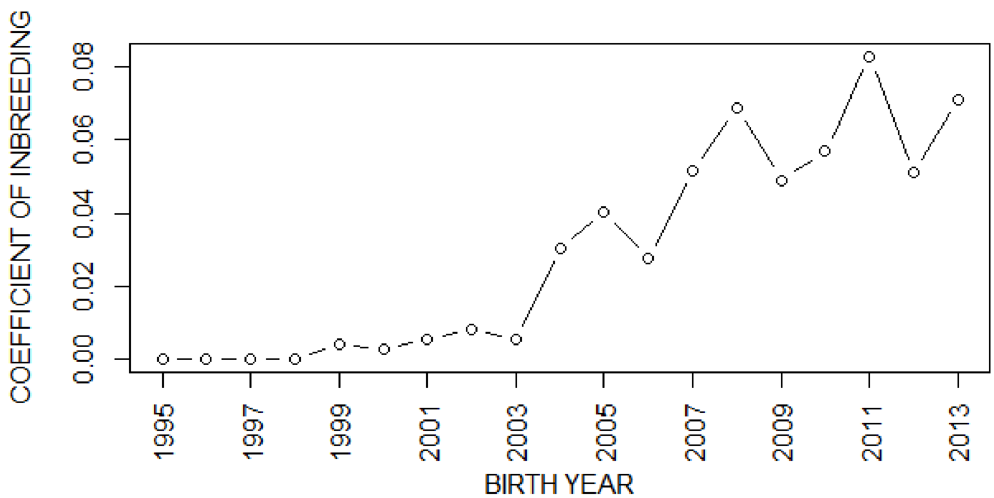
$B_{i,j}$ was calculated for every possible ram-ewe pair. The constraints were that each ram was allowed to "breed" 20 ewes and, obviously, a ewe can only be "bred" to one ram. Positive assortative mating was employed so that the 20 ewes that resulted in the largest $B_{i,j}$ were assigned to the highest ranking ram. Then $B_{i,j}$ was re-calculated for the remaining animals and the 20 ewes resulting in the largest $B_{i,j}$ were assigned to the second highest ranking ram, and so on until each ram was assigned 20 ewes.

The weighting factor to be placed on a specific ram-ewe relationship, $\lambda$, varied from 0 to 1500 by 10. For example, when $\lambda$ has a value of 0 there is no weight placed on a ram-ewe relationship and the ram with the highest 180d MY EBV was bred to the 20 available ewes with the highest 180d MY EBV. Resulting average progeny 180d MY estimated breeding value and average inbreeding coefficient was calculated for each level of $\lambda$.

## Results

Average inbreeding coefficient of the Spooner milking ewe flock by year of birth is shown in Figure 1. The average coefficient of inbreeding was very close to zero until the early 2000's when Spooner began raising most of its own replacement rams. Since then inbreeding levels have gradually increased, even though some rams are periodically purchased from other flocks.

**Figure 1. Average coefficient of inbreeding by year of birth**




*Effect of individual inbreeding on performance*: Least squares means of the main effects on lamb 30 day weaning weight are presented in Table 1. All main effects were highly significant ($P < 0.0001$). Lambs born to first parity ewes weighed less at weaning than lambs born to older dams. Ram lambs weighed 0.81 kg (1.8 lb.) more than ewe lambs at 30 d of age. Similarly, lambs born as singles weighed 0.86 kg (1.9 lb.) more at weaning than multiple born lambs. Level of inbreeding class affected lamb 30d WW in a fairly linear fashion. Lambs that were not inbred weighed 1.1 kg (2.5 lb.) more ($P < 0.0001$) at 30 days of age than lambs that were greater than 10% inbred.

Least squares means of the main effects on ewe 180d MY and LL are presented in Table 2. 180d MY and LL both peaked at 3 years of age. Dairy breeding had a significant effect ($P < 0.001$) on both 180d MY and LL, ewes of greater than 75% dairy breeding had the highest milk yield and numerically longest lactations. Ewes that gave birth to multiple lambs produced 10.6 kg (23.3 lbs) more milk than ewes that had a single lamb, but did not have a longer LL ($P > 0.70$). The main effect of level of inbreeding on ewe milk yield and lactation length tended toward significance ($P < 0.06$). Ewes that were more than 10% inbred produced less milk and had shorter lactations than ewes with a lower level of inbreeding.

| **Table 1.** Least squares means ± standard errors for 30d adjusted weaning weight of Spooner lambs. | | |
|---|---|---|
| Effect | Level | 30 d WW (kg) |
| Age of Dam | 1 | 12.6 ± 0.20$^{a}$ |
| | 2 | 13.8 ± 0.20$^{b}$ |
| | 3 | 14.1 ± 0.21$^{b}$ |
| | 4+ | 14.0 ± 0.22$^{b}$ |
| Sex | Ewe | 13.2 ± 0.20$^{a}$ |
| | Ram | 14.0 ± 0.20$^{b}$ |
| Birth Type | Single | 14.0 ± 0.21$^{a}$ |
| | Multiple | 13.2 ± 0.20$^{b}$ |
| Inbreeding Class | 0% | 14.2 ± 0.20$^{a}$ |
| | 1% to 5% | 13.8 ± 0.22$^{b}$ |
| | 6% to 10% | 13.4 ± 0.22$^{c}$ |
| | > 10% | 13.1 ± 0.23$^{c}$ |

$^{a,b,c}$Means within a column and an effect without a common superscript are different ($P < 0.05$).

| **Table 2.** Least squares means ± standard errors for 180d adjusted milk yield of Spooner ewes. | | | |
|---|---|---|---|
| Effect | Level | 180 d MY (kg) | LL (days) |
| Age of Ewe | 1 | 197.5 ± 5.5$^{a}$ | 168.4 ± 4.5$^{a}$ |
| | 2 | 275.4 ± 5.0$^{b}$ | 193.1 ± 4.4$^{b}$ |
| | 3 | 297.2 ± 5.2$^{c}$ | 207.1 ± 4.5$^{c}$ |
| | 4+ | 284.5 ± 5.4$^{d}$ | 203.7 ± 4.5$^{c}$ |
| Dairy Breeding | 25% to 50% | 223.9 ± 6.4$^{a}$ | 186.5 ± 4.5$^{a}$ |
| | 51% to 75% | 266.8 ± 6.3$^{b}$ | 195.4 ± 4.4$^{b}$ |
| | > 75% | 300.2 ± 4.7$^{c}$ | 197.4 ± 4.2$^{b}$ |
| Number of Lambs Born | Single | 259.1 ± 5.1$^{a}$ | 193.3 ± 4.3$^{a}$ |
| | Multiple | 268.2 ± 4.8$^{b}$ | 192.9 ± 4.2$^{a}$ |
| Inbreeding Class | 0% | 266.9 ± 4.3$^{a,b}$ | 195.2 ± 4.1$^{a}$ |
| | 1% to 5% | 271.3 ± 6.9$^{b}$ | 192.9 ± 4.5$^{a,b}$ |
| | 6% to 10% | 265.3 ± 6.9$^{a,b}$ | 195.6 ± 4.5$^{a}$ |
| | > 10% | 251.1 ± 7.3$^{a}$ | 188.7 ± 4.6$^{b}$ |

$^{a,b,c,d}$Means within a column and an effect without a common superscript are different ($P < 0.05$).

*Organizing breeding groups*: Figure 2 shows the average coefficient of inbreeding in the lamb crop of the resulting sire-dam crosses for each level of $\lambda$. Not surprisingly, as more focus is placed on the relationship between ewes and rams when organizing breeding groups (i.e. increasing $\lambda$), the resulting lambs are less inbred. When no weight was placed on the relationship between rams and ewes ($\lambda = 0$), the average inbreeding of the resulting progeny was the highest at 8.5%. The minimum average inbreeding in the progeny was 2.8% ($\lambda > 1{,}100$). If our desired average inbreeding in the progeny is 3.5% or lower we would have to set $\lambda$ at a value greater than 520.

**Figure 2. Average Progeny Coefficient of Inbreeding**

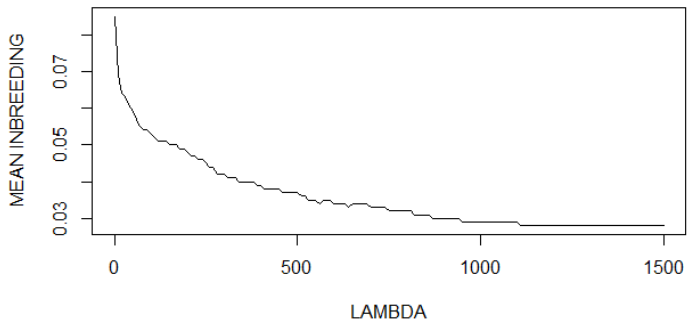
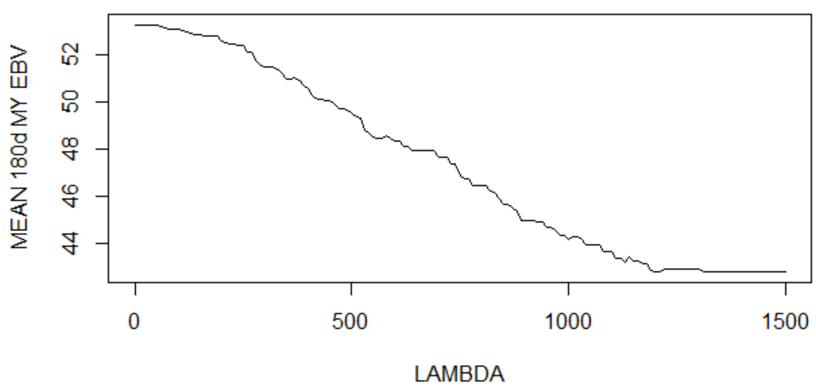



Figure 3 shows how the lamb crop estimated breeding value for 180d MY changes as more emphasis is placed on their sire-dam relationship. Our highest average progeny 180d MY EBV is 53.3, when no emphasis is placed on ram-ewe relationship ($\lambda = 0$). This is expected since high performing animals have many of the same alleles, some of which came from common ancestors. As more emphasis is placed on ram-ewe relationship, the average 180d MY EBV of the resulting lambs continues to decrease to a minimum value of 42.8 ($\lambda$ > 1,300). If our desired level of inbreeding in the progeny is again 3.5%, the resulting average progeny 180d MY EBV would be 48.8 ($\lambda$ > 520). In this case, the genetic merit of our lambs would be 8.4% less than the maximum but their inbreeding would decrease by nearly 60%.

**Figure 3. Average Progeny 180d MY Estimated Breeding Value**




## Conclusions

Inbreeding was shown to have an effect on the performance of both ewes and lambs at Spooner ARS. A level of inbreeding of greater than 10% (which could be the result of breeding half-sibs, for example) significantly impacted the growth of young lambs as well as the milk yield and lactation lengths of ewes. In closed or semi-closed flocks, relationships between mates are often more complicated than a simple sire-daughter or half-sib mating. For these situations, the use of computer software is faster and more accurate for determining the relationships between potential mates. Most genetic evaluation programs will supply their members with inbreeding coefficients of their enrolled animals. However, breeding group allocation software is not common.

It was shown that with a relatively minor penalty placed on the relationship between ram-ewe pairs, major decreases in average progeny inbreeding without sacrificing much genetic gain can be realized. In the future, I plan to make a version of similar software publicly available so that producers can more easily manage inbreeding in their flocks.

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# THE EFFECT OF LATE GESTATION AMBIENT ENVIRONMENTAL TEMPERATURE ON SUBSEQUENT LITTER BIRTHWEIGHT IN TWIN-BEARING DAIRY EWES

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## Introduction

Environmental factors can have a marked effect on many traits of economic importance in animal agriculture. Seasonal effects, specifically temperature and humidity, on livestock performance have been extensively studied across species. Extreme temperature and humidity may lead to stress in animals which can have adverse effects on milk production and somatic cell score in dairy cattle and feed intake and growth in beef cattle, swine, and sheep.

Another trait that temperature seems to affect is birth weight (BW). In experimental studies, ewes that were placed in high temperature chambers (32 and 41°C) gave birth to lighter lambs than ewes placed in mild temperature chambers (24°C; Shelton and Huston, 1968). One observational study analyzing the effect of environmental temperature on pregnant does found that kid BW decreased by 40 g for every 1°C increase in average temperature during gestation (Mellado, et al., 2000).

There are fewer reports on the effect of cold temperature during gestation on neonate BW. Genetically similar cows bred to the same sire over several years gave birth to calves that weighed , on average, 5 kg heavier in the coldest Winter of the experiment (average temperature = -7 °C) than in the warmest Winter (-1 °C; Deutscher, et al., 1999 ). No similar reports were found on lamb BW from ewes exposed to varying environmental temperatures throughout gestation. However, it is well known that ewes shorn in late gestation give birth to heavier lambs than unshorn ewes (Cam and Kuran, 2004).

## Materials and Methods

The Spooner Agricultural Research Station, UW-Madison has been recording daily temperature and weather events since the 1930's. Since 2006, a digital logger has recorded temperature and relative humidity at 15 minute intervals, automatically storing the information in a data file. Multi-parous ewes that lambed live twins in January, February, and March in the 2006-2014 lambing seasons were extracted from the Spooner flock records. Since the majority of fetal growth occurs in the last few weeks of gestation, the average temperature during the 28 days prior to parturition was calculated for each ewe.

The MIXED procedure of the Statistical Analysis System (SAS) for Windows 9.3 was used to analyze the 881 records of total BW of twin bearing ewes. The final model included the main fixed effects of ewe age at lambing (Age; 2, 3, or 4+ years), the sex of the litter (Sex; female-female = FF, female-male = FM, or male-male = MM), the type of service sire (Sire; Dairy or Terminal), average temperature class in late gestation (Temp; > -10 °C, -10 to -12 °C, or < -12

°C) and the random effects of year (2006-2014) and ewe (n = 536). Fixed two-way interactions included: Sire x Age, Sire x Sex, and Age x Temp.

**Results**

Least squares means of the levels of main effects are presented in Table 1. All of the main effects included in the model were significant (*P* < 0.01). Not surprisingly, total twin BW increased with age as 2 year old females gave birth to lighter lambs than 3 year and older ewes. Ewes that were bred to terminal rams gave birth to a set of twins that weighed 0.6 kg more than ewes that were bred to dairy rams. Combined sex of the twins resulted in a 0.3 kg increase in BW with each additional ram lamb in the litter.

**Table 1.** Least squares means ± standard errors for litter BW of twin bearing ewes.

| Effect | Level | Litter BW (kg) |
|---|---|---|
| Age | 2 | $10.4 \pm 0.2^{a}$ |
| | 3 | $10.7 \pm 0.2^{b}$ |
| | 4+ | $10.9 \pm 0.2^{b}$ |
| Sire | Dairy | $10.4 \pm 0.2^{a}$ |
| | Terminal | $11.0 \pm 0.2^{b}$ |
| Sex | FF | $10.4 \pm 0.2^{a}$ |
| | FM | $10.7 \pm 0.2^{b}$ |
| | MM | $11.0 \pm 0.2^{c}$ |
| Temp | > -10 °C | $10.2 \pm 0.2^{a}$ |
| | -10 to -12 °C | $11.0 \pm 0.2^{b}$ |
| | < -12 °C | $10.9 \pm 0.2^{b}$ |

$^{a,b,c}$Means within a column and an effect without a common superscript are different (*P* < 0.05).

Finally, ewes that were exposed to an average temperature of -10 °C and colder during late gestation gave birth to a heavier set of twins. One possible reason for this effect is that pregnant ewes that are cold consume more feed, resulting in heavier lambs at birth. Another possible reason is that cold animals direct more blood flow away from their extremities, increasing blood flow to their core and nutrients to the fetus. Both of these reasons likely contribute in tandem to the increases in lamb birth weight from colder temperatures during gestation.

Birth weight can have subsequent effects on other traits of economic importance. Obviously too large of lamb birth weight can lead to increases in dystocia. However, it's known that lamb survivability until weaning increases nonlinearly with birth weight. Additionally, in past reports, we have found that ewes that give birth to multiple lambs produce more milk in their subsequent lactation, which may be due to an increase in litter birth weight with more lambs. In future studies, the relationship between environmental temperature during late gestation with subsequent lactation traits in the ewe and weaning traits in the lamb will be studied.

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# NUMBER OF LAMBS BORN AND MILK PRODUCTION

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## Background

A positive association between the number of lambs born (prolificacy) and milk yield (MY) has been shown in many species (goats – Hayden et al. 1978; swine – Auldist, 1998 and cows – Hossein-Zadeh, 2010). However, such an association has not been reported in the reviewed scientific literature for dairy ewes.

In dairy sheep production, it is economically important for producers to know which variables in the system affect the amount of milk produced. However, making such conclusions from data collected at the farm is very challenging because these data were not designed and collected to test such effects (as they would be in a lab experiment with all other variables being controlled). The effects observed might be confounded with other effects. For example, if we want to estimate the effect of number of lambs born on MY, we can't ignore the fact that first lactation ewes will generally produce fewer lambs and less milk than older ewes or that there are some breeds that may produce more lambs or more milk than others. In order to estimate a meaningful effect of potential factors (such as the number of lambs born) on MY from farm data, it is necessary to correct for this confounding. It should be considered that using carefully collected farm data might be more beneficial than using lab data because it better represents the real scenario that we see day-by-day at the farm.

The statistical techniques used so far to explore the relationship between the number of young born and milk production in the other species mentioned above (such as regressions or analysis of variance) provide only the association between MY and prolificacy. However, in a system of production where producers want to make interventions to increase the number of lambs born (such as including in the flock breeds that are more prolific – for example the Romanov breed, super ovulating the ewes, or selecting the flock for increased prolificacy) we want to know how milk production will change. To answer such a question, we have to make use of a relatively novel set of statistical tools, which allows the inference of "causal effects".

One statistical tool that allows for estimation of these "causal effects" and solving the problem of confounding in farm data is called Propensity Score (PS) methods (Rosenbaum, 1983). This is a relatively new, powerful, and easy to apply set of methodologies commonly used in other fields (such as medical sciences and social sciences) that we now bring to an animal production context for the first time in order to be able to answer the question: "How does the amount of milk produced by dairy ewes change as a consequence of the number of lambs born?".

## Our Dairy Ewes and Statistical Analysis

The data was collected at the Spooner Agricultural Research Station of the University of Wisconsin-Madison, located in northwest Wisconsin. Our dairy sheep flock is composed of crossbreds of two or more breeds from 12 different breeds. The average ewe breed composition was mostly of the dairy breeds (East Friesian 45.15%, and Lacaune 27.63%), with smaller contribution of other breeds (Dorset 10.39%, Polypay 4.98%, Targhee 3.19%, Romanov 2.61%, Rideau 2.01%, Commercial 1.07%, Kathadin 1.02%, Rambouillet 0.96%, Finnsheep 0.82%, Texel 0.08%, Hampshire 0.06%). 4,319 lactation and lambing records from 1,534 crossbred ewes were collected from 1997 to 2013.

The set of confounders (variables that are known to have an effect on both prolificacy and MY, therefore causing confounding when we try to estimate the effect of number of lambs born on MY) were lactation number/ewe age and proportion of East Friesian (EF) and Lacaune (L) breeding in each ewe. The dairy breed composition was divided in three categories: smaller than 50%, 50% - 75% and larger than 75% genetic composition of EF or L. Lactation records were categorized in three groups: $1^{st}$, $2^{nd}$ and $3^{rd}$-$6^{th}$.

The "treatment" for which we wanted to explore the effect on MY was prolificacy. It was composed of two categories: single and multiple births. The multiple birth category included 2, 3 or 4 lambs born per parturition but was considered as a single category because the vast majority of ewes (78%) gave birth to 2 lambs. MY was considered as the total volume of milk produced per ewe for the whole lactation (mean = 268.5 L, sd = 116.4 L). Only ewes that lactated for at least 80 days were considered in this analysis.

The PS (based on the set of confounder variables) was calculated for all ewes. From the set of methodologies available in PS analysis, we chose to use Matched Samples Analysis for which a total of 1,166 pairs of single/multiple lamb ewes with similar PS values were formed. After correcting for confounding effects by balancing the data using the matching technique, we estimated the causal effect of number of lambs born on MY as the difference in MY between ewes giving birth to single and multiple lambs.

**How Does the Number of Lambs Born Change the Amount of Milk Produced?**

Results indicated that the estimated causal effect of the number of lambs born on MY was 20.52 L, se = 3.77 L, 95% confidence interval = 13.13-27.91 L (since the interval does not include zero, the results are statistically significant). The meaning of this result is that ewes that gave birth to a single lamb would be expected to have their MY increased by 20.52 L, on average, if they had given birth to multiple lambs. This implies that management practices that increase the number of lambs born (superovulation, crossing with more prolific breeds, or selecting for more prolific ewes) is expected to cause an increase in the amount of milk produced.

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