Proceedings of the 63rd Annual Spooner Sheep Day

Saturday, August 22, 2015

Spooner Agricultural Research Station
University of Wisconsin-Madison
Spooner, Wisconsin

The Wisconsin sheep industry and the Spooner Agricultural Research Station lost a true shepherd, mentor, and friend when Rudolph A. 'Rudy' Erickson died on Oct. 2, 2014. Rudy grew up in the Spooner area and had a long history with the Spooner Station. He was first hired as a High School student in 1952 to "pick rock" on Saturdays for 50 cents an hour on the fields south of the sheep barn where several short day hybrid corn varieties were developed. He was working part-time at the station when the first Spooner Sheep Day was held in 1953, and he attended almost every Sheep Day program for the following 61 years. Since at least 1991, Rudy was the presenter of the Sheep Industry Award due to his intimate knowledge of the people involved in the Wisconsin sheep industry.

At the 50th Spooner Sheep Day in 2002, Rudy made a presentation on the early history of the station. In his written paper he related helping to build the "new" sheep barn in 1952, helping prepare the station for the first Sheep Day in 1953, purchasing his first commercial ewes in 1953 at the station that were brought in by train carload from Montana by Central Livestock Association, and working with Meat and Animal Science Extension Specialists (Fred Giesler, Quin Kolb, and Dick Vatthauer) up through the 1960's in barbecuing the lamb for the lunch at Spooner Sheep Days.

Rudy attended a Sheep Shearing School at the Spooner Station with 31 other students in 1953. Ed Warner from Sunbeam Corporation was the lead instructor with other instructors from the university (Art Pope, sheep researcher at Madison; Carl Rydberg, Spooner Shepherd; and Vern Felts and Fred Giesler; Livestock Extension Specialists at Madison) and Roy Richards, Executive Director of the Wisconsin Cooperative Wool Growers Association. Rudy and Roger Harris, subsequent Executive Director of the Wisconsin Cooperative Wool Growers Association, would go on to teach many more Sheep Shearing Schools at the Spooner Station.

Rudy had a long association with the Targhee breed of sheep. The first Targhee sheep in Wisconsin, two rams, were shipped by rail from Montana to the Spooner Station in 1953, and Rudy and Carl Rydberg, the Station Shepherd, picked them up at the Spooner depot. In the spring of 1964, Rudy purchased a small flock of commercial ewes as a birthday present for his wife, Martha, for their farm near Wilson, WI. In that flock were the two Targhee rams that Rudy had helped unload 10 years earlier at the Spooner depot! The two rams, 'Pat' and 'Mike', lived to be 13 and 15 years of age and were the start of the Erickson's purebred Targhee flock. Rudy was an active member of the U.S. Targhee Sheep Association and was an inductee into the Targhee Hall of Fame.

Rudy enrolled at the University of Wisconsin-Madison at age 17 and completed B.S. (1959) and M.S. (1969) degrees in Meat and Animal Science. Rudy served in the U.S. Army, was employed as a fieldman for Central Livestock Association, and served as a UW-Extension agriculture agent in Dunn County. In 1969, Rudy was hired as the farm manager of the UW-River Falls lab farms, a position he held for 27 years until his retirement in 1996.

Rudy is survived by his wife and shepherdess, Martha, his children Lorry Ann Erickson (Jack Potter), Sheri Ann Erickson, and Mark A. (Tammy) Erickson, 3 grandchildren, and a sister and brother.

The LORD is my shepherd, I shall not want – Psalms 23:1

This is the 63rd consecutive, annual sheep field day at the Spooner Agricultural Research Station. Spooner Sheep Day was held annually at the Spooner Agricultural Research Station for 50 years – from 1953 through 2002. After the 2002 Spooner Sheep Day, the decision was made to hold the event every-other year on even-numbered years. This decision was made so that a Spooner Dairy Sheep Day could be held on odd-numbered years with a program that could be better tailored to the focused issues of the dairy sheep industry. This procedure was followed for 10 years from 2003 through 2012. Since dairy sheep production has been mainstreamed into the Wisconsin sheep industry, we are returning to using the title of Spooner Sheep Day for each annual sheep field day at the station. Therefore, the program this year will be the 63rd consecutive sheep field day at the Spooner Agricultural Research Station. We believe that it is the longest running agricultural field day of the several organized each year on the various Agricultural Research Stations of the College of Agricultural and Life Sciences, University of Wisconsin-Madison. Have a great day!

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2015

Cover photograph: Dairy ewes and the donkey used for predator control on pasture at the Spooner Agricultural Research Station. Photograph by Sevie Kenyon, Communications Specialist, College of Agricultural and Life Sciences, University of Wisconsin-Madison.

63^{rd} ANNUAL SPOONER SHEEP DAY

Spooner Agricultural Research Station of the University of Wisconsin-Madison
Spooner, Wisconsin
Saturday, August 22, 2015

8:30 a.m.	**Registration -** *Station Headquarters*
9:15	**Welcomes –** *Dwight Mueller, Director, Agricultural Research Stations, and Daniel Schaefer, Chair, Department of Animal Sciences, College of Agricultural and Life Sciences (CALS), UW-Madison, Madison, WI*
9:20	**Updates at the Spooner Station –***Philip Holman, Superintendent, Spooner Agricultural Research Station, CALS, UW-Madison, Spooner, WI*
9:30	**Estimated Breeding Values Do Predict Future Performance** – *Tom Murphy, Ph.D. Graduate Student, Department of Animal Sciences, CALS, UW-Madison, Madison, WI*
10:00	**Strategic Use of Terminal Meat Sires to Improve Flock Production –** *Dave Thomas, Professor of Sheep Management and Genetics, Department of Animal Sciences, CALS, UW-Madison, Madison, WI*
10:30	**Break**
10:45	**What Quality Means to Those Responsible for Buying and Selling American Lamb, and How the Industry Needs to Bring that Quality to the Table –** *Cody Hiemke, Lamb Program Manager, Niman Ranch, Stoughton, WI*
11:25	**Effects of Breed and Hybrid Vigor on Lamb Survival –** *Vera Ferreira, M.S. Graduate Student, Department of Animal Sciences, CALS, UW-Madison, Madison, WI*
11:55	**Presentation of Sheep Industry Award –** *Dave Thomas*
Noon	**Lamb Barbecue Lunch –** *$8.00/adult, $5.00/child 6 to 12, Free/child 5 and under*
1:00 p.m.	**Maintaining a Healthy Sheep Flock –** *Kay Nelson, D.V.M., Research Animal Resource Center and CALS Veterinarian, UW-Madison, Madison, WI*
1:45	**Research Snippets:** **Sodium Bicarbonate; Hay; Parasites –** *Emily Petzel, UW-Madison Animal Sciences Undergraduate Student and Spooner Summer Intern, Centuria, WI* **Caseous Lymphadenitis; Temperature, Inbreeding –** *Tom Murphy* **Number of Lambs Born and Milk Production –** *Vera Ferreira*
2:45	**Open House at Sheep Barn with a Focus on Sheep Facility and Handling Innovations –** Sharing of ideas among all participants.

Spooner Sheep Day is sponsored by the Agricultural Research Stations and Department of Animal Sciences, College of Agricultural and Life Sciences, University of Wisconsin-Madison and Cooperative Extension, University of Wisconsin-Extension.

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SPOONER AGRICULTURAL RESEARCH STATION UPDATE 2015

Philip W. Holman
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Spooner, Wisconsin

As always, there is plenty going on at the Station. A major loss to the sheep program came in April when Rusty Burgett, Spooner Sheep Researcher, left to become Director of the National Sheep Improvement Program in Ames, IA. He has not been replaced, which has meant much extra sheep work for the remaining staff.

We started the year by switching to selling our milk directly to Carr Valley Cheese. We wish the Wisconsin Sheep Dairy Cooperative well and continued success selling their signature cheeses, Dante and Mona, and pooling milk for sale to cheese plants. Lambing season went well. Adult ewes averaged 1.88 lambs/ewe, and ewe lambs averaged 1.73 lambs/ewe. The immediate removal of lambs and tube feeding colostrum has greatly improved our lamb survival. Lamb survival and less breeding to terminal sires in 2014 allowed for sale of over 100 excess ewe lambs for breeding stock. We had some Shropshire terminal cross lambs, and twice sold groups of feeder lambs directly to growers. Lastly, breeding dairy rams have been sold to Maryland, Pennsylvania, New York, Indiana, Minnesota, Iowa, Nebraska, Arizona and Washington. So the station continues to be a source of genetics for producers across the United States. Genetic selection in the dairy flock and sale of dairy breeding stock to other farms has been enhanced due to the development of Estimated Breeding Values (EBVs) for milk yield for every ewe, ram, and lamb in the flock by Tom Murphy, Ph.D. graduate student in Animal Sciences.

Sheep Research projects include:

- Sodium bicarbonate offered free choice to milking ewes
- Grazing with offering dry hay to ewes after milking
- Parasite treatment products and effects on ewe lamb growth
- Caseous lymphadenitis testing of ewes and its impact on production
- Ovine Progressive Pneumonia (OPP) testing of the flock
- Genetic evaluation of the adult ewe flock with the Illumina 50K SNP Chip

Research results and updates will be presented during today's Sheep Day and at the Dairy Sheep Association of North America Symposium, November 5-7, 2015 in Madison.

Crop production-wise (being an Agronomist), we are having a very good year for yields and quality. Planting was early, temperatures were moderate, and rains have been frequent. Thus, the silo is full, the hay shed is almost full, and the corn looks as good as I can remember.

Agronomic research projects include:

- Variety trials of corn, corn silage, soybeans, oats and barley
- Soybean date of planting and soybean maturity management trial
- Soybean pH trial
- Switchgrass, Big Bluestem, Indiangrass and Meadow Fescue trials

Organic grass species and variety trial
Crabgrass for forage (??Yes - Forage Crabgrass!??)
Boron product trial on alfalfa production

Feel free to ask me about any of the research trials during the day or give a call another time!

We are very fortunate to have a very talented and dedicated staff at the station that has been augmented this summer with two great student interns. Be sure to thank them if you see them today or at other times.

Full-time Staff of the Spooner Ag Research Station
Scott Butterfield – Animal Research Technician
Forrest Anderson – Ag Research Equipment Operator
Lorraine Toman – Program Assistant
Heidi Hoeffelt – Animal Research Technician (lead milker)
Larry Graber – Animal Research Technician (project)

Limited Term Employees (sheep milking crew)
Laurie Smith
Mary Langland
Luke Langland
Caitlyn Schaefer
Brianna Schaefer

Summer UW-Madison Student Sheep Intern
Emily Petzel

Summer UW-River Falls Student Garden Intern
Brent Arnoldussen

ESTIMATED BREEDING VALUES DO PREDICT FUTURE PERFORMANCE

Thomas W. Murphy
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Introduction

Selection is the process by which man or nature determines whether an individual is fit enough to pass its genetic information to the next generation of its breed, line, or species. The criteria to determine fitness is generally very different whether man or nature is making the selection decision. This is evident when comparing domesticated species to their wild ancestors. For example, the field corn we are all familiar with as livestock feedstuff bears little resemblance to its forebear, teosinte. Likewise the wild mouflon and the domestic sheep breeds of North America have very different characteristics. However, regardless of the vehicle which drives selection, the basic laws of inheritance remain true. That is, an animal passes one half of its genes on to the next generation.

An animal's phenotype is its performance for a trait that we can see or measure. A phenotype is determined by the combined effects of the genes of the animal and the environment under which the animal is raised, both of which can have a negative or positive effect on performance. The number of lambs a ewe gives birth to is dependent upon the versions of genes she contains which may affect prolificacy (e.g., ovulation rate, embryo survival, uterine capacity) and also non-genetic (environmental) factors (e.g., age at breeding, breeding season temperature, flushing). The degree to which a phenotype is affected by non-genetic factors can vary considerably between traits, but non-genetic factors are not inherited in future generations. This leads to the question: "when you buy a ram based on his phenotypes, how much of his birth farm's environment are you paying for?"

Selecting sheep based on their phenotype or the phenotype of their close relatives has been the gold standard since their domestication over 10,000 years ago. Development of wool follicles, out of season breeding, high prolificacy, rapid growth rates and many other traits that separate domestic breeds from wild species can all be attributed to phenotypic selection. However, phenotypic selection is inaccurate which makes progress painfully slow. Since the mid-1900's, advances have been made in statistics and computing power that enable us to accurately estimate an animal's true genetic potential for one or more traits. This estimate, called an estimated breeding value (EBV), takes into account the performance of the individual and all of its relatives while adjusting for known sources of non-genetic variation.

EBVs are available for most livestock species in both individual traits and multiple trait indexes. The National Sheep Improvement Program (NSIP) has been providing American sheep producers with EBVs since the late 1980's. Despite this, modern genetic evaluation programs like NSIP have not been widely adopted by U.S. sheep producers. There are many reasons why this might be the case:

"Genetic improvement has a negative connotation". To people not involved in animal agriculture,"genetic improvement" may conjure up images of someone in a white lab coat "injecting genes" into a lamb fetus. Using EBVs to select replacement stock is fundamentally the same thing that has been occurring for several thousand years. The difference is that we now have more accurate ways of determining which animals genetically excel in a trait(s).

"My flock is too small for genetic improvement to work". Given that flock records contain parentage information and individual performance traits, an animal's genetic merit can be estimated no matter the size of your operation.

"I have a commercial ewe flock, and EBVs are only available for purebred sheep". At present, NSIP calculates EBVs for purebred sheep; this may certainly change to include crossbred animals. At any rate, buying terminal rams with the aid of their estimated breeding values will give you more confidence in their future lamb crops' growth and carcass characteristics.

"My sheep are primarily raised on pasture, they can't compare to confinement raised sheep". The statistical models used in genetic evaluation programs account for all management differences between farms (or even seasonal management differences on the same farm). They are able to do this provided that your farm is "genetically linked" to other farms in the program. Genetic evaluation programs will never ask you to fit the mold of the "traditional" sheep flock, they are extremely flexible like the future of the sheep industry will need to be.

"I know what a productive sheep looks like, EBVs can't tell me anything new". EBVs are another tool to aid in your selection decisions. They won't tell you if a ram is poor structured or if a ewe is flat ribbed, that is for YOU to decide. They will, however, give you accurate and unbiased estimates of an animal's true genetic merit for production traits that make YOU money.

"Genetic improvement programs cost money". Estimating breeding values at a nation-wide level requires a lot of collaboration, data editing, computing power, and time. The people involved in this process aren't going to work for free (unless they're a graduate student). Like any production decision, there are costs and returns to consider. The returns from increased performance that EBVs provide far outweigh the costs of calculating them.

Selecting Replacement Sheep at Spooner ARS

At present, there is no genetic evaluation program for dairy sheep in North America. Because of this, producers are left to select replacement animals based upon their dam's (or other close female relative's) production records. The procedure has largely been the same at Spooner ARS up until 2014. There are many non-genetic factors that can influence a ewe's lactation performance. Some examples include: a ewe's age, the quality of stored feed fed through winter, the quality of pasture, parasite load, disease, ambient temperature, and many more. If these effects aren't accounted for, we will inevitably biasedly select replacement animals. For example, if a ewe's milk yield peaks at 3 years of age, we may only select replacement animals from these females and miss the truly genetically superior animals from younger or older ewes.

Over the past year, I've been mining the Spooner flock database and combining production records with pedigree information in order to estimate breeding values of both rams and ewes.

The 2015 lamb crop was the first whose sire-dam combinations were determined with the aid of EBVs for total lactation milk yield. Recently, I've replaced total lactation milk and component yields with 180 day adjusted yields to account for differences in lactation lengths among ewes. The question remains whether or not selecting replacement animals with the aid of EBVs leads to actual gains in lactation performance in future generations. The following research results help shed light on this very important question.

Materials and Methods

The trait I will be focusing on is 180 day adjusted milk yield (180d MY). Although component traits are certainly important for cheese production, milk is currently purchased from Spooner ARS on a weight basis. I will set up the following scenario: suppose I have a group of ewe lambs that I've grown out to 6 months of age, and I plan to keep half of them as replacements. Which half should I keep? I can select replacements using one of three pieces of information: 1) their dam's 180d MY from the current lactation (RAW 180d MY), 2) their dam's 180d MY from the current lactation adjusted for dam age and number of lambs born (ADJ 180d MY), or 3) their dam's estimated breeding value for 180d MY (EBV 180d MY).

The data set I will be using to address this scenario is from ewe lambs born in 2013. In reality, all of them were kept as replacements. That is, all of them have a first lactation 180d MY from 2014 - <u>we'll pretend we don't know this at the time of selection</u>. The actual first lactation 180d MY of the group of ewe lambs that were "selected" (based on one of the three selection criteria of their dams) can then be compared to the first lactation 180d MY of the group of ewes that were "not selected". The differences of actual 180d MY between these groups will give us a good idea of whether or not EBVs are indeed the best selection criteria, or if we're better off just selecting based on their dam's phenotype for lactation performance.

The actual first lactation 180d MY records from 2013 born ewe lambs (n = 75) will be analyzed with the following simple general linear model for each selection criteria separately:

$$y_{ij} = \mu + \; Dam\ Group_i + \; e_{ij}$$

where y_{ij} are the first lactation 180d MY observations, μ is the overall mean 180d MY, $Dam\ Group_i$ is the fixed effect of the dam's ranking for a selection criteria (whether the ewe lamb's dam was in the top ½ or bottom ½ of all dams for RAW 180d MY, ADJ 180d MY, or EBV 180d MY), and e_{ij} is the random residual term.

Results and Conclusions

The additive adjustment factors to transform 180 day adjusted milk yield records from RAW 180d MY to ADJ 180d MY are listed in Table 1. Age is a non-genetic factor that will influence the amount of milk a ewe will produce. At younger ages, a ewe's body is still growing and her udder may not be fully developed, while at older ages a ewe's conformation may have decayed somewhat. Similarly, ewes that give birth to two or more lambs produce more milk than ewes that have a single lamb. These adjustment factors were used in the mixed model equations to obtain 180d MY EBVs based on a single trait repeatability animal model (Meyer, 2007).

Table 1. Adjustments for 180 day adjusted milk yield for age of ewe in years and number of lambs born prior to lactation (NLB).

Effect	Level	Adjustment (kg)
Age	1	+67.9
	2	-24.8
	3	-46.6
	4	-42.2
	5	-19.7
	6	+0.0
NLB	Single	+15.4
	Multiple	+0.0

The results from the 3 separate selection criteria models are listed in Table 2. When ewe lambs were ranked by their dam's RAW 180d MY the top ½ milked, on average, 5.7 kg (12.5 lbs.) more than the bottom ½, but this difference was not statistically significant ($P > 0.60$). Next, when the 2013 born ewe lambs were ranked by their dam's ADJ 180d MY, the top ½ milked 12.1 kg (26.6 lbs.) more than the bottom ½ in 2014, but this difference was also not statistically significant ($P > 0.25$). Finally, when the ewe lambs were ranked by their dam's EBV for 180d MY, the top ½ tended to milk significantly more ($P < 0.07$), 20.2 kg (44.4 lbs.) on average, than the bottom ½ in their first lactation.

Table 2. Least square means ± standard errors for 180d MY between ewe lambs whose dam was in the top or bottom half among all dams for 3 selection criteria.

	Selection Criterion		
Dam Group	**RAW 180d MY (kg)**	**ADJ 180d MY (kg)**	**EBV 180d MY (kg)**
Top ½	212.7 ± 7.8^{a}	215.8 ± 7.6^{a}	219.8 ± 7.5^{a}
Bottom ½	207.0 ± 7.7^{a}	203.7 ± 7.7^{a}	199.6 ± 7.6^{b}

^{a,b}Means within a column without a common superscript are different ($P < 0.10$).

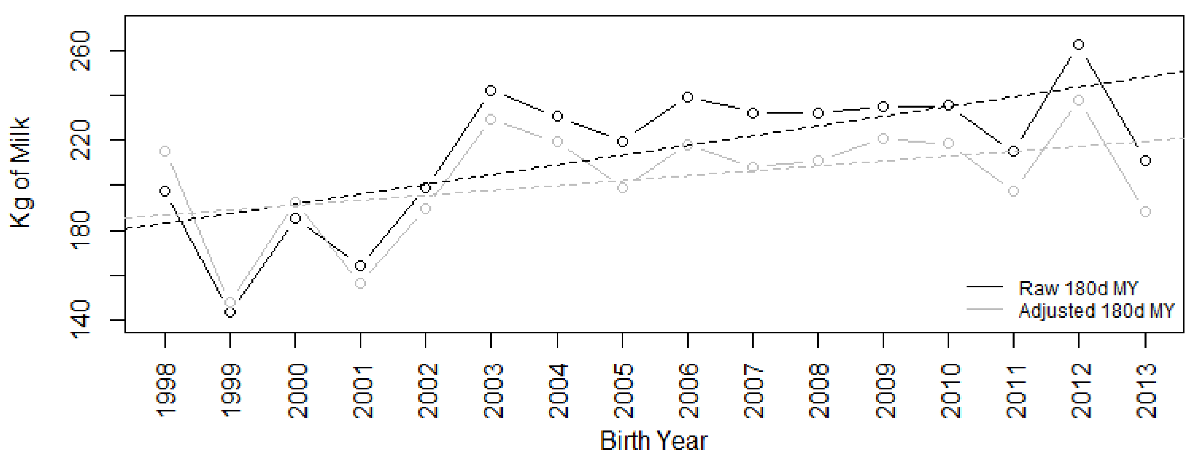
When the ewe lambs were selected based upon their dam's EBV for 180 d milk yield, they produced 7.1 kg (15.6 lbs.) more in their first lactation than the ewe lambs selected based on their dam's actual 180 d milk yield. This may not seem like much, but if milk were sold for $0.95/lb, these 38 ewe lambs over 5 lactations stand to return **$2,816** more in milk sales. Using the same logic, even if the ewe lamb's dam's 180 d MY was adjusted for known non-genetic effects, the ewe lambs selected based on their dam's EBV could still return **$1,588** more in milk sales.

It is worth pointing out that only dam EBVs were used as a selection tool here, accounting for only ½ of the genetic merit of the ewe lambs. I only included dam EBVs because some of the ewe lamb's sires were purchased from outside flocks and had no daughters with milking records, i.e. their breeding values could not be estimated at the time of ewe lamb selection. If all sires of these ewe lambs had EBVs, we could have more accurately separated the genetically superior half, and it is likely they would have realized first lactation 180 day milk yields higher than all three selection criteria.

The higher the heritability of a trait, the better an animal's own phenotype (or phenotype of their close relatives) estimates their breeding value for the trait. In general, traits like frame size in livestock species are highly heritable (0.5 to 0.6). Estimates of breeding value for highly heritable traits are generally not necessary. For example, if we breed a large framed ram to a large framed ewe, we're likely to get large framed lambs, that is, the environment is going to play much less of a role in the expression of these traits. The heritability of 180d MY estimated from this dataset was 0.35, which is moderate. That being said, the 180 d MY phenotype of a ewe lamb's dam turns out to be a pretty poor estimator of the true genetic merit and predictor of future performance of the ewe lamb, as was shown in our selection scenario.

To further strengthen this point, Figure 1 displays the average first lactation 180 d MY of the Spooner ewe flock by birth year. The black trend line with circles shows the raw average 180 d MY of first parity females by birth year and the black dashed line is a least-squares regression for these points. There's a lot of fluctuation from year to year but the slope of the regression line is positive, showing an increase of **+4.3 kg of milk/year** (+9.5 lb. of milk/year).

Figure 1. Mean First Lactation 180 Day Adjusted Milk Yield by Birth Year



As we all know, production can fluctuate from year to year not only because of things such as pasture conditions and the quality of our hired labor, but also because of the dynamics of our ewe flock. The breed makeup of the Spooner ewes has changed over time. The gray trend line with circles is the average first lactation 180 d MY further adjusted for percentage of dairy breeding (East Friesian + Lacaune) and NLB by year of birth. The gray dashed line is then the least-squares regression line between these points. Again, there's still a lot of fluctuation from year to year, but substantially less than the raw 180 d MY. The regression line still shows a positive slope of **+2.2 kg of milk/year** (4.8 lb. of milk/year).

We can compare performance of ewes across birth years by using the gray regression line equation of: $180d\ MY_i = -4181.3kg + 2.19kg\ x\ BirthYear_i$. The solutions from this equation show that ewes born in 1998 produced an average of **194.3 kg** (427.5 lb.) of milk through 180 days of their first lactation in 1999, and ewes born in 2013 produced an average of **227.2 kg** (499.8 lb.) of milk in 2014. On average, a first parity ewe in 2014 milked **32.9 kg** (72.4 lb.) more than a first parity ewe in 1999. At a milk price of $0.95/lb., a first parity ewe in 2014 grossed **$69** more through 180 days of lactation than a first parity ewe in 1999. How much of this performance increase has been because of better management and nutrition?

Now imagine other traits of economic importance such as ability to breed out of season, prolificacy, weaning weight, and feed efficiency. These are traits that will make or break any commercial or purebred sheep operation, and they are lowly heritable (0.08 to 0.20). Phenotypic selection for these traits isn't going to cut it. The take home message is that the use of estimated breeding values for production traits is the only selection tool that allows us to make both rapid and permanent gains from year to year.

Yes, enrolling in a genetic improvement program costs money. Yes, the reports from a genetic improvement program may not tell you what you want to hear – that your sheep aren't as genetically superior as you may have thought. But computers and the formulations they use to estimate breeding values are not biased like a show ring judge or a producer's "stud" ram may be. We can assess structural soundness, breeding soundness, and udder and foot health by visually appraising an animal but we <u>cannot</u> visually evaluate productivity.

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Resources

www.nsip.org

STRATEGIC USE OF TERMINAL MEAT SIRES TO IMPROVE FLOCK PRODUCTION

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Introduction

There are large and significant genetic differences among breeds of sheep for levels of performance for economically important traits. The very first use of genetic tools for a sheep producer is to start with a breed or breeds of sheep that excel genetically for a trait or traits that are important to the economic viability of the operation. While it is true that there are large genetic differences within a breed for all production traits, it just makes sense to start with a breed that is noted for high average levels of performance for traits important to your operation. For example, if your goal is to produce and market fine-fibered fleeces, you would not start with Hampshire sheep and select for fine, white fleeces. Instead, you would start with Rambouillet, Merino, or Targhee sheep and improve them even further through selection.

In addition, there is no single breed of sheep that excels for all economically important traits – no matter what the promotional literature from the breed association promises! There are over 60 recognized breeds of sheep in the U.S., and each breed has traits for which it is noted to have a higher level of performance than many other breeds and traits for which it is below average in performance. Commercial sheep producers can make good use of the differences among breeds by utilizing crossbreeding systems that make “complementary” use of the different desirable characteristics of the various breeds of sheep. Crossbreeding systems also make use of “hybrid vigor”, the increased performance of crossbred animals over the average performance of the purebreds in the cross, which is especially beneficial for the very important traits of ewe reproduction and lamb survival.

Little Ewes and Big Rams

An excellent example of the good use of “breed complementarity” is to mate ewes of a breed noted for small to moderate body size with good reproduction and milk production (a maternal breed) to rams of a breed with large body size, fast growth rate, and lean, muscular carcasses (a paternal or terminal breed). The use of small- to moderate-sized maternal ewes results in the production of lots of lambs while keeping ewe feed costs to a minimum, and the use of large terminal sires results in greater growth rate, feed efficiency, and carcass merit of the crossbred lambs than if they had been of only maternal breeding plus the extra boost in lamb performance obtained from hybrid vigor. We need to note that here are a group of breeds that are classified as maternal breeds that do not excel for reproduction and milk production. These are breeds that are well-adapted to harsh or unique environments where other breeds would have a difficult time surviving. An example are the fine-wooled breeds of Rambouillet and Merino that are adapted to arid range conditions and the hill breeds of the U.K. such as the Scottish Blackface.

For the most part, the maternal and terminal breeds are color-coded – maternal breeds tend to be white-faced and terminal breeds tend to be non-white-faced. Of course, there are exceptions to this rule (Texel is a terminal breed and white-faced, and Romanov is a maternal breed and black-and white-faced), but the novice would make few mistakes in sorting breeds in a State Fair sheep barn into maternal and terminal breeds based on face color. Prime examples of maternal breeds are Polypay, traditional Dorset, Rambouillet, Targhee, Finnsheep, Romanov, Katahdin, and the dairy breeds of East Friesian and Lacaune, and the most common terminal breeds are the Hampshire and Suffolk and, to a lesser extent, Shropshire, Texel, and Oxford.

Spooner Experience

Starting in 1996 with the first milking of ewes at the Spooner Agricultural Research Station, the research program has been focused on issues concerning the dairy sheep industry, and the flock was graded-up to a dairy breed composite of East Friesian and Lacaune breeding. In the early years as we were building dairy ewe numbers, all ewes were bred to dairy (maternal) breed rams. However, in several of the later years, only the number of higher milk-producing ewes needed to produce the required number of dairy ewe and ram lamb replacements were bred to dairy sires, and the remainder of the ewes (the lower milk-producers) were bred to terminal sires to produce a higher quality market lamb. Terminal sire breeds used included Hampshire (most numerous), Suffolk, Shropshire, and SireMax (a Columbia-Texel-Suffolk composite).

Spooner Advantage from Using Terminal Sires

Birth and 30 day weaning weights from lambs that were raised artificially from 2005 through 2015 were extracted from the Spooner database. Since very few first parity ewes have been bred to terminal sires, the data set was further edited to include only mature (2 years of age and greater) ewes. Finally, to ensure we were accurately estimating the effect of the sire breed type (Dairy or Terminal) on lamb weights, only lambs whose dams were 85% and greater dairy breeding (i.e., had a very small proportion of non-dairy genetics) were included. Lamb weaning weights were adjusted to 30 days (30d WW) with the following equation:

$$30d\ WW = \left[\left(\frac{wean\ wt - birth\ wt}{wean\ age}\right)\ x\ 30\right] + birth\ wt$$

where *wean wt* is the lamb's actual weight at weaning, *birth wt* is the lamb's weight at birth, and *wean age* is the lamb's actual age in days at time of weaning.

To determine the effect of sire breed type on lamb birth weight (BW) and 30d WW, the following mixed model was analyzed in the MIXED procedure of SAS:

$$y_{ijklmn} = \mu + sex_i + sire\ type_j + dam\ age_k + birth\ type_l + year_m + dam_n + \varepsilon_{ijklmn}$$

where y_{ijklmn} are the observations (n = 2,915 lambs), μ is the overall mean, sex_i is the fixed effect of lamb sex, $sire\ type_j$ is the fixed effect of lamb sire type (Dairy or Terminal), $dam\ age_k$ is the fixed effect of the lamb's dam's age (2, 3, or 4+ years), $birth\ type_l$ is the fixed effect of the lamb's birth type (Single or Multiple), $year_m$ is the random effect of year (n = 11), dam_n is the random dam effect (n = 615 different dams) , and e_{ijklmn} is the random residual. All two-way fixed interactions were fit but none were significant ($P > 0.10$) for the 30 d WW model. The BW model included the two-way interactions of sex_i x $sire\ type_j$, $sire\ type_j$ x $dam\ age_k$, and sire $type_j$ x $birth\ type_l$.

Table 1 presents the number of ewes that were bred to each ram breed type by ewe age. From 22 to 51% of the ewes were bred to terminal sires during the past 11 years, with a higher percentage of older ewes bred to terminal sires than younger ewes.

Table 1. Number and percentage of ewes bred by sire breed type and age of dam.

	Dam Age		
Sire Type	2 (%)	3 (%)	4+ (%)
Dairy	696 (78.0)	447 (56.1)	606 (49.4)
Terminal	196 (22.0)	350 (43.9)	620 (50.6)
Total	892	797	1226

Table 2 presents the birth and 30 day weights of the lambs for each of the effects in the model. Results are as expected with lambs from older dams, single lambs, and male lambs having the heaviest weights. The one exception was that lamb birth weights were not affected by age of dam, and other data sets, including some of ours, have shown greater birth weights from lambs born to older ewes. Terminal sires produced lambs that weighed 1.1 lb. more ($P < 0.01$) at birth and 3.3 lb. more ($P < 0.01$) at 30 days of age than lambs sired by dairy sires. This results in an increased daily gain of approximately 0.1 lb./day for the lambs sired by terminal sires compared to lambs sired by dairy sires through 30 days of age (0.7 vs. 0.6 lb./day, respectively). The superiority of the lambs from terminal sires in body weights and average daily gain is due to both the genetic superiority of the terminal breeds over the maternal breeds for these traits and the increased amount of hybrid vigor exhibited by terminal x dairy crossbred lambs compared to dairy x dairy lambs.

Table 2. Least squares means ± standard errors for lamb birth weight and 30 day adjusted weaning weight.

Effect	Level	Birth weight (lb.)	30d WW (lb.)
Age of Dam	2	12.4 ± 0.2^a	31.4 ± 0.5^a
	3	12.4 ± 0.2^a	32.2 ± 0.5^b
	4+	12.5 ± 0.2^a	32.7 ± 0.5^b
Birth Type	Single	13.2 ± 0.2^a	33.0 ± 0.5^a
	Multiple	11.6 ± 0.1^b	31.1 ± 0.5^b
Sex	Male	12.7 ± 0.2^a	32.7 ± 0.5^a
	Female	12.1 ± 0.2^b	31.4 ± 0.5^b
Sire Type	Dairy	11.9 ± 0.2^a	30.4 ± 0.5^a
	Terminal	13.0 ± 0.2^b	33.7 ± 0.5^b

[a,b]Means within a column and an effect without a common superscript are different ($P < 0.01$).

Unfortunately, we do not have a complete set of growth records to traditional market weights on lambs from these more recent years at the Spooner Station because lambs were often sold shortly after weaning as light feeder lambs. However, prior to 2005, most lambs were fed to a market weight, and these earlier results, adapted from a previous paper (Thomas et al., 2004), reported birth weights, 30 day weights, and 150 day weights of dairy- and terminal-sired lambs as 10.6 vs. 11.6, 30.3 vs. 32.1, and 107.0 vs. 119.3 lb., respectively. These 2004 figures provide estimates of postweaning average daily gains of dairy- and terminal-sired lambs of 0.64 and 0.73 lb./day, respectively.

If we use the 30 day weights presented in Table 2 and the previous results from Thomas et al. (2004) for postweaning average daily gain and if we assume that a group of lambs with equal numbers of dairy- and terminal-sired lambs are to be marketed at an average market weight of 120 lb., then the lambs sired by the dairy sires would weigh 113 lb. and lambs sired by terminal sires would weigh 127 lb. at 158 days of age. If lambs are worth $1.50 per pound live weight, the terminal-sired lambs bring $190.50 per head and the dairy-sired lambs bring $169.50 per head for a difference in favor of the terminal-sired lambs of $21.00 per head. The terminal-sired lambs may eat more feed per head per day, but they may also have better feed efficiency than the dairy sired-lambs so the feed costs per pound of gain may be similar between the groups – at least this is what we will assume to make future calculations easier. The terminal-sired lambs will have leaner and more muscular carcasses than the dairy-sired lambs, which is usually not rewarded in traditional lamb marketing channels, but could be an additional economic benefit of the terminal-sired lambs in a value-based marketing program.

A Crossbreeding System Using Terminal Sires in a Meat Sheep Operation

A very simple simulation, with three scenarios, will be presented below to compare the lamb production and total returns expected from a flock using maternal ewes bred to maternal rams with a flock using maternal ewes bred to both maternal and terminal rams.

Assumptions and Results, Scenario 1 – Maternal ewes mated to maternal rams of the same breed

1. 100 ewes mated each year
2. Ewes are mated to lamb first at 1 year of age
3. 90% of ewes mated will lamb
4. 1.50 lambs are raised to market weight or replacement age/ewe lambing
5. 20 ewe lambs are retained as replacements for 20 ewes that die or are sold as culls each year
6. Rams are purchased
7. 115 market lambs are sold at 160 days of age at 114 lb. live weight (average daily gain of .64 lb./day from birth to market) for $1.50/lb. = **$19,665 of lamb income per year**

Assumptions and Results, Scenario 2 – Maternal ewes mated to maternal rams of the same breed and terminal rams (assume no hybrid vigor from the production of crossbred lambs)

1. 100 ewes mated each year (35 ewes mated to maternal rams and 65 ewes mated to terminal rams)
2. Ewes are mated to lamb first at 1 year of age
3. 90% of ewes mated will lamb
4. 1.50 lambs are raised to market weight or replacement age/ewe lambing
5. 20 maternal-sired ewe lambs are retained as replacements for 20 ewes that die or are sold as culls each year
6. Rams are purchased

7. 27 maternal-sired market lambs are sold at 160 days of age at 114 lb. live weight (average daily gain of .64 lb./day from birth to market) for $1.50/lb. **($4,617 income from maternal lambs)** and 88 maternal-sired market lambs are sold at 160 days of age at 128 lb. live weight (average daily gain of .72 lb./day from birth to market) for $1.50/lb. **($16,896 income from maternal x terminal lambs)** = **$21,513 of total lamb income per year**

The expected increase in lamb income from breeding the majority of the maternal ewes to terminal sires from the above scenarios is $1,848 ($21,513 - $19,665) or a 9.4% increase. This increase from using terminal sires to produce crossbred lambs assumes that there is no hybrid vigor exhibited for reproduction or survival. However, we know that when ewes are mated to a different breed of ram, the ewes tend to have a greater reproductive rate than when they are mated to their own breed of ram and that crossbred lambs are expected to have a greater survival rate than purebred lambs. Estimates of individual hybrid vigor from an old but extensive review of the sheep literature by Nitter (1978) were +2.6% for ewe fertility, +2.8% for ewe prolificacy, +9.8% for lamb survival, and +13% for number of lambs raised per ewe lambing. Below are the Assumptions and Results if these increases in performance from hybrid vigor are included in the simulation.

Assumptions and Results, Scenario 3 – Maternal ewes mated to maternal rams of the same breed and terminal rams (hybrid vigor from the production of crossbred lambs is included)

1. 100 ewes mated each year (35 ewes mated to maternal rams and 65 ewes mated to terminal rams)
2. Ewes are mated to lamb first at 1 year of age
3. 90% of ewes mated to maternal rams will lamb
4. 92% of ewes mated to terminal rams will lamb (+2.6% increase due to hybrid vigor)
5. 1.50 lambs are raised to market weight or replacement age/ewe lambing for ewes mated to the maternal sires
6. 1.70 lambs are raised to market weight/ewe lambing for ewes mated to the terminal sires (+13% increase due to hybrid vigor)
7. 20 maternal-sired ewe lambs are retained as replacements for 20 ewes that die or are sold as culls each year
8. Rams are purchased
9. 27 maternal-sired market lambs are sold at 160 days of age at 114 lb. live weight (average daily gain of .64 lb./day from birth to market) for $1.50/lb. **($4,617 income from maternal lambs)** and 102 maternal-sired market lambs are sold at 160 days of age at 128 lb. live weight (average daily gain of .72 lb./day from birth to market) for $1.50/lb. **($19,584 income from maternal x terminal lambs)** = **$24,201 of total lamb income per year**

The difference between Scenario 3 (terminal sires with hybrid vigor) and Scenario 1 (no terminal sires) in total lamb income is $4,536 ($24,201 - $19,665) or +23.1%.

Conclusions

1. Maternal breeds that have high reproductive and maternal performance or that are well-adapted to the production environment and are small to moderate in mature size should be used for the commercial ewe flock.
2. Only the proportion of the ewe flock needed to produce ewe lamb replacements should be mated to maternal breed sires each year. The remainder of the flock should be bred to terminal sires with all the male and female lambs sold as market or feeder lambs.
3. Depending on the amount of hybrid vigor exhibited by maternal ewes mated to terminal sires for reproduction traits and by crossbred maternal x terminal lambs for survival, the increased flock income in lamb sales from the use of terminal sires may be from +10 to +20%.

Literature Cited

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WHAT QUALITY MEANS TO THOSE RESPONSIBLE FOR BUYING AND SELLING AMERICAN LAMB, AND HOW THE INDUSTRY NEEDS TO BRING THAT QUALITY TO THE TABLE

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Lamb quality means different things to different people. That definition can differ within the numerous segments of the sheep industry (i.e. seedstock producer, commercial lamb producer, lamb feeder, packer, distributor, chef, retailer, direct marketer, and consumer). All segments of the sheep industry must focus on the delivery quality lamb to those farther down the supply chain – the distributor, chef, retailer, and consumer – to maintain a viable industry. An alternative but equally valid statement is that the sheep industry needs to prevent poor quality lamb from reaching the marketplace.

Historical Industry Efforts in Lamb Quality

In 1991 the American Sheep Industry developed the Sheep Safety and Quality Assurance (SSQA) program. The goal of this program was to improve management to produce safe and high quality sheep products. Prior to the development of the Sheep Industry Roadmap, the Sheep Industry Advisory group identified the lack of participation in SSQA as a concern for the sheep industry.

There have been three National Lamb Quality Audits. All were done by Colorado State University (CSU), with the most recent done cooperatively by both CSU and The Ohio State University.

The first National Lamb Quality Audit was performed in 1992 at the request of the American Sheep Industry Association (ASI). The audit identified carcass bruising and excess fat as the greatest industry challenges.

The second National Lamb Quality Audit was done in 2007. This audit focused on the sheep supply from producer to harvest. The 2007 study identified concerns over seasonal supply, feeder lamb genetics and health, and a need to improve muscling.

The third and most recent National Lamb Quality Audit, which serves as the primary source for information within this proceedings article, was funded by the American Lamb Board and conducted in 2014 and early 2015. One part of the study focused on product already in the marketplace by sampling and evaluating retail lamb cuts from stores in 11 states (Wisconsin included). Another part of the study focused on the perceptions and preferences of protein purchasers (n=120) representing the retail (n=60), foodservice (n=45) and purveyor (n=15) sectors of the lamb supply chain.

For the purposes of these proceedings we will focus on the definition of quality by the aforementioned sectors of lamb buyers, but the 120 page Final Report is full of interesting results including willingness-to-pay evaluations and the evaluation of American and imported lamb available at retail.

How Do Lamb Buyers Define Quality?

During the interview process lamb purchasers were asked a series of leading questions that were designed to rank and define various quality attributes. Those attributes, with the ranking of those attributes for all respondents, are listed below in Table 1. Following Table 1 is a breakdown of how various segments protein purchases rank the attributes.

Table 1. Preference of Quality Attribute for all (n=120) respondents.

Quality Attribute	Shares of Preference
1. Eating Satisfaction	38.9%
2. Origin	17.2%
3. Sheep Raising Practices	13.5%
4. Product Appearance/Composition	10.5%
5. Weight/Size	8.5%
6. Nutrition Wholesomeness	7.1%
7. Product Convenience/form	4.2%

Specific to supermarket respondents (n=31), these ranked 1) Eating Satisfaction (39.2%), 2) Origin (18.2%), 3) Product Appearance/Composition (16.5%), 4) Weight/Size (8.2%), 5) Sheep Raising Practices (7%), Nutrition/Wholesomeness (6%), and 7) Product Convenience/Form (4.9%).

Specific to butcher market respondents (n=11), these ranked 1) Eating Satisfaction (38.6%), 2) Origin (23.4%), 3) Sheep Raising Practices (19%), 4) Weight/Size (7.4%), 5) Product Appearance/Composition (5.2%), 6), Nutrition/Wholesomeness (5.1%), and 7) Product Convenience/Form (1.3%).

Specific to direct and farmer's market respondents (n=18), these ranked 1) Eating Satisfaction (27.8%), 2) Sheep Raising Practices (22.4%), 3) Origin (21.2%), 4) Product Appearance/Composition (8.4%), 5) Nutrition/Wholesomeness (8.4%), 6) Weight/Size (7.8%), and 7) Product Convenience/Form (4.1%).

Specific to fine dining respondents (n=23), these ranked 1) Eating Satisfaction (48.8%), 2) Sheep Raising Practices (20.5%), 3) Origin (12.7%), 4) Product Appearance/Composition (6.4%), 5) Nutrition/Wholesomeness (5.5%), 6) Weight/Size (4.0%), and 7) Product Convenience/Form (2.2%).

Specific to casual dining respondents (n=22), these ranked 1) Eating Satisfaction (54.3%), 2) Sheep Raising Practices (13.7%), 3) Origin (12.1%), 4) Product Appearance/Composition (5.6%), 5) Weight/Size (5.4%), 6) Nutrition/Wholesomeness (5.3%), and 7) Product Convenience/Form (3.6%).

Specific to purveyor respondents (n=15), these ranked 1) Eating Satisfaction (27.9%), 2) Weight/Size (20.4%), 3) Product Appearance/Composition (16.5%), 4) Origin (14.3%), 5) Nutrition/Wholesomeness (7.7%), 6) Sheep Raising Practices (7.7%), and 7) Product Convenience/Form (5.5%).

With how the interview questions were arranged, the researchers were able to better-define what these attributes meant. Those results are as follows:

- Eating Satisfaction was defined by 75.8% of the respondents as being associated lamb flavor/taste.
- Origin was defined by 44.2% of respondents as locally raised, 25% as American, and another 20% as region- or state-specific. For the direct/farmer's market interviewee Origin was defined as traceable to the ranch.
- Sheep Raising Practices was most commonly defined as being grass fed (37.5%), humanely raised (21.7%), a specific feeding regime (15.8%), and in regard to animal well-being (15.8%).
- Product Appearance/Composition was categorized as fresh lamb color (31.7%), fat trim level (26.7%), freshness (21.7%), and attractive appearance (20.8%).
- Weight/Size was received various responses depending on the sector interviewed. Consistency was most important for food service in order to maintain plate cost and visual uniformity. Purveyors wanted larger carcasses, whereas retailers and direct markers were concerned about cuts being too large.
- Nutrition/Wholesomeness also had varied answers, but most consistent were "healthy" and "lean". For supermarkets, "grass-fed" and "all-natural" were the most important descriptors for nutrition/wholesomeness. Fine dining and purveyors noted that consumers don't eat lamb for health or nutrition (instead they felt that consumers were looking for eating satisfaction). Food safety was considered a strength for the lamb industry.
- Product Convenience/Form was most often referred to by availability, packaging and product specifications.

How Will the Industry Respond to the National Lamb Quality Audit?

On 23rd and 24th of June, 2015, a twenty-five person group representing all segments of the sheep industry met in Denver, CO for a National Lamb Quality Audit Workshop. The group reviewed the National Lamb Quality Audit and developed appropriate next steps for the industry.

In review of the audit it was agreed that Lamb Quality is a difficult attribute to define so that it is most meaningful to all segments of the lamb buying and consuming public. Furthermore, there is limited research on factors affecting lamb quality and the numerous anecdotal stories are not always consistent.

Those gathered at the Workshop developed the following mission: Improve the consistency of quality, cutability, and marketability of American Lamb with a consumer driven focus. Three strategic goals were developed. These are ranked below, with specific action plans included as sub-points:

1) Address factors contributing to lamb flavor, their impact on consumer satisfaction, and align flavor characteristics with target markets.
    a. Develop Total Quality Management approach on production management effects on flavor to identify and eliminate practices that result in objectionable lamb flavor.
    b. Determine the current diversity of lamb flavor attributes and consumer flavor preferences.
    c. Develop a rapid at-processing tool to identify flavor attributes that will allow for carcass segregation at production-line speeds. Then develop value-based purchasing systems to price lamb according to flavor (among other importance carcass attributes).

2) Improve lamb management to hit market-ready targets for product size, composition, and eating satisfaction while reducing production costs.
    a. Continue to emphasize the importance of value-based (grid) marketing to send the proper market signals to producers.
    b. Address the need for seasonal supply of lambs with the compounded problem of excess fat (holding lambs to fill supply voids).
    c. Identify and communicate the historical cost of fat to each segment of the sheep industry, including the consumer.
    d. Identify market factors that lead to compositional changes, and strive to reduce Yield Grade 4 and 5 lambs.
    e. Communicate through an all-encompassing, brief, and interactive approach best management practices that affect end product quality.

3) Identify and capitalize on market opportunities for American Lamb.
    a. Take advantage of local trends, sheep raising practices, use of SSQA, etc.
    b. Continue to promote the lamb story at point of purchase.
    c. Provide branded, source-verified, and differentiated lamb into the marketplace.

Literature Cited

Preferences and Complaints associated with American Lamb Quality in Retail & Foodservice Markets. Final Report Submitted to the American Lamb Board, April 2015. Hoffman et. al.

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Table 13. Categorized responses from interviewed companies defining what seven quality attributes mean to their company as it relates to lamb

Eating Satisfaction		Origin		Sheep Raising Practices		Product Appearance/ Composition		Weight/Size		Nutrition/ Wholesomeness		Product Convenience/Form	
Definition[1]	Freq.[2]	Definition	Freq.	Definition	Freq.	Definition	Freq.	Definition	Freq.	Definition	Freq.	Definition	Freq.
Lamb Flavor/Taste	75.8%	Locally Raised	44.2%	Grass-Fed	37.5%	Fresh Lamb Color	31.7%	Consistent Cut Size	32.5%	Healthy	19.2%	Availability	20.8%
Tenderness	32.5%	American	25.0%	Humanely Raised	21.7%	Fat Trim Level	26.7%	Consistent Cut Weight	24.2%	Lean	14.2%	Cut Specifications	15.8%
Customer Satisfaction	31.7%	Region/State	20.0%	Feeding Regime	15.8%	Freshness	21.7%	Carcass Weight	20.0%	Nutritious	10.0%	Pre-Packaged Cuts	14.2%
Consistency	10.0%	Traceable Product	19.2%	Animal Well-Being	15.8%	Attractive Appearance	20.8%	Cut Specifications	16.7%	Grass-Fed	9.2%	Portion Cut/ Uniformity	14.2%
Product Quality	10.0%	Colorado	10.0%	Antibiotic Free	15.0%	Product Quality	15.8%	Carcass/Cuts Too Big	14.2%	Vitamins	9.2%	Vacuum Packaged	12.5%
Marbling	9.2%	Source Verified	6.7%	No Added Hormones	12.5%	Lean to Fat Ratio	12.5%	Uniformity	8.3%	Protein	7.5%	Frenched Product	5.0%
Texture/ Mouthfeel	7.5%	Where They Are Raised	6.7%	Animal Care	8.3%	Marbling	9.2%	Live Weight	8.3%	Don't Eat Lamb For Nutrition	6.7%		
Fat Content	5.0%	Know The Farmer	5.8%	How They Are Raised	7.5%	Packaging	6.7%	Primal Weight	8.3%	All-Natural	6.7%		
		Australian	5.8%	Humane Slaughter	7.5%	Uniform Size	6.8%	Prefer Bigger Cuts	8.3%	No Added Hormones	6.7%		
		New Zealand	5.8%	Naturally Raised	6.7%	Consistent	5.8%			Customer Satisfaction	6.7%		
				Grain-Fed	5.8%	Trimness	5.0%			Food Safety	6.7%		
				Breed	5.8%	White Fat	5.0%			Freshness	6.7%		

[1] Definition = the interview response for the definition or description of seven quality attributes

[2] Freq. = Most frequent responses (=/> 5.0%) in descending order. Response data were evaluated as the number of times that interviewees in each market sector identified the attribute as a definition or description of the given category divided by the total number of responses (N = 120).

NATIONAL LAMB QUALITY AUDIT STRATEGY WORKSHOP SUMMARY

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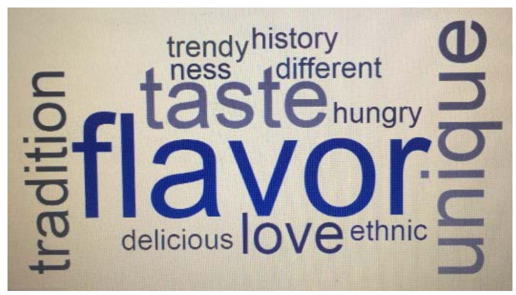
The American Lamb Board hosted a Strategy Workshop pertinent to American Lamb Quality in June 2015. The focus of a 25 person group that represented all sectors of the lamb supply chain was to develop a vision, goals, and an action plan from findings of a research project "Preferences and Complaints associated with American Lamb Quality in Retail and Foodservice Markets" (a.k.a. National Lamb Quality Audit). Researchers from Colorado State University and The Ohio State University presented results that included personal interviews with 120 protein purchasers within U.S. retail and foodservice. Further results included a benchmark of lamb product characteristics (i.e., size, cutability, and product label claims) available at retail from 12 geographically diverse locations.

Fundamental discussion of the workshop included defining "lamb" and "quality" from the retail and foodeservice perspective. The central themes for the definition of lamb included being described as: 1) young sheep (32%); 2) red meat alternative (25%); 3) delicious and flavorful attributes (20%); 4) delicacy, high end meat (9%); 5) healthy protein (7%); and 6) other (7%). The predominant answer was "young sheep"; while the definition of lamb varied by respondent in foodservice, retail, and purveyor sectors of the industry, lamb was most commonly defined as a young sheep less than 12 months of age. Also, the Strategy Workshop participants interacted and provided responses on "Why do people purchase lamb?" (shown at right).



Quality, in general, is a more ambiguous term to define. Interview responses for "define quality" show a variety of answers for supermarket, butcher, direct/farmer's market, fine dining, casual dining, and purveyor representatives of the lamb industry. Customers' needs and expectations are always changing, and lamb quality is a moving target that means different things to sheep/lamb industry stakeholders throughout the supply chain. Best/Worst scaling questions of structured interviews quantified the importance of quality categories through choosing the most important and least important attributes. The total shares of preference (relative percentage of preference) for all interviews was the greatest for <u>eating satisfaction</u> (38.9%). Credence attributes and production management traits of <u>origin</u> (17.2%) and <u>sheep raising practices</u> (13.6%) ranked second and third overall, respectively. Physical product characteristic traits of <u>product appearance/composition</u> (10.5%) and <u>weight/size</u> (8.5%) were ranked fourth and fifth in the shares of preference, respectively. <u>Nutrition/wholesomeness</u> (7.1%) ranked sixth and <u>product convenience/form</u> (4.2%) ranked seventh in the overall ranking across all sectors of retailer, foodservice, and purveyor interview respondents.

Consequently, according to retail and foodservice entities Lamb Quality can most appropriately be defined as eating satisfaction, and more specifically lamb flavor. A strategic emphasis on quality attributes identified in this research should strive to ensure that eating satisfaction and lamb flavor are optimized for American lamb, and to produce lamb with credence attributes that may be valuable for sheep producers and requested by retail and foodservice sectors, and inevitably American lamb consumers. Additionally to the importance of eating satisfaction, differentiation in the marketplace had value for lamb products. Results from an evaluation of 148 lamb shoulder chops available at retail from 11 states identified premiums for lamb with source branded (+$1.94/lb), locally raised (+$1.69/lb), and grass-fed (+$1.12/lb) labeling claims.

The active participants engaged in a day and a half discussion on identifying the current status of American Lamb Quality, including current strengths, deficiencies, and determining necessary steps for future improvement critical to maintaining and increasing American Lamb marketshare. The Strategy Workshop attendees developed a mission to: <u>Improve the consistency of quality, cutability, and marketability of American Lamb with a consumer driven focus</u>.

With a consumer centric goal for American Lamb, three <u>strategic goals</u> that will drive the future progress associated with quality of lamb produced in the U.S. include:

1) Address factors contributing to lamb flavor, their impact on consumer satisfaction, and align flavor characteristics with target markets.
2) Improve lamb management to hit market-ready targets for product size, composition, and eating satisfaction while reducing production costs.
3) Identify and capitalize on market opportunities for American Lamb.

The Strategy Workshop participants ranked the goals in order and 64% of the audience determined the primary goal was an added emphasis on lamb flavor and its impact on consumer satisfaction A resulting action plan consists of the development of a Total Quality Management approach on production management effects on flavor that should be utilized to identify and eliminate practices that contribute to negative lamb flavor attributes and utilize best practices that ensure eating satisfaction. Also, an assessment to determine current diversity in lamb flavor and define consumer flavor preferences and expectations in the market place for American Lamb will be important to identify our target. Lastly, we will strive to develop rapid, processing plant-based tools to identify flavor attributes and compounds, segregate current lamb product supply into groups that fit market channels, and implement value-based marketing that delivers predictable flavor.

The second goal to address future improvement in American Lamb Quality focused on actual lamb management with targets for product size, composition, and eating satisfaction. The continued importance of value-based marketing was considered essential to deliver market signals for premium quality and appropriate size and composition. Inherent industry challenges of seasonal supply and demand create a challenge of excess fat that must be addressed. An action plan was created to identify and communicate the cost of fat to each segment (producer to consumer) of the lamb industry, and identify market factors that lead to compositional challenges, and strive to reduce the YG 4s and YG 5s. Lastly, the industry should communicate best management practices on the sheep/lamb supply chain and decisions that affect end product lamb quality through an all-encompassing, brief, and interactive approach.

The third goal as determined by Strategy Workshop participants was to identify and capitalize on market opportunities for American Lamb. Producers that wish to direct market as well as retailers can identify and capitalize on market opportunities (e.g. local, sheep raising practices, SSQA, etc.). The U.S. sheep and lamb industry should continue to promote the lamb story at the point of purchase (story lamb, source verified, market claims, environment, etc.). Lastly, an opportunity exists to mirror the farmer's market and local trends that verified and locally sourced lamb can be branded and differentiated in the market place. The American Lamb Board cordially hosted the workshop conducted by Colorado State University and The Ohio State University, and a huge thanks for all industry participants that kindly provided their expertise to create a direction for future action in the quest for continuous improvement of consistency of quality, cutability, and marketability of American Lamb.

EFFECTS OF BREED AND HYBRID VIGOR ON LAMB SURVIVAL

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Background

The introduction of new breeds into flocks in order to improve desirable traits (such as milk or meat production) can also have an effect on survival rates of lambs in the flock. This happens because different breeds have different rates of survival (e.g., Gamma et al., 1991; Thomas et al., 2000a and 2000b), which is most likely due to an additive genetic component. With increased lamb mortality, there are substantial economic losses and animal welfare concerns.

It is known that crossbred lambs have greater survival when compared to purebred lambs (Gama et al., 1991), indicating that lamb survival exhibits a high amount of 'hybrid vigor'. This term is familiar to sheep producers, and it is a result from crossbred animals having more pairs of genes that are different (heterozygous, e.g. AB) and fewer pairs of genes that are the same (homozygous, e.g. AA or BB). Since each parent of crossbred lambs comes from a different breed (or breed combination), there is a greater chance that the two genes at a given location will be different. Having more genes that are different is beneficial both because many of the deleterious genes that cause disease in livestock are recessive (e.g. AA is deleterious), so they will not be expressed if one of them is different (e.g. AB); and also because animals that are heterozygous (e.g. AB) will tend to present higher performance than the average of their parents for many traits.

In order to guide producer's decisions when inserting a new breed into the flock, it is important to determine the lamb survivability of different breeds as well as to quantify the extent to which crossing of breeds will be beneficial for survival.

Our Flock and 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 by crossbreds of two or more breeds from 14 different breeds (East Friesian, Lacaune, Hampshire, Suffolk, Dorset, Texel, Polypay, Targhee, Romanov, Arcott Rideau, Katahdin, Rambouillet, Commercial, and Finnsheep), and is being upgraded to the dairy breeds of East Friesian and Lacaune. Because there were relatively small contributions of the 12 non-dairy breeds in the lambs in this study, these 12 breeds were grouped into either meat breeds (Hampshire, Suffolk and Texel) or maternal breeds (Dorset, Polypay, Targhee, Romanov, Arcott Rideau, Katahdin, Rambouillet, Commercial, and Finnsheep).

Survival was analyzed in three time periods, in order to determine the age of greatest susceptibility of death: up to and including 1day of age (7,933 lambs), from 2 to 30 days of age (5,370 lambs) and from 2 to 60 days of age (5,216 lambs). All lambs were born from 1998 to

2011 and were reared on a milk replacer after ingestion of colostrum from their dams for the first 36 to 48 hours of life. The date of death (if the animal died), sex, age of the dam, birth type, month and year of birth, and breed composition were recorded for each lamb.

In order to determine the effect of crossbreeding separately from the effect of the individual breed in each cross, the proportion of retained hybrid vigor was calculated for each animal. This value is 100% for animals whose sire and dam are of completely different breeds, such as an F1 cross of two pure breeds (eg. Lacaune ram x Suffolk ewe) and is equal to 0% for purebred animals. The proportion of retained hybrid vigor is reduced when the same breed appears on both the sire and dam side of a cross, such as a backcross (Lacaune ram x Suffolk-Lacaune ewe, hybrid vigor = 50%), with the amount of reduction depending on how much of the common breed is found in each parent. Retained maternal hybrid vigor (the degree of crossbreeding in the dam of the lamb) was calculated in the same manner. More detailed information about the analysis can be found at Ferreira, et al. (2015).

Breed Effects

Lacaune was set in the analysis as the baseline breed (all values deviated from the predicted survival percentage of purebred Lacaune lambs). We can see in Table 1 that the predicted survival of meat breed lambs and maternal breed lambs was significantly greater than either Lacaune or East Friesian lambs during all three time periods. The predicted survival of East Friesian lambs was numerically greater than for Lacaune lambs, but the difference was not statistically significant.

Table 1. Effect of breed of lamb on survival (%) and its significance level (*P*-value).

Breed[1]	Period of life		
	All animals	Artificially raised animals	
	through 1d	2 to 30 d	2 to 60 d
East Friesian	5.98 (0.27)[a]	5.32 (0.14)[a]	6.06 (0.28)[a]
Maternal breeds	**13.41 (0.01)**[a,b]	**14.13 (<0.01)**[b]	**18.01 (<0.01)**[b]
Meat breeds	**15.77 (<0.01)**[b]	**10.98 (<0.01)**[a,b]	**15.40 (<0.01)**[b]

[1]Difference of all breeds when compared to the Lacaune breed.
[a, b] Values with no superscripts in common are different ($P < 0.05$).

Hybrid Vigor Effects

Increased individual hybrid vigor was associated with an increase in survivability in all periods analyzed, and statistically significant for the periods of 2 to 30 and 2 to 60 days of age. In Table 2 we can see that, the predicted increase in survival of F1 crossbred lambs compared to purebred lambs was +8.8% for 2 to 30 days of age and reached +14.6% for 2 to 60 days of age. These are the most important results of this analysis. Maternal heterosis did not significantly affect lamb survival during any of the periods. This finding is not unexpected since animals were artificially raised, and positive effects of crossbred dams for maternal care and milk production were not experienced by the lambs beyond a very short period immediately after birth.

Table 2. Non-genetic and heterosis effects on lamb survival (%) and its significance level (*P*-value).

Item	Group	Period of life		
		All animals	Artificially raised animals	
		trough 1 d	2 to 30 d	2 to 60 d
Sex[1]	Female	**-5.64 (<0.01)**	**3.27 (0.01)**	**6.02 (<0.01)**
Birth type[2]	2	0.33 (0.83)[a]	-1.61 (0.45)[a]	-1.77 (0.45)[a]
	3[3]	**-6.18 (<0.01)**[b]	-0.66 (0.80)[a]	-1.97 (0.50)[a]
Birth month[4]	December/January	-2.02 (0.32)[a]	-3.81 (0.11)[a]	-0.30 (0.90)[a]
	March/April/May	**-10.27 (<0.01)**[b]	**-6.55 (<0.01)**[a]	**-8.19 (<0.01)**[b]
Age of dam[5]	2	**4.50 (<0.01)** [a]	2.79 (0.15)[a]	3.97 (0.07)[a]
	3	1.00 (0.62)[a,b]	4.04 (0.10)[a]	**6.13 (0.02)**[a]
	4[6]	-1.47 (0.48)[b]	2.24 (0.39)[a]	4.28 (0.13)[a]
Individual heterosis[7]		15.64 (0.17)	**8.82 (<0.05)**	**14.57 (0.04)**
Maternal heterosis[8]		-21.38(0.42)	-17.78 (0.44)	-22.43 (0.96)

[1]Sex: difference when compared to males.
[2]Birth type: differences when compared to a single birth.
[3]Includes 3, 4, or 5 lambs born per ewe per parturition.
[4]Birth month: differences when compared to February.
[5]Age of the dam: differences when compared to 1-yr-old ewes.
[6] Includes dams from 4 to 9 yr of age.
[7]Percentage survival of F1 lambs (100% retained heterosis) – percentage survival of purebred lambs (0% of retained heterosis).
[8]Percentage survival of lambs from F1 dams (100% retained heterosis) – percentage survival of lambs from purebred dams (0% retained heterosis).
[a, b] Values with no superscripts in common are different ($P < 0.05$).

Environmental Effects

Survival of females was 5.6% lower than males trough 1 day of age, but 3.3% higher from 2 to 30 days of age and 6% higher from 2 to 60 days of age. Lambs born in litters of 3 or more were 6.2% more likely to die than singles through 1 day of age and lambs from one year old lambs were 4.5% more likely to die than lambs from 2-year-old ewes in the same period. Lambs born in the months of March/April/May had significantly higher probabilities of death than animals born in December/January or February for all periods.

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MAINTAINING A HEALTHY SHEEP FLOCK

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Avoid Bringing in Disease

When new animals are purchased, a period of quarantine where the new animals are not allowed to contact the current flock can prevent bringing in new diseases to the current flock. Sheep can carry latent (meaning clinical signs are not yet seen) diseases. Therefore by keeping them separated for 2 to 3 weeks and testing them for diseases can prevent a herd outbreak. At the UW the newly purchased animals are kept separated for at least 2 weeks or longer depending on the test results. Diagnostic tests may including testing for Q Fever, Corynebacterium pseudotuberculosis, Johnes disease, Ovine progressive pneumonia, and brucellosis ovis. A physical exam is performed to look for sheep keds, foot rot, and sore mouth. Preforming preventative screening can protect your flock.

Likewise animals that return from a show or exhibit should be quarantined and their feed buckets and other equipment taken to show thoroughly cleaned and disinfected.

Ovine Progressive Pneumonia (OPP)

OPP is caused by a virus, which is slow growing. It causes over time (2+ years) a chronic progressive pneumonia and mastitis known as hard bag. In general these clinical sings are seen in older ewes where despite having a good appetite continue to lose weight, develop a cough with rapid breathing and become weak. In some ewes the udder becomes large and hard with decreased milk production and unthrifty lambs. This virus is spread by nose-to-nose contact, in the colostrum and milk and in some cases in utero. There is not treatment and no vaccine.

The UW-Madison developed an OPP control program when in the first year of control all ewes were tested for OPP prior to lambing and separate groups (negative and positive) created within the flock. The following years the negative ewes were bred to lamb before the positive ewes. The jugs were designated to house either positive or negative ewe/lamb pairs and jugs cleaned and disinfected between groups. Whenever possible ewe lambs from positive ewes were cross fostered to negative ewes and in some cases ewe lambs were orphaned and raised separately. A colostrum bank was made from high producing negative ewes or cow colostrum obtained from cows vaccinated with CD&T.

Separate needles were used on all sheep during procedures and all management tools were disinfected between animals (Drenching gun, tattoo pliers, oral deworming guns, etc.)

Caseous Lymphadenitis (CLA)

This is a bacterial disease that affects the lymph nodes of the sheep and causes abscesses. These abscesses occur in lymph nodes on the outside of the body but also internal lymph nodes.

Death can occur if these abscesses rupture internally. When the abscesses rupture externally the organism is further disseminated in the environment where it can survive in soil up to 8 months. Common wounds that occur due to shearing, tail docking, tagging or other causes that damage the mucosal membranes allow the organism to invade the body. Shearing can quickly spread the disease if abscessed material contaminates the blades without cleaning and disinfecting. Treatment consists of lancing and draining the purulent material and flushing with disinfectants. The material should be contained and not allowed to contaminate the environment. Treatment is NOT curative. Penicillin DOES NOT WORK. Tulathromycin (Draaxin) at 2.5 mg/kg SQ can help to manage the infection.

There is a blood test to identify carriers/exposure and can be used to help make culling decisions. A vaccine is available which can help decrease incidence and reduce severity. Prevention and control consists of shearing young animals first followed by test negative animals or animals without lesions. Animals with abscesses should be shorn last with disinfection of blades. Clean animals should be moved to clean areas, especially following shearing.

Contagious Ecthyma (aka Contagious Pustular Dermatitis, Orf, Sore Mouth)

A virus causes this disease. The most common presentation is scabs and sores on the mouth and nose, although it can be found elsewhere on the body. Usually the disease is seen on young animals since over time they develop some resistance. Treatment consists of separating infected animals from the rest of the flock and supportive care as needed. Do not remove the scabs since that does not enhance the healing time. The scabs contain live virus. This is a zoonotic disease meaning people can get these sores as well from touching the lesions on the sheep. WEAR GLOVES.

It generally takes 3 to 14 days to see the sores after exposure. The sores and scabs resolve in 3 to 6 weeks depending on the severity. Usually the majority of the young animals exposed will develop lesions and ewes can get these sores on their udders which leads them to orphan the lambs, or limit their nursing times so that the lambs become unthrifty.

There is a vaccine available but people can get the lesions from the vaccine so care must be used when giving vaccine. Vaccine should ONLY be used in INFECTED flocks to decrease the severity of the disease. Do not vaccinate in uninfected flocks.

This vaccine is modified live and must be placed on skin that has been abraded. Typical sites for application include medial thigh, underside of ear or under the tail. A scab should occur at the vaccination site. The vaccine is labeled for lambs 6-8 weeks of age but if necessary in an outbreak younger and older animals can be vaccinated. Generally immunity lasts 2-3 years however there is a belief that different strains may exist so the vaccine may work differently flock to flock.

Coxiella Burnetii (Q-Fever)

This bacterial infection is also zoonotic. It is spread to other sheep and people by aerosols and is highly infectious. In humans typically the clinical signs mimic the flu, i.e. high fever, muscles aches, and lasts one to two weeks. However there can be atypical signs such as pneumonia, hepatitis, abortion, or in chronic form endocarditis. Tell your doctor if you have these signs that you are concerned about Q fever (if you own sheep). There is a blood test and if positive you should be treated with antibiotics. (This is different that influenza which is a virus and treated with antivirals.)

Cattle, sheep and goats can act as carriers. The organism is shed in large numbers in the placenta and uterine fluids. It can also be found in the colostrum, milk, urine and feces. This rickettsial organism is extremely resistant in the environment and resistant to many disinfectants.

In sheep the clinical signs can range from the ewe being clinically normal (most common). Or can result in late 3rd term abortions, with the fetus appearing normal but the placenta looks abnormal with white chalky areas and red-brown exudate. Treatment and control consists of segregation of aborting animals, and treating all animals with oxytetracycline. The placental and aborted fetuses should be carefully disposed of and blood tests can be used to identify carrier animals.

Since this is a serious zoonotic disease, high risk people such as those who are pregnant, immunosuppressed and those with pre-existing heart valve defects are at high risk to develop chronic Q fever and they should avoid being around ewes that are lambing. Likewise everyone should wear gloves and a face mask around aborting ewes.

Clostridial Diseases

There are numerous clostridial strains that cause disease in sheep. These bacteria are anaerobic which means they like to grow in environments that do not have oxygen. Black leg is caused by C. Chauvoei and results in fever, pain, swelling and gas under the skin. The organism gets into the muscle due to soil or fecal contamination of wounds. (Docking, castration, hearing, obstetrics, etc. can cause these wounds). C. Novyi and C. Sordelli cause bighead. The wounds the organism enters are on the head caused by head-butting and tissue damage. Red Water Disease is caused by C. hemolytica and this organism is found in standing water and alkaline pastures. Flukes damage the liver and set up the environment for the organism to grow. When it is ingested the sheep develops clinical signs of liver infections with weakness, depression, red urine and feces, fever and yellow mucous membranes. Treatment in all cases of clostridium involved high and frequent doses of penicillin as well as banamine and supportive care. If a necrotic wound is visible it should be cleaned and expose the tissue to air. Enerotoxemia is a clostridial disease of lambs and often the lambs are found dead or if still alive they are painful, grinding their teeth, and have bloody diarrhea. Treatment consists of oral and SQ treatment with penicillin and clostrium C&D antitoxin and well as fluids. Preventions vaccination and good colostrum from vaccinated ewe.

Sheep should be vaccinated for clostridium. In general the younger animals receive C&D toxoid vaccine either at 1-3 weeks of age if the dam was unvaccinated or at 1-2 months of age if dam was vaccinated. The booster injections should be given 3-4 weeks after first vaccination. There is an 8 way clostridium vaccine that is used on older sheep.