Enhanced genetic selection of dairy sheep for the Southern US

2010 Final Report

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Summary

Ewes from a cross using East Friesian (dairy) sheep and two “hair” breeds (St. Croix, Katahdin) were bred and tested for their ability to transmit traits associated with low-input dairy production in the heat and humidity of the southeastern United States. Data on milk production, parasite resistance, and penetrance of the “hair” (shedding) trait were collected on a total of 178 sheep born on this farm between 2008 and 2010. A scoring system, based on these traits, was used to select optimal breeding stock to continue development of the line for each breeding season. The result show that the sheep produced from this breeding scheme can provide commercially viable seasonal milk production and relative parasite resistance on a largely forage-based diet. This project demonstrates the feasibility of rapid selection of a productive dairy sheep flock for the Southeastern United States.

Introduction

The sustainability of traditional small farming operations is rapidly declining. Factors contributing to this decline include the following:

- diminishing/unreliable sources of labor
- rapidly increasing costs for fuel to support farm operations and transport of product
- rapidly increasing costs for inorganic fertilizer and non-renewable plant resources

- requirement for increasingly intensive, costly management of biological threats
- low market prices for commodities requiring off-farm processing or distribution.

Most sustainable small farms will need to be manageable by a single individual, operating either alone with occasional hired labor or with a partner employed full-time off the farm. From recent farm census data, it is also clear that the primary farmer will increasingly be female and may have little or no background in farming. In order to be profitable, small farming operations cannot rely on heavy mechanical input or support a large recurring investment in seed stock, fertilizer, or health management costs. They will also require a focus on farm-based "value-added" strategies and the development of local markets to minimize transport, distribution, and storage costs. In return for operating with these constraints, however, small farms should have advantages of improved flexibility in response to changes in environmental conditions and shifts in local consumer demand.

One farming opportunity that will meet these requirements is a dairy sheep operation producing aged ewe's-milk cheeses. Given reasonable availability of feed generated off-farm or adequate pasture, an operation milking 50-60 ewes over a 5-month season should produce sustainable income for a single farmer-operator in the Southeast region with a limited requirement for extra labor, land, or expensive equipment. However, there are impediments to realizing this opportunity.

The dairy breeds currently available in the US, East Friesian (EF) and Lacaune, are handicapped by extremely limited genetic variability and poor health performance under conditions of high heat and humidity. The limited genetic variability, which may play a role in their high risk for developing pneumonia and serious worm infestations, limits the ability of breeders to optimize both general health and the components in milk (fat, protein) that are required for high-quality cheese production.

These breeds are also poorly suited to production of meat lambs for a supplemental income stream, require routine shearing for optimal performance in very warm, humid areas, and produce wool of low quality. At present, there are few sheep breeds of any sort that thrive and are highly productive in the southern US. Consequently, sheep production in this region has reached very low levels, and few in the farming community have the expertise in husbandry, breeding, and health maintenance required to manage sheep as a profitable enterprise.

Development of a dairy sheep breed that will thrive under low-input conditions in the Southern region will require a focused effort involving individuals with expertise in breeding for the selection of complex traits and in the husbandry of small ruminants, as well as a network of individuals capable of working together to expand and test the breeding stocks under development. This proposal addresses both issues.

Objectives/Performance Targets

The original goal of this proposal was to support a systematic analysis of genetic variation in a foundation flock of crossbred sheep carrying 50-60% East Friesian (dairy) genetics, to develop a composite tool for selection of genetically determined parasite-resistance, and to generate an expansion flock suitable for selection based on milk volume and quality. To support data collection and flock management, I proposed the development of an interactive database with links for lineage analysis and pedigree plotting.

Methods

Breeding

From the original foundation flock (13-25% East Friesian), I generated 40 lambs from outcross to a high percentage East Friesian ram in 2008. Using criteria heavily weighted toward parasite resistance (McMaster's fecal helminth egg counts <1000/gm and FAMACHA), I used selected older ewes and 2008 lambs to generate an expanded selection pool of 82 lambs in 2009 and an additional 56 lambs in 2010. This has provided a large dataset from which I have established solid characterization of the three primary selection characteristics I had identified as optimal for a successful, low-maintenance dairy flock: milk production, parasite resistance, and wool shedding.

Milk production

Milk production was tracked using the surrogate trait of adjusted weight gain between 30 and 60 days of age in the lambs. In order to compensate for differences in litter size, number of lambs raised by an individual dam, sex of the lambs, and age of the dam, I used the following table from the

Sheep Industry Development Handbook.

Table 1. Adjustment factors for Lamb weights

	Age of dam (yrs)		
Ewe lambs	**1 yr**	**2 yr or >6 yrs**	**3-6 yrs**
Single	1.13	1.08	1
Twin - raised as twin	1.38	1.29	1.19
Twin - raised as single	1.29	1.19	1.1
Triplet - raised as triplet	1.8	1.54	1.36
Triplet - raised as twin	1.51	1.38	1.27
Triplet - raised as single	1.4	1.28	1.18
Ram lambs			
Single	1.02	0.98	0.91
Twin - raised as twin	1.21	1.17	1.08
Twin - raised as single	1.15	1.08	1
Triplet - raised as triplet	1.53	1.38	1.23
Triplet - raised as twin	1.31	1.25	1.15
Triplet - raised as single	1.23	1.16	1.07

Parasite resistance

Parasite resistance was initially tracked by fecal sampling and McMaster's egg counts performed by the Virginia Department of Agriculture Laboratory in Lynchburg, VA. Anemia was assessed using the FAMACHA method because it is less invasive than hematocrit testing, correlates extremely well with packed red blood cell volume, and can readily be performed on a weekly or bi-weekly basis.

Hair (shedding) trait

Spontaneous shedding was graded on a scale from 0 (no detectable seasonal wool loss) to 3 (complete spontaneous wool loss by shedding to a "slick" hair coat). Animals were graded at one year of age, since no significant shedding occurs before the second summer except in the case of severe illness or stress.

Database and website development

In order to collect, store, and analyze the data collected for this project, I began the development of a suitable database using MySQL with Aaron Mackey, Ph.D. I also developed a website with Dr. Mackey's guidance to disseminate information on this project and on the new sheep breed under development (http://www.allenscreek.org).

Outcomes and Impacts

Lamb growth/milk production

All animals were maintained on pasture and stored forage (grass hay supplemented with local alfalfa hay during the late stages of pregnancy and milking). Small amounts of grain (<4 oz per ewe) were supplied during extremely cold weather during the late stages of pregnancy for supplemental energy.

Data on lamb growth as a surrogate for milk production in the dam is shown in Table 2. As expected, increasing the percentage of East Friesian genetics in the dams significantly increased the rate of growth in their lambs ($P = 0.007$), demonstrating an increase in the volume and/or nutrient content of the milk produced. Whether this can be attributed solely to the increase in dairy genetics is not completely clear, since the calculated percentage of the St. Croix contribution was decreased in these ewes to a greater degree than that of the Katahdin contribution. However, it does suggest that the resulting higher % East Friesian ewes will be more efficient dairy animals than the foundation flock.

Table 2. Lamb growth

% East Friesian[1]	Range	Growth[2] (SD)	*N*	*P*[3]
<26%	13-25%	2.0 (0.95)	112	
>50%	50-55%	2.4 (0.69)	35	0.007

[1] Calculated percentage of genetic background in the dams

[2] Growth scores at an average of 45 days: 0 = less than 0.6 lb/day; 1 = 0.6-0.74 lb.day; 2 = 0.75-0.89 lb/day; 3 = greater than 0.9 lb.day

[3] Significance calculated using a 2-tailed, unpaired t-test

Assessment of the method: Although this system provided some normalization of weights based on maternal and litter characteristics, I found that it was not ideal for gauging weight gain in triplets/quadruplets or for lambs raised as singletons or twins from a larger litter in which one of the lambs died (4 litters) or was raised artificially (approximately 10% of the lambs per year, all due to maternal neglect). However, the method was, in general, robust for the majority of litters and allowed prediction of weight gains from individual ewes in succeeding years.

Limited experience with hand-milking from the higher percentage ewes in 2010 suggests that individual ewes from the current stock will be capable of producing at least 2 quarts of milk per day during the milking season on a largely grass and hay diet, for a seasonal output of at least 660 pounds of milk.

Parasite resistance

Parasite resistance was initially tracked by fecal sampling and McMaster's egg counts performed by the Virginia Department of Agriculture Laboratory in Lynchburg, VA. For the 2008 and 2009 lamb crops, I compared the sensitivity of fecal egg counts with screening for anemia using the FAMACHA system and demonstrated that the sensitivity of FAMACHA for parasite load with Haemonchus contortus was excellent. Therefore, I used FAMACHA every two weeks during the 2010 lamb season, confirming estimated fecal parasite loads with egg counts in only a sample (14 of 54) of the lambs. Over the period of this grant, the cost of the McMaster's test rose from $6 to $10 per sample. Training in the performance of the test is available in several regional facilities, the cost of purchasing/maintaining an adequate microscope, the cost of counting slides, and the time required for individual fecal sample preparation and analysis are all prohibitive for many producers. In addition, fecal sampling itself requires either substantial time or extensive handling equipment. Therefore, the excellent correlation between

FAMACHA and McMaster's results suggests that the FAMACHA method is adequate for routine parasite management and scoring. Using the McMaster's results, I did identify a small number of lambs that appeared to be "parasite tolerant" rather than "parasite resistant" in that they carried a high H. contortus egg burden but had excellent weight gain and showed no evidence of anemia or hypoalbuminemia ("bottle jaw"). Since these animals would not be selected against in a FAMACHA-based breeding scheme, they could conceivably dilute the effectiveness of a genetic improvement scheme for parasite resistance. I believe, however, that the small number of sheep carrying the tolerance trait would serve to provide an ongoing "refugia" as now recommended for induction of protective immune responses in the resistant sheep and will therefore play a useful role in the flock.

The data in Table 3 show clearly that increasing the percentage of East Friesian contributions to the genetic background over 68% significantly increases susceptibility to intestinal parasites (P<0.01), but animals with less than 56% are substantially resistant.

Table 3. Parasite resistance in progeny with varying percentage of dairy genetics

Group	% East Friesian[1]	Range	Parasites[2] (SD)	*N*	*P*[3] (vs. A)	*P*[3] (vs. B)
A	<50%	13-49%	2.1 (1.86)	44		
B	50-55%	52-55%	2.1 (1.76)	96	0.42	
C	>55%	69-77%	0.5 (0.84)	6	0.05	<0.01

1 Calculated percentage of genetic background in the lambs

2 Parasite scores: 0 = required repeated doses of antihelminthics by FAMACHA score <2 and/or severe bottle jaw; 1 = required antihelminthics by FAMACHA score <2 and/or severe bottle jaw during year 1; 2 = mild anemia or bottle jaw, resolved without anti-helminthics; 3 = no clinical evidence of of severe parasite load, McMaster's egg count >25%ile; 4 = no clinical evidence of of severe parasite load, McMaster's egg count <25%ile

3 Significance calculated using a 1-tailed, unpaired t-test

Wet spring weather in both 2009 and 2010 was associated with increased coccidiosis as a health problem in our region. Using the McMaster's method, I found that resistance to H. contortus did not correlate with resistance to a heavy, frequently symptomatic Coccidia burden. Therefore, coccidiosis is likely to remain a substantial issue during some years in the lambs of the dairy flock. It was reassuring that the adult ewes tolerated high levels of exposure to Coccidia well and did not require treatment.

Hair (shedding) trait

Retention or acquisition of the hair (shedding) trait was largely limited to cross-bred animals after loss in the outcross to East Friesian. Roughly 50% of the intercrossed sheep, however, show good spontaneous wool loss, suggesting that this trait will be relatively easy to recapture as the breed develops over the next generation.

Database and website development

With Dr. Mackey, I began the development of a web-accessible database using MySQL to store and analyze the data from this breeding project. I am continuing the development of the database to add functionality for rapid graphic analysis, for automated pedigree drawing, and for additional phenotype and genotype data processing. This is clearly a work-in-progress which is benefiting from developmental projects in the wider genetics research community on handling and processing complex datasets. I plan to make the final database freely accessible and usable as a web application suitable for data processing and genetic selection in livestock with complicated breeding systems.

Genetic mapping

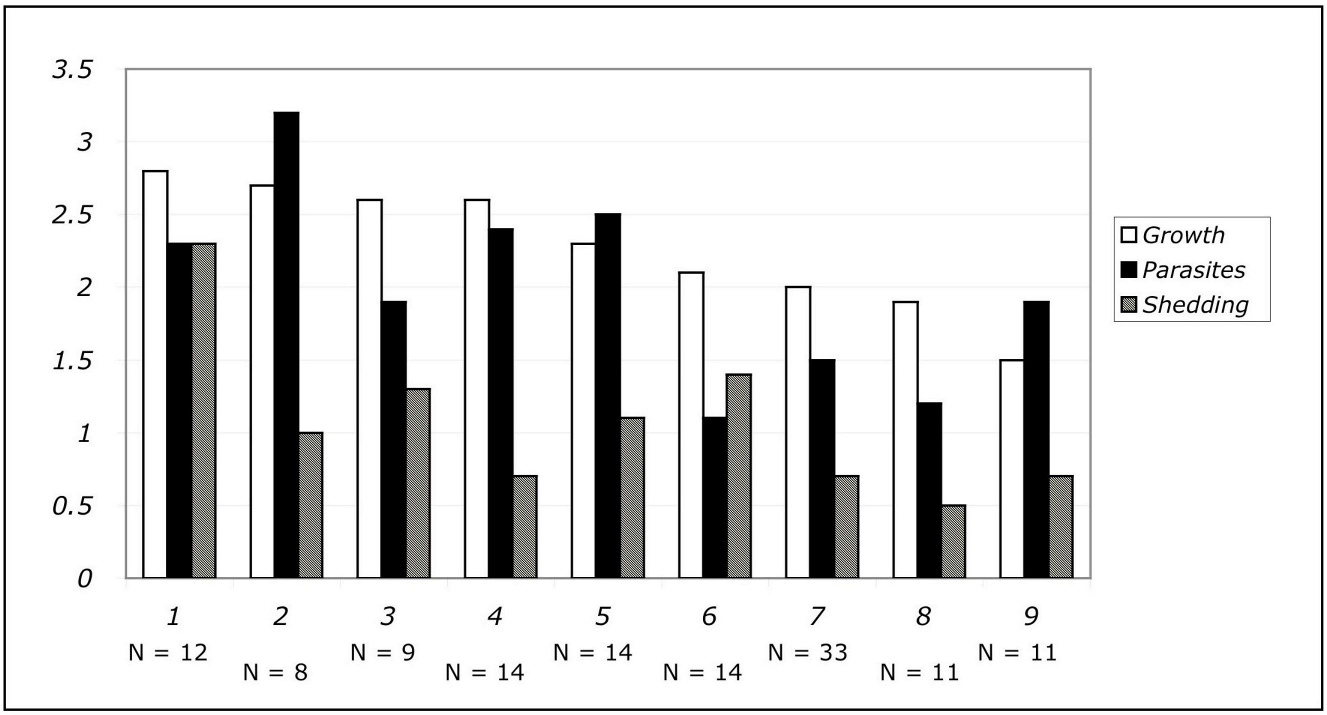
In the application for funding, I proposed to perform microsatellite mapping to demonstrate the genetic diversity in the original flock and as a precursor to genetic mapping of the traits. With the release of the SheepChip for genotyping using single-nucleotide polymorphisms in January, 2009, the approach using microsatellites became obsolete. I have made contacts with individuals in the International Sheep Genetics Consortium and am working to have this project continued under their auspices. None of the funds initially requested for the genotyping project were expended or invoiced.

Accomplishments

Line breeding and selection

Data on lamb growth, parasite resistance, and shedding from the offspring of 9 founder ewes with adequate numbers of offspring for analysis is shown in Figure 1. For the coming season, I will concentrate on selecting “line” rams from the progeny of ewe #1 who has transmitted optimal milk production, parasite resistance, and shedding characteristics to her offspring. A focus on generating ewe lambs from the progeny of founders 2-5 should allow sufficient production to supply my own needs as well as starter flocks for an additional 3 farms that have contacted me about this project and are willing to be active participants in breed development. Animals with the highest scores on the selecting traits will also be retained from the progeny of ewes 6-9. These animals will be retained as sources for re-introduction of genetic diversity as the line breeding continues. My goal for the 2011 and 2012 lambing seasons is to produce animals that will allow better definition of the "break-point" between improvement in milk production and parasite resistance in the ewes carrying 55-70% East Friesian genetics (my own personal "donut hole"). The ultimate goal will be to define an optimal dairy sheep breed with sufficient genetic diversity to permit maintenance as a closed flock on farms of moderate size (100-200 ewes).

Figure 1. Progeny data from nine founder ewes



Recruitment of additional farms for flock expansion and field testing

Distribution of dairy stock has begun. I supplied a foundation flock of 9 ewes and a ram to a dairy in southern Virginia in 2009, and breeding rams with high percentage dairy genetics and excellent parasite resistance were provided for 2 additional flocks in 2010. A nucleus of 4 bred ewes will also be sent to a small dairy in eastern Virginia in November, 2010. All of the recipient farms have agreed to provide data on dairy production and hardiness.

Potential Contributions

I have demonstrated the feasibility of selecting for high levels of parasite resistance and the "hair" (shedding) trait while improving milk quality and/or quantity in a 3-way cross of East Friesian (dairy) with Katahdin and St. Croix sheep. This project has attracted the interest of other small farmers in the region who are willing to commit to aiding the expansion and further selection of a new "hairy-dairy" breed (as yet unnamed). I have validated a low-tech, low-cost method for monitoring parasite resistance and will introduce direct measures of milk output and quality (volume, total solids, protein, fat) for the later years of selection.

As outlined in the Outreach section, I have developed a working relationship with two county agents for the Virginia Cooperative Extension program. A major new focus of this project will be the presentation of topical workshops on small ruminants. We have two workshops on dairy production from sheep and goats in the planning stages: one focused on flock development and management; a second, on cheese-making. These will include presentations by veterinarians who have donated their time, as well as veteran cheese-makers and representatives of the regulatory agencies involved. A third workshop on pasture management for small ruminants and small ruminant nutrition have also been requested by the attendees of our initial small ruminant workshop and is planned for 2012. Additional topics will be developed in the workshop format based on demonstrated need. We plan to supplement Cooperative Extension administrative resources with small grants and industry support as appropriate in order to minimize the cost to participants. As an example, we received a donation of $300 from the Virginia Wool Sheep Association to supplement funds for outreach available from the SSARE grant and were able to charge participants only the cost of a FAMACHA color chart ($15) for the full day's events.

Publications/Outreach

Workshop

In the first year of funding (2008), I attempted to start a local group interested in small ruminant agriculture. Although I had a few enthusiastic responses, there was little consensus on a format for meeting or on shared goals. In 2009, I was approached by John Thompson, a local Virginia Cooperative Extension agent. With organization and administrative support from John's office, as well as support from the SSARE grant and my county agent, Michael Lachance, we put on a fantastic day-long workshop on small

ruminants. The workshop included presentations by Susan Schoenian of the Maryland Small Ruminant Project, Scott Jerrell of the Scott County Hair Sheep Association, a panel of local producers with varied operations, FAMACHA training, and a farm visit for hands-on FAMACHA experience. We attracted 49 attendees from all over the state of Virginia, in addition to the invited speakers and extension personnel. Evaluations were very enthusiastic about the content and organization of the workshop and provided excellent consensus on the need for future workshops. In response to specific requests from multiple attendees, we have planned a series of 2-3 workshops per year for the next two years. A summary of the program fro the initial workshop is available on-line:
http://allenscreekfarm.org/home/workshops/small-ruminant-seminar.html.

Website

In 2009, I also published a website for the farm:
http://www.allenscreekfarm.org. The website carries links to SARE and SSARE, as well as details about our sheep and the breeding project, and will soon also carry a link to this report. I will post information about upcoming and past workshops on the site and continue to develop links to other resources on dairy sheep and genetic selection. The website has generated contacts with three of the individuals who will be helping with distribution and off-site characterization of the new sheep breed.

Future Recommendations

As noted in the original application, use and distribution of the dairy stock developed with this funding will be most effectively supported by the development of an active working cooperative that can share and direct regional flock improvement, bulk purchasing, and joint marketing efforts. I have made a start on developing such a working group in central Virginia, based on the successful model provided by the Scott County Hair Sheep Association in southwestern Virginia, and I will continue to seek funding and administrative support for this effort through industry, cooperative extension, and university-based sources.

SSARE funding for this project, both to Amy Hayner who developed the original base flock and to me, was absolutely essential to its success. These grants provided support for the additional time required to breed and characterize the flocks, as well as venues for publicizing their availability to the broader community. It is my hope that SARE will continue to support small producer-initiated projects that will encourage on-farm development of similar resources.

Appendix

Photographs of sheep from the expansion flock

VA61017-0042 (2008 ram; 55% East Friesian; wooled)

VA61017-0130 (2009 ram; 40% East Friesian; hair trait, grade 3)

VA61017-0037 (2008 ewe; 55% East Friesian; hair trait, grade 2)

VA61017-0137 (2009 ram; 55% East Friesian; hair trait, grade 2)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