The Katahdin Sheep breed has embraced the collection of performance data for the National Sheep Improvement Program (NSIP), and members now use a national database to identify top sires. However, the rate at which superior genetics can be incorporated into the breed is limited because most Katahdin lambs are still produced through natural breeding. Natural mating results in the production of insufficient lambs to adequately evaluate an individual sire’s genetic contribution to his offspring, and limits the dissemination of genetic traits through the breed. Artificial insemination (AI) has the potential to increase a ram’s annual lamb crop to a meaningful level. Artificial insemination can be performed either through surgical uterine injection, by passage into the cervix, or by vaginal deposition. Surgical AI has not been widely adopted in the U.S. because of its expense and technical difficulty. Cervical AI is also technically difficult and has produced inconsistent results. Vaginal AI (VAI) is a simple, inexpensive method that can be taught to producers, but is underutilized in U.S. sheep due to a perception that VAI pregnancy rates are low. However, Scandinavian and Icelandic breeders have achieved high pregnancy rates for decades using VAI with chilled and frozen semen, and there is evidence that Katahdin sheep can also achieve acceptable pregnancy rates using VAI. The proposed work will increase the rate of genetic improvement in the Katahdin breed through on-farm testing in U.S. Katahdin ewes of VAI techniques for chilled and frozen semen that have been successful in Iceland and Scandinavia, and will initiate a discussion among leaders in the Katahdin breed about the economic and practical implications of three different approaches to semen collection and transport. We also hope to reach out to Private Industry to meet breeder needs at capable reproductive technology labs or veterinary clinics. We plan to concentrate on the Katahdin breed because of its popularity in the U.S., and because Katahdin breeders submit production data at high rates to the NSIP database. During this NSIIC-supported project, leaders within the Katahdin breed organization will meet to compare, adopt and promote VAI models that are a good economic “fit” for their industry. In addition, Katahdin sheep producers at regional workshops will be taught semen processing and insemination techniques that have been proven successful in other sheep breeds. These actions will accelerate the rate of genetic improvement in Katahdin Hair sheep and increase the profitability of Katahdin sheep breeders.
Project Objectives

Our overall goal is to develop a VAI model that will be willingly adopted by the Katahdin sheep industry because it achieves high pregnancy rates while assigning technically difficult and time-consuming aspects of semen collection/packaging to trained personnel in private industry. We hope to accomplish this goal through discussions with a representative sampling of Katahdin sheep breeders about the financial costs, time expenditures and technical experience needed for success with three different models for ram semen processing and VAI: 1) on-farm ram collection / semen processing by owner; 2) on-farm collection / semen processing by local veterinarian; or 3) centralized ram collection / semen processing / semen straw distribution by a private lab that specializes in livestock reproduction. During national and regional meetings of the Katahdin Hair Sheep Association, we plan to schedule discussions among members on how to make exceptional genetics available to the most members at reasonable cost. We also plan to offer a number of regional training sessions that will train producers on all aspects of VAI.

Description of efforts – Anticipated results

Determine pregnancy rates after VAI of 150 ewes on 5 commercial Katahdin sheep farms (published historical rates using the commercial Iceland techniques average >65% for chilled semen and 50% for frozen semen, and U.S. Katahdin Hair Sheep rates would need to be similar for widespread adoption). We have achieved rates of >80% in Maine for Icelandic and dairy breeds using chilled semen VAI, and will be evaluating frozen semen VAI methods in fall 2017).

Train 200 producers to perform ram semen collection, semen evaluation and processing, ewe estrous synchronization, and vaginal artificial insemination using techniques developed in Iceland. Result – Producers will be better able to decide whether to conduct VAI by themselves, or contract with a reproductive expert to assume some or all of the technical procedures.

Organize discussions among Katahdin Sheep breed leaders, economists, reproductive technology experts and with equine repro and small ruminant veterinarians to develop a breed-wide approach to VAI that makes economic sense and that can be incorporated within existing producer work loads.

Applicant Matching Funds

| Local/State/Federal Funds previously awarded for project | $6166 in Maine Experiment Station Funding |

Type of Expenditure

<table>
<thead>
<tr>
<th>Personnel – list each</th>
<th>Relationship to Project</th>
<th>Number of Hours</th>
<th>Rate of Compensation</th>
<th>Total</th>
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<tr>
<td>Temporary lab technician</td>
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<td>500</td>
<td>$24.00</td>
<td>$12,000</td>
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<td>Tech fringe benefits</td>
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Equipment

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Travel

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<tr>
<td>Out of State travel to conferences, training sessions</td>
<td>Air / auto travel (estimate $600 per trip)</td>
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<tr>
<td>Lodging</td>
<td>Food and lodging ($200 / day)</td>
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Other Related Expense

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<tbody>
<tr>
<td>Materials and Supplies</td>
<td>VAI-related supplies for research and training</td>
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Overhead

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<tr>
<td>Indirect costs</td>
<td>7.5% of total funds</td>
<td>Total funds requested = $26,148 + $2118 = $28,266</td>
<td>($26148 + $2118) x 7.5% = $2118</td>
<td>$2118</td>
</tr>
</tbody>
</table>

Provide a qualitative summary, or justification for budget expenditures: (200 word or less)

Total request: $28,266.

Temporary classified employee ($12,948 wages plus fringe benefits). Works to identify participants in VAI breeding trials. Develops surveys for monitoring economic activity related to VAI sales and purchases, collects economic data, summarizes information for upload to an Extension-based Website that will be available as a learning tool, and develops Website for on-line advertising of VAI ram semen.

Domestic out-of-State travel ($7200). Dr. Weber will travel to national meetings of the Katahdin Hair Sheep Association to lead meetings related to the development of economic models for the use of VAI in the U.S. sheep industry. He will also travel to the American Association of Small Ruminant Practitioners to speak to veterinarians about the application of VAI as a value-added tool for their clients.

Materials and Supplies ($6000). We anticipate purchasing supplies related to ram evaluation / collection and processing, and for the synchronization / insemination of ewes. We will use these supplies to supplement producers with hormonal treatments and disposables for their first VAI breeding season, and to provide training materials for a series of hands-on VAI courses.

Indirect Costs ($2118): The University requests the maximum allowed indirect costs under this program (7.5%).
Technical Objectives

Technical objectives of the expected work include 1) validating the Iceland VAI technique on Katahdin sheep in the U.S., 2) developing a VAI cooperative network for the collection of ram semen and for processed semen movement to breeders on Katahdin sheep farms throughout the U.S., and 3) developing on-line resources for VAI training that will be available to producers on Extension websites.

Responsiveness to NSIIC Stated Priorities (from web site)

The proposed work addresses NSIIC priorities # 1, 2 and 5:

**Priority 1: Strengthen and enhance the production and marketing of sheep and sheep products in the United States through the improvement of infrastructure, business, resource development and the development of innovative approaches to solve long term problems.**

A major goal of our project is to enhance the production of valuable Katahdin breeding stock through an increase in producer use of VAI, and distribution of processed semen for insemination. We plan to improve the infrastructure for disseminating ram genetics by helping Katahdin producers to organize around regional and national ram collection / processing centers that make economic sense to their industry.

**Priority 2: Provide leadership training and education to industry stakeholders.**

A component of this project is the training of Katahdin sheep producers to become competent in aspects of ram semen collection / packaging and VAI, including synchronization of ewe estrous cycles. We plan to achieve this goal through regional training sessions, and by posting training-related materials on an Extension website.

**Priority 5: Enhance the sheep industry by coordinating information exchange and by seeking mutual understanding and marketing within the industry community.**

One potential outcome of the proposed discussions with the Katahdin leadership / membership is the organization of the Katahdin Sheep breeding industry into regional centers where semen would be collected from multiple high NSIP index rams. Catalogues of available semen would be posted on-line, and semen would be marketed within the Katahdin breed (i.e., semen would be collected at a centralized location from Industry-selected rams and a plan would be developed for annual delivery to breeders). This would enhance the sheep industry by making superior Katahdin ram genetics available to breeders at a reasonable cost.

Prior USDA or other Federal Support

None.
Identification and significance of the issue being addressed

Katahdin sheep breeders have shown a remarkable interest in pooling their performance data into the National Sheep Improvement Program database, and they are beginning to see the fruits of their labor through the accurate identification of superior rams. While genetic selection based upon data is extremely important, it will not result in significant changes to the Katahdin Hair Sheep breed if the superior genetics are purchased as live rams, each of which will naturally breed ewes on only a handful of farms. Based on my conversations with Katahdin breed leaders (Lynn Fahrmeier (KHSA president) and Tom Hodgman (large Maine KHS breeder)) a great deal of producer interest is currently directed toward identifying a reproductive technology that will efficiently disseminate proven Katahdin ram genetics throughout the U.S. at low cost / labor. Vaginal artificial insemination of chilled / cryopreserved ram semen would be an ideal method for regional / national transport and insemination of ewes, if we can 1) document that it achieves commercially acceptable pregnancy rates in the Katahdin breed; and 2) develop an affordable nation-wide system of VAI-based semen distribution / producer training that will result in high rates of producer acceptance and use.

What are the goals to be achieved with this grant funding?

1. Inform producers about the various options available to them in artificial insemination, including costs and risks.
2. Teach producers how to collect and process semen from their rams for fresh semen VAI.
3. Identify, using field studies on five commercial farms, whether cryopreserved semen will result in high enough pregnancy rates to be a viable option for Katahdin breeders.
4. Organize discussions within the Katahdin Industry to compare various options for VAI against one another. Examples of options include; on-farm collection / processing of semen versus contracting of a centralized facility for ram work, and VAI with cryopreserved versus chilled semen. Our goal is to identify a protocol that makes economic sense and that can be accomplished by a majority of Katahdin breeders in the U.S.
5. Recruit livestock and reproductive veterinarians in sheep-dense regions of the U.S. to work with Katahdin breeders to implement VAI on their farms.

Work Plan – Task, Methodology, Individual responsible, and location where work will be done.

Dr. Weber will be responsible for all aspects of this grant, although some programming and organizing activities will be covered by a paid assistant. Work will be based out of the University of Maine in Orono (note that the Orono campus is about 70 miles away from Abbott, Maine, the birthplace of the Katahdin Hair Sheep breed). Much of the planned work in this grant will be in the field, either on commercial farms (VAI research studies – five farms inseminating 30 ewes apiece), at national Katahdin Sheep Breed meetings, or at veterinary conferences. On-line data and Standard Operating Procedures shared with producers will be housed on a University of Maine Cooperative Extension website. We have not yet identified an Industrial Partner who might be willing to centrally house Katahdin rams for semen collection / packaging and transport, but there are several large reproductive technology firms that will be invited to attend our VAI discussions.
Related Research or other efforts in this area of which you are aware, including an analysis of the competitive landscape if the award is for a commercial application.

While sheep researchers at other Experiment Stations are evaluating VAI as a reproductive technology, no one is asking “Industry” about their needs related to the use of artificial insemination. The proposed project is unique from existing work in two ways: we will be using methods of VAI that have been proven in hundreds of thousands of sheep over decades in Iceland and Scandinavia, and we will be working directly with sheep industry leaders to develop a system of AI that makes economic sense to producers.

Potential Post application in this area of development of research or commercial endeavor

If successful, the proposed work could potentially result in one or more regional or national reproductive centers where semen from genetically superior rams could be collected, packaged, and distributed to producers. Alternatively, discussions among veterinarians in livestock reproduction practices and owners of valuable Katahdin rams might lead to collaborations where the vets would expand their practice emphasis to include collection and packaging of ram semen. Selection of an economically viable model for VAI will ultimately depend on the willingness of Katahdin producers to invest animals, time and money to the project. My role in this process is to act as an informal mediator and to provide unbiased data on the positive / negative aspects of each VAI alternative.

Background and rationale (citation of publications if any)

The Katahdin Sheep breed has embraced the collection of breed-wide comparative performance data through the National Sheep Improvement Program (NSIP). Members now use a national NSIP database to identify their top sires, who are then purchased at national and regional sales to breed ewes through natural mating. However, natural mating results in the production of insufficient lambs to thoroughly evaluate an individual sire’s genetic contribution to his offspring, and limits the dissemination of genetic traits through the breed.

Artificial insemination (AI) has been used for decades in Europe, and has resulted in rapid rates of genetic improvement in European breeds. For example, the use of AI in the French sheep dairy industry between the 1960’s and 1990 resulted in an increase in milk production from 70 to 300 liters of milk per lactation (Barillet et al., 1993). In contrast, surgical AI, the only AI alternative available at present, has not been widely adopted in the U.S. because of its expense and technical difficulty. Vaginal AI (VAI) is a simple, inexpensive alternative to surgical AI that can be taught to producers, but it is underutilized in U.S. sheep due to a perception that VAI pregnancy rates are low. However, Scandinavian and Icelandic breeders have achieved high pregnancy rates for decades using VAI with chilled and frozen semen (Dyrmundsson et al., 2007), and there is evidence that Katahdin sheep can also achieve acceptable pregnancy rates using VAI (Wildeus et al., 2012). The widespread adoption of VAI is likely to accelerate the rate of genetic improvement in Katahdin Hair sheep and increase the profitability of Katahdin sheep breeders.


Relationship to industry, including technical, economic and social benefit

The U.S. sheep industry lags behind other U.S. livestock species in its rate of genetic improvement due to the lack of affordable and technically simple reproductive technologies that are available to commercial sheep producers. An insemination method such as VAI that can be completed by producers at low cost / labor with minimal investment / training will greatly increase the use of off-farm transported semen by U.S. sheep breeders, and will lead to increased rates of genetic gain in sheep breeds that practice centralized data gathering, including the Katahdin Hair Sheep breed. This genetic improvement will increase sheep owner profitability.

Cost benefit analysis

Vaginal (non-surgical) insemination, the reproductive technology that we hope to incorporate into the Katahdin sheep breeding industry, is a low-cost alternative when compared to the costs of existing methods of surgical (laparoscopic) insemination. Producers can be trained to perform VAI during a one-day course, while laparoscopic AI requires surgical skills of a large animal veterinarian, and the costs of equipment and supplies for VAI are much lower than what is needed to become equipped for laparoscopic insemination. The costs associated with obtaining, processing, storing and shipping semen for either surgical or vaginal AI are similar, but the cost structures for cryopreserved semen differ significantly from the costs to handle chilled semen. Costs to transport frozen semen in liquid nitrogen shippers are much higher than to ship chilled semen on ice packs, but frozen semen requires an expensive liquid nitrogen tank at the receiving farm. However, frozen semen VAI would be less complicated and expensive than chilled semen VAI because there would be no need to coordinate a shipment of semen to arrive within 12 hours of when an individual ewe ovulated.

Policy or decisions affected by results

The proposed work, if it results in the widespread incorporation of artificial insemination into the Katahdin Hair Sheep breed, may result in changes to the requirements for entering AI-bred sheep into the registry. For example, some livestock breeds have required DNA paternity testing for offspring produced through AI or embryo transfer. On individual farms, sheep producers will need to weigh the benefits / costs of a new system of VAI against their existing mechanism(s) for incorporating new genetics into their flocks.
CURRICULUM VITAE - JAMES A. WEBER
School of Food and Agriculture
5735 Hitchner Hall, University of Maine, Orono, ME 04469-5735
(207) 581-2774; FAX (207) 581-2729, jaweber@maine.edu

EDUCATION
University of Connecticut. BS (Biological Science). 1982.

EXPERIENCE
2008-2009, 2012-2013 University of Maine, Orono, Maine. Chair, Dept. of Animal and Veterinary Sciences
1995-present University of Maine. Associate Professor in Department of Animal and Veterinary Sciences.
2008 to present Attending Veterinarian, University of Maine, Bates College, and Husson University.

REFEREED PUBLICATIONS


BOOK CHAPTERS, PROCEEDINGS AND OUTREACH


GRANT PROPOSALS:


Weber, JA and Lichtenwalner, AB. Maine Technology Institute, Maine Technology Asset Fund Competition. 2009. Maine Agricultural and Aquatic Animal Technology Transfer and Diagnostic Lab. $5,000,000 requested. Not awarded.


USDA NRI-CGP Seed Grant (increasing reproductive efficiency). Sex determination of bovine embryos by noninvasive immuno-PCR. 1998-2001. $50,000 awarded.

University of Maine Regular Faculty Research Fund Award. Effect of Protein Synthesis Inhibitors on Cytoplasmic Maturation, mRNA Synthesis and Viability of Bovine Oocytes Matured and Fertilized In vitro. October 1996; $5800 awarded.

University of Maine Scientific Equipment and Book Fund. Funding request for veterinary ultrasound unit. February, 1995; $7000 awarded.

University of Maine Summer Faculty Research Award. Contribution of the uterine environment to postpartum infertility in dairy cows. January, 1995; $5000 awarded.
**Financial Feasibility** (i.e., Is the budget proportionate to the endeavor, and will the outcome have a financial benefit to the industry in the near term or will additional funding be required?)

The requested level of funding will fully cover the costs of the proposed project for an 18-month period, and will lead to completion of the stated objectives of this proposal. A project that results in a nation-wide system for disseminating Katahdin sheep genetics through VAI would be of great benefit to the U.S. sheep industry. Since Katahdin sheep are only one breed within the U.S. industry, additional funding would be needed to cover the costs associated with organizing economically relevant VAI centers in other sheep breeds that rely heavily on NSIP data (i.e., Targhee, Polypay, Suffolk, etc.)

**Business Soundness** (i.e., Are project participants qualified and experienced)

Dr. Weber, DVM, PhD, the Principal Investigator, is a large animal veterinary scientist with over 30 years of experience in large animal reproduction and infectious disease. He has published research in both male and female reproduction in a variety of species including livestock, horses and camelids. Dr. Weber has most recently been working with the Northeast U.S. sheep industry to develop region-specific methods for parasite control that work in areas with a severe winter, and that rely on non-chemical means to control outbreaks. Within this project, his lab has run over 5000 parasite diagnostic samples, and he has personally consulted about parasite management with over 300 commercial farmers throughout northern New England. Although he holds an Animal Science appointment at the U of Maine, Dr. Weber has worked closely with University of Maine Cooperative Extension experts in his work, including Dr. Anne Lichtenwalner (directs the Maine Animal Health Lab) and Dr. Richard Brzozowski (Extension administrator with long-term ties to the Northeast sheep and goat industries).

**Management Ability** (i.e., Are project participants qualified and experienced)

Dr. Weber is experienced in the management of large Federal grants, having been active as a Principal Investigator in an Animal Science department for nearly 25 years. He has also managed many grants funded by private industry, and he works with both agricultural and biomedical partners in Industry. Dr. Weber runs a reproductive physiology laboratory in Hitchner Hall in Orono, Maine, and also has access to sheep housing and data collection facilities, including facilities for collecting and processing ram semen, at the Witter Research and Teaching Center on the University of Maine’s Orono campus. As preparation for the proposed work, Dr. Weber recently taught a hands-on VAI course to local sheep producers (some Katahdin breeders, but many other breeds were represented). This course stressed many of the same discussions about economic models for VAI that will be the subject of the proposed study. The course filled up rapidly, and we had a very interactive day of teaching on September 9, 2017. Due to heavy demand from producers, we plan to teach a repeat of the course later this fall. This course will be modified to fit the needs of the Katahdin breeders, if the grant is funded. Copies of course materials are available on-line at; https://drive.google.com/file/d/0BjdGsBVMMVeVUmFCc2xfZjVvNnFXeWI5Q3phZ3BWZl8wR1BR/view?usp=sharing and https://drive.google.com/file/d/0BjdGsBVMMVeVWUdZMEFWWjFOWFI1TjU4MWRsRUJyYnNkTWpz/view?usp=sharing
Potential Industry Impact (i.e., How can the industry be expected to benefit in both qualitative and quantitative measures?)

The Katahdin Hair sheep breed, if its producers switch from natural breeding to artificial insemination, should experience a faster rate of genetic improvement for traits such as lamb weight gain, carcass muscling and leanness, fecundity, parasite resistance and out-of-season breeding ability. Incorporating desirable traits into Katahdin sheep will result in higher profits for producers due to increased sales of meat and breeding stock. Our plan for the proposed grant is to use it as a test case, with results being immediately available to the Katahdin industry. We then hope to take what we learned with Katahdin sheep and apply it to other U.S. sheep breeds that contribute data at high rates to NSIP (i.e., Polypay, Suffolk and Targhee breeds).

Industry Support (i.e., What data or other information is available to substantiate industry’s need or desire for this project?)

Interest in the application of artificial insemination is high in the Katahdin breed, as evidenced by discussions at national Katahdin meetings in recent years (personal communication, Tom Hodgman, Winterport, Maine). Additionally, a number of field studies have been completed with VAI in Katahdin sheep in Virginia, Ohio and in NY. All of these studies were carried out by Experiment Station or Cooperative Extension researchers, and data were collected on commercial farms, demonstrating that Industry is already supporting multiple efforts to incorporate VAI. The U.S. sheep industry as a whole is lagging behind other livestock species that use artificial insemination, and we are jeopardizing our consumer base because we cannot produce market lambs that produce a consistent food product at an affordable price. Progressive sheep producers are aware of our reduced competitiveness in the U.S. market, and realize that economically valuable qualities can be added to a flock through vaginal artificial insemination, if a cost effective system of processing, transport and distribution were in place.

CERTIFICATION

To the best of my knowledge and belief, all data in this application is true and correct. The document has been duly authorized by the governing body of the Applicant and the Applicant will comply with all Grant requirement if the assistance is awarded.

Signature

Digitally signed by Christopher E. Boynton
DN: cn=Christopher E. Boynton, o=University of Maine, ou=Office of Research & Sponsored Programs
date: 2017.09.15 15:44:25 -04'00'
Date 9-14-2017

Name of authorized representative:

Title Christopher Boynton, Director, ORA

Email umgrants@maine.edu

Phone 207 581-1484
Return this application to: stevelee@nsiic.org
If you prefer to send hard copies:
Steve Lee,
Executive Director and Program Manager
National Sheep Industry Improvement Center
Box 646
Rockland, Maine 04841
207-236-6567

For FedEx or Other Delivery Services:
32 Gleason St
Thomaston, ME 04861

Download form to your computer, complete it and save it to your computer prior to submitting to the Sheep Center.

Additional Information for Applicants:

Matching funds:
In order to leverage funds available, NSIIC will assign 10 points to any application in which a match of cash or in-kind labor is contributed. In-kind matches may only account for 50% of the total match. Additionally, salaries or other expenditures that will be made by the applicant or the applicant's employer, irrespective of a potential grant award, cannot be used as a match.
A subtraction of 10 points will be made from the total score of any application that includes an overhead budget of more than 7.5% of the total grant request. Request for capital expenditures are discouraged, and may not exceed 20% of the total budget in any event. Please justify any requested funding for equipment or other capital expenditures.

Notification to Applicants: Applicants will be notified via e-mail that their application has been received within a day or two of receipt: After Review, all applicants will be sent a notice to the e-mail of the person listed as the contact person on the application. That notice will be one of three possible responses: 1) Your application did not score high enough for funding consideration 2) Your application scored high enough for funding as submitted 3) Your application scored high enough for funding but with modifications needed in the budget. You will be given the opportunity to make those modifications for funding or you may reject the modifications in which case the grant funding offer will be withdrawn. Instruction will be included in the notice. Please note that the Review Committee will not provide feedback to applicants however in some cases the Board may elect to encourage re submission with certain specific changes (i.e. those the Board feels were good causes but poor application preparation or those with a good idea but not sustainable as presented). In some instances the Board may want to provide a written statement, with the understanding that no further discussion is available. Please note that proposals submitted more than twice will not be evaluated. The NSIIC Board request that applicants refrain from communicating with Board Members specifically about the project (i.e. Lobbying your project). Under no circumstances will applications arriving past the deadline for submission be considered.