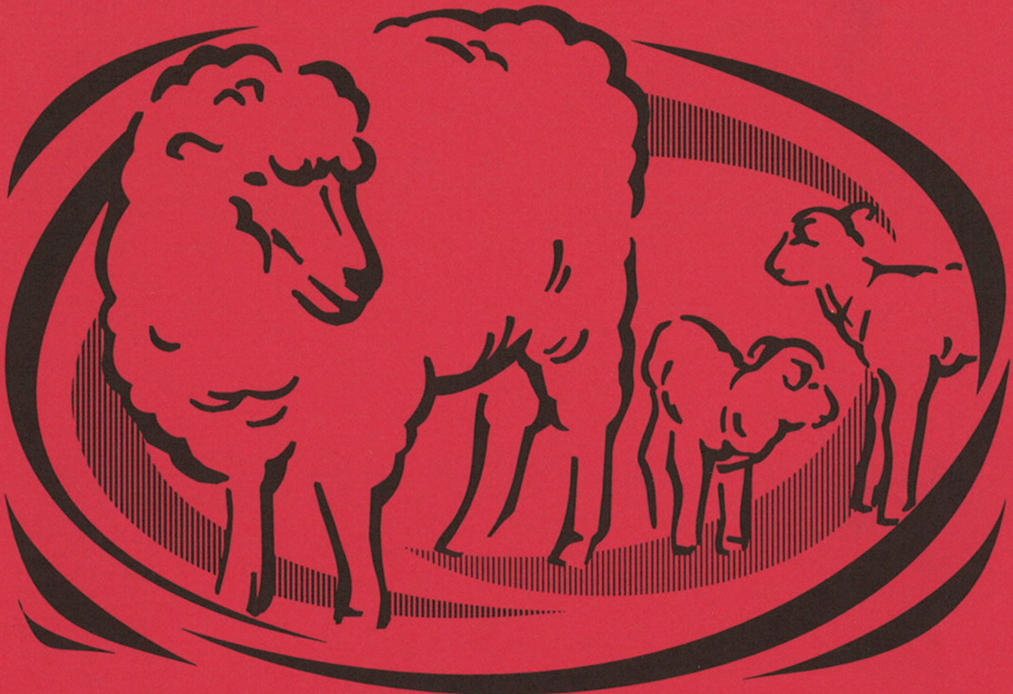
REPORT NO. 42



WESTERN DAKOTA SHEEP DAY

February 14, 2001

HETTINGER ARMORY

Hettinger Research Extension Center
and
Department of Animal and Range Sciences
North Dakota State University

February 14, 2001

Dear Sheep Producer:

On behalf of the Hettinger Research Extension Center and the Department of Animal and Range Sciences, let us welcome you to "Sheep Day". This report collectively represents North Dakota State University's efforts at both locations to provide information for the support of the sheep industry. We welcome your comments as grassroots users of the efforts of both Extension and Experiment Station resources. Your constructive comments assist us to participate meaningfully in the future of your industry.

A collective, positive and participatory attitude by producers and caretakers of their land grant resources will go far to solve problems confronting the sheep industry.

Best wishes for a day of sharing and learning.

Timothy C. Faller
Director
Hettinger Research Extension Center
NDSU, Hettinger, ND
(701) 567-4323

James Tilton
Chair
Dept. of Animal & Range Sciences
NDSU, Fargo, ND
(701) 231-7658

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PROGRAM

9:00-10:00 AM (MST)	**OPEN HOUSE** at barns to tour projects and view the rams on the "RAM TEST"
9:30 AM	**DOORS OPEN** - and coffee at Hettinger Armory (Adams County Farm Bureau)
10:10 AM	Early Bird Door Prize Drawing (for Columbia Ewe Lamb)
10:15 AM	**HETTINGER, FARGO, AND SDSU REPORTS** Paul Berg (Lean Lamb) Marc Bauer (Nutritional Studies) Jack Dahl, Luke Samuel, Donovan Craig and Mitch Faulkner (Grazing Studies) Jeff Held (SDSU Report) Tim Faller and Dan Nudell (EZ Sheep and Out-of-Season Lambing) Roger Haugen (Hair Sheep Discussion)
12:00 NOON	**LUNCH: AMERICAN LAMB DINNER**
1:00 PM	**WELCOME:** Keith Bjerke, Executive Director of University Relations North Dakota State University
1:10 PM	**"BASICS OF BAGGING FORAGE FOR A PROFIT"** (Presented by Kevin James of Ag-Bag Corporation)
2:00 PM	**"MANAGING A PROLIFIC FLOCK AND PREDATOR CONTROL USING A PASTURE SYSTEM"** Janet McNally, Hinkley, Minnesota
2:55 PM	**"EASY SHEEP AT MY PLACE - A PROSPECTUS"** Dean Swenson, Walcott, North Dakota Rancher
3:15 PM	**"SOUTHWEST FEEDERS REPORT"** Tim Faller, HREC and Dr. Woodrow Poland, DREC
3:25 PM	**"CLOSING COMMENTS"** Burt Pfliger, President North Dakota Lamb and Wool Producers Association

*Also featured that day at 1:00 PM will be **"FOOD FAIR"**
hosted by Adams County Family Community Education Clubs.

Colleen Svingen, Adams County Extension Agent and West River Health Services Wellness Educator, Hettinger, North Dakota will be the coordinator.

SHEEP DAY DIGEST

by
Timothy C. Faller, Director
Hettinger Research Extension Center
North Dakota State University

SECTION I
REPORTS OF RESEARCH IN PROGRESS
AT THE
HETTINGER RESEARCH EXTENSION CENTER
AND MAIN STATION
NORTH DAKOTA STATE UNIVERSITY

AT THE
42ND ANNUAL SHEEP DAY

HETTINGER RESEARCH EXTENSION CENTER
HETTINGER, NORTH DAKOTA

FEBRUARY 14, 2001

Year 2: Effects of Gonadotropin Treatment on Incidence of Estrus and Pregnancy Rate in Ewes Synchronized with Synchro-Mate-B (SMB) and Subjected to Laparoscopic Artificial Insemination (LAI) During the Breeding Season

D.A. REDMER[1], F. LOPES[1], J.T. CHOI[1], D.R. ARNOLD[1], C. NAVANUKRAW[1], W. LIMESAND[1], K.C. KRAFT[1], J.J. BILSKI[1], R. WEIGL, R.G. HAUGEN[1] A.T. GRAZUL-BILSKA[1], D.D. GOURLEY[2], AND L.P. REYNOLDS[1].

[1]*North Dakota State University, Fargo, and* [2]*Elite Genetics, Waukon, IA*

INTRODUCTION

Artificial insemination (AI) is a useful technique for improving reproductive performance in ewes as well as providing a means to introduce new genetics. Many different techniques have been used for AI; however, direct uterine insemination with the aid of a laparoscope has become the "industry standard" for AI in ewes because of the relatively high conception rates compared to other techniques (Gourley and Riese, 1990). Laparaoscopic AI (LAI) requires the use of estrus synchronization and timed insemination techniques, for LAI otherwise would be virtually impossible from a labor stand-point.

Herein we are reporting the results of Year 2 in a multi-year trial to study the use of gonadotropins in procedures to synchronize estrus in ewes. The protocols that we used in this study include a synthetic progestin implant to synchronize estrus along with pregnant mare's serum-gonadotropin (PMSG) to stimulate ovarian activity. Insemination is conducted at 58 - 60 hr after removing implants. Because, conception rates can vary widely, most likely due to variation in individual ovarian response to falling progestin levels and response to PMSG, this study was designed to test the importance of using PMSG at the time of implant removal, as well as, an injection of gonadotropin releasing hormone (GnRH) 36 hrs after implant removal in an effort to tighten the time of ovulation among individual ewes.

Data conducted from this study will provide valuable insight into improving the procedures used for timed-insemination in ewes.

MATERIALS AND METHODS

Materials and Methods are as reported last year (Redmer et al., 2000). Briefly, for Year 2, purebred Hampshire and Montadale ewes were implanted with SMB for 14 days and randomly assigned to one of four gonadotropin treatments (n=13/group) in a 2 x 2 factorial design (+/- PMSG and +/- GnRH). Ewes received i.m. injection of pregnant mare's serum-gonadotropin (PMSG; Folligon, Intervet, Whitby, Ontario; 400 IU) or vehicle (V1) at SMB removal and gonadotropin releasing hormone (GnRH; Cystorellin, Merial, Athens, GA; 25 μg) or vehicle (V2) at 36 hr after SMB removal. Vasectomized rams with markers were penned with the ewes at SMB removal and estrous activity was recorded. All ewes were subjected to LAI at 58-60 hr after SMB removal. Intact rams with markers were turned in with the ewes 10 days after LAI and rebreeding was recorded. Ewes were evaluated for pregnancy 35-40 days after LAI by real-time ultrasonography. LAI was conducted in the months of August and September.

RESULTS

Data regarding synchronization of estrus, estrus return rates, and pregnancy rates are presented in the following tables for Year 1 and 2, as well as combined data. No differences were observed among treatments (P>0.10; chi-square test) for pregnancy rates, however, across Year 1 and 2, a significant treatment effect was observed on expression of estrus.

Table 1. Year 1 Data (conducted Fall 1999; data taken from Redmer et al., 2000): Percentages in estrus, rebred, and pregnant for ewes synchronized with Synchro-Mate-B and then subjected to laparoscopic artificial insemination following various gonadotropin treatments during the breeding season.*

Treatment	n	% Ewes in Estrus† (n)	% Ewes Rebred (n)†	% Pregnancy Rate (n)†
V1/V2	19	89.5 (17)	52.6 (10)	47.4 (9)
V1/GnRH	20	70.0 (14)	40.0 (8)	50.0 (10)
PMSG/V2	18	77.8 (14)	38.9 (7)	66.7 (12)
PMSG/GnRH	21	90.5 (19)	47.6 (10)	47.6 (10)
Overall	78	82.1 (64)	44.9 (35)	52.6 (41)

*Estrus refers to the estrus after Synchro-Mate-B removal and gonadotropin treatment; rebred refers to breeding mark at next estrus; and pregnant refers to pregnancy diagnosed by ultrasonography at 35-40 days after LAI, and pregnant to LAI.

†No differences were observed among treatments (P>0.10) for % Estrus, % Rebred, or % Pregnant by Chi-squared test.

Table 2. Year 2 Data (conducted Fall 2000): Percentages in estrus, rebred, and pregnant for ewes synchronized with Synchro-Mate-B and then subjected to laparoscopic artificial insemination following various gonadotropin treatments during the breeding season.*

Treatment	n	% Ewes in Estrus† (n)	% Ewes Rebred (n)†	% Pregnancy Rate (n)†
V1/V2	13	100 (13)	38.5 (5)	61.5 (8)
V1/GnRH	13	85 (11)	46.2 (6)	53.9 (7)
PMSG/V2	12	100 (12)	25.0 (3)	75.0 (9)
PMSG/GnRH	13	100 (13)	30.8 (4)	69.2 (9)
Overall	51	96.1 (49)	35.3 (18)	64.7 (33)

*See note in Table 1.

†No differences were observed among treatments (P>0.10) for % Estrus, % Rebred, or % Pregnant by Chi-squared test.

Table 3. Combined Year 1 and Year 2 Data: Percentages in estrus, rebred, and pregnant for ewes synchronized with Synchro-Mate-B and then subjected to laparoscopic artificial insemination following various gonadotropin treatments during the breeding season.*

Treatment	n	% Ewes in Estrus (n)	% Ewes Rebred (n)†	% Pregnancy Rate (n)†
V1/V2	32	93.8 (30)	46.9 (15)	53.1 (17)
V1/GnRH	33	75.8 (25)[a]	48.5 (16)	51.5 (17)
PMSG/V2	30	86.7 (26)	30.0 (9)	70.0 (21)
PMSG/GnRH	34	94.1 (32)	44.1 (15)	55.9 (19)
Overall	129	87.6 (113)	42.6 (55)	57.4 (74)

*See note in Table 1.
[a]Different ($P<0.05$) from other treatments by Chi-squared tests.

†No differences were observed among treatments ($P>0.10$) for % Rebred, or % Pregnant by Chi-squared test.

DISCUSSION

As demonstrated in last year's study, the present data indicate that treatment with PMSG and/or GnRH does not improve the estrous response or pregnancy rate to timed insemination by LAI in seasonally estrous ewes synchronized with SMB. In fact, the combined Year 1 and 2 data suggest that GnRH may block the expression of estrus in some ewes. As discussed last year, PMSG frequently has been used in estrus synchronization programs in sheep. However, some potential short term and/or long-term risk occurs with the use of PMSG. Our objective was to determine if PMSG that is commonly used in estrous stimulation/synchronization procedures during seasonal anestrous is necessary for these same procedures during the breeding season. The results from Year 1 and 2 trials have shown that PMSG had no significant effect on percent of ewes expressing synchronized estrus or on percent of ewes conceiving to LAI, suggesting that PMSG may not be necessary in these procedures.

A second objective of this study was to determine if GnRH, which induces ovulation 24 hrs after treatment, could increase the conception rates to LAI by "forcing" ovulation at a desired time so that all oocytes would be at approximately the same stage of maturation at the time of insemination. The results from the combined data of the two trials showed that GnRH when used alone (no PMSG) reduced the percent of ewes expressing synchronized estrus by reducing the number of ewes expressing estrus after removal of SMB. This effect was likely due to the fact that GnRH forced a few ewes to ovulate before they would have normally expressed estrus. However the data for these two trials indicate that GnRH had no adverse effect on conception rates. These data do continue to suggest that use of GnRH has no distinct advantage in this protocol.

Although Year 1 trial showed that 64 percent of the ewes that expressed estrus after synchronization conceived to LAI, whereas only 53 percent of the total number of ewes conceived to LAI, Year 2 trial showed that all ewes expressed estrus in all treatment groups except for GnRH alone.

Results from Year 1 and 2 continue to indicate that there is no advantage to using PMSG and/or GnRH in this particular timed LAI procedure. It is important to note that the data reported herein is based on approximately 30 animals per treatment group. A larger scale study would be necessary to detect small but significant effects. Future studies regarding the optimization of procedures used to synchronize estrus in ewes both during and after the breeding season will provide improved pregancy rates and overall success of these assisted reproductive techniques.

ACKNOWLEDGMENTS

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Effects of epidermal growth factor (EGF) on oocyte maturation, in vitro fertilization (IVF) and blastocyst formation in ewes treated with follicle stimulating hormone (FSH)

A.T. Grazul-Bilska, J.T. Choi, J.J. Bilski, R. Weigl, K.C. Kraft, J.D. Kirsch, L.P. Reynolds, and D.A. Redmer

Department of Animal and Range Sciences, North Dakota State University, Fargo, ND 58105

INTRODUCTION

The world population is increasing at dramatic rates; therefore, the demand for meat and milk products will continue to grow (CAST, 1999). Consumers also are demanding a more uniform, higher quality, nutritious product at a low price, requiring producers to raise animals that meet these specific demands. Altering herd genetics is a slow and expensive process because of the limitation of having a set number of offspring produced by each animal. However, through the use of assisted reproductive technology (ART) each animal has the ability to produce an increased number of offspring, thereby allowing the producer to more easily alter herd genetics to meet the consumers demands. Using ART, such as induction of superovulation, IVF or embryo transfer, farmers will be able to increase the number of offspring produced by genetically superior parents.

New introductions and improvements to ART have facilitated the creation, advancement and preservation of animal genetics as well as continued improvement of animal reproductive efficiency (Gordon, 1997). In sheep reproduction, ART has been introduced to obtain multiple embryos, in vivo or in vitro, and to obtain transgenic or cloned animals (Schnieke et al., 1997; Wilmut et al., 1997; Cognie, 1999). To obtain large numbers of oocytes (eggs) or embryos from ewes, the method of inducing follicular development with follicle stimulating hormone (FSH) is widely used (Gordon, 1997; Cognie, 1999; Stenbak et al., 1999, 2000). Optimal culture conditions are critical to obtain the high rates of fertilization and blastocyst formation for embryo transfer or cryopreservation (Jablonka-Shariff et al., 1994, 1996; Gordon, 1997). Media containing gonadotropins, estradiol, growth hormone, and growth factors including EGF and/or other supplements have been shown to exert positive effects on oocyte maturation, IVF and blastocyst formation in several species including sheep (Longergan et al., 1996; Izadyar et al., 1998; Lim and Hansel, 1999; Abeydeera et al., 2000; Guler et al., 2000; Watson et al., 2000). The aim of this study was to determine the effects of EGF on the rate of fertilization and blastocyst formation in vitro in sheep in which multiple follicles development was induced with FSH.

MATERIALS AND METHODS

Ewes of mixed breeds (n=15) that exhibited an estrous cycle of normal duration (15-17 days) immediately proceeding the treatment were used for these experiments during the reproductive season of fall and winter 2000. Day 0 of the estrous cycle (standing estrus) was determined by using vasectomized rams. Beginning on day 13 of the estrous cycle, all ewes received twice daily i.m. injections of FSH for two days (on day 13, 5 units/injection, and on day 14, 4 units/injection) as described before (Stenbak et al., 1999, 2000). On day 15 ewes were slaughtered and ovaries collected.

The number of follicles was counted on each ovary and oocytes were then collected using a 22-gauge 1-inch needle and a syringe containing approximately 0.2 ml of collection media that consists of TCM-199 (Sigma, St. Louis, MO), 2% heat inactivated fetal bovine serum (FBS; Gibco, Gaithersburg, MD), heparin (Sigma), and penicillin/streptomycin (Watson et al., 1994; Stenbak et al., 1999, 2000).

By using a stereoscope, dish with oocytes was searched and the recovered oocytes were transferred to a petri dish with fresh collection media without heparine. Oocytes were then evaluated based on morphology and categorized as healthy or atretic according to Thompson et al. (1995). All oocytes were washed three times in maturation media (TCM-199, 10% FBS, ovine FSH [oFSH-RP-1; NIAMDD-NIH, Bethesda, MD], ovine LH [oLH-26; NIADDK-NIH], estradiol [Sigma], glutamine [Sigma], sodium pyruvate [Sigma], and penicillin/streptomycin; Watson et al., 1994). For each ewe, half of the oocytes was incubated in stabilized (incubated overnight under oil at 39^0 C, 5% CO_2, and 95% air) maturation media without addition of EGF, and other half was incubated in the same media containing 10 ng of EGF (Sigma). Dose of EGF was chosen on the basis of previously published experiments (Longergan et al., 1996; Abeydeera et al., 2000; Guler et al., 2000).

The oocytes were matured for 21-24 hours at 39^0 C, 5% CO_2, and 95% air followed by cumulus cells were removal by using a 1% hyaluronidase (Type I-S; Sigma) treatment. Then, the oocytes were again evaluated for health based on morphology (Thompson et al., 1995). Oocytes classified as healthy were used for in vitro fertilization (IVF). The oocytes were transferred to stabilized fertilization media, consisting of synthetic oviductal fluid (SOF; Tervit et al., 1972) and 2% heat inactivated sheep serum collected from sheep on day 0-1 of the estrous cycle (O'Brian et al, 1997; Brown and Radziewic, 1998; Wang et al., 1998).

Frozen semen, which was pooled from 4 Hampshire rams, was thawed and viable sperm were separated using the swim up technique (Yovich, 1995). In the swim up technique, the healthy and viable sperm from a semen fraction swim into the media (Modified Sperm Washing Medium, Irvine Scientific, Santa Ana, CA) which lays on top of the thawed semen pool. This media containing the motile sperm was then centrifuged, counted and used for in vitro fertilization. 0.5-1.0 x 10^6 sperm/ml was added to the oocytes (up to 20 oocytes/500 µl/well). The oocytes were incubated with the sperm for 17-20 hours at 39^0 C, 5% CO_2, 5% O_2 and 90% N_2. Then, the embryos were washed three times with culture media without glucose (SOF supplemented with BSA, glutamine, MEM amino acids, BME amino acids [Sigma], and penicillin/streptomycin; Catt et al., 1997), and cultured at the same media for 36 h at 39^0 C, 5% CO_2, 5% O_2 and 90% N_2. The dishes were then evaluated to determine the number of cleaved zygotes. The cleaved zygotes were then washed three times in culture media (SOF) containing glucose (Stenbak et al., 1999). After 48 h, developmental stage of zygotes was evaluated and zygotes were transferred to fresh culture media with glucose. On day 8-9 of culture (day 1=day of fertilization) presence of blastocysts was determined.

Statistical analysis

All data are reported as means $\pm$ the standard errors. Data were analyzed by using general linear models (GLM) procedure of the Statistical Analysis System (SAS, 1985) with the main effect of EGF presence in the maturation media. When the F-test was significant ($P<0.05$), differences between specific means were evaluated using Bonferroni's multiple comparison procedure (Kirk, 1982). Correlations between specific parameters were evaluated by using SAS.

RESULTS

For all ewes, number of follicles was 25.0±2.4/ewe, number of recovered oocytes was 22.1±2.1/ewe, oocyte recovery rate was 88.3±2.7/ewe, number of healthy oocytes was 17.7±1.6/ewe, number of atretic oocytes was 4.4±0.7/ewe and percentage of healthy oocytes was 80.9±2.0/ewe.

Total number of oocytes used for IVF was 232, 109 oocytes were incubated without EGF, and 123 oocytes were incubated with EGF.

EGF affected morphology of cumulus oocyte complex (COC). After maturation, cumulus cells were more expanded in cultures with EGF than in cultures without EGF.

Table 1 shows the effects of EGF on the rates of fertilization, and morula and blastocysts formation.

Table 1. Effects of EGF on parameters of IVF procedures. Data are expressed per one ewe.

	No of oocytes used for IVF	No of cleaved zygotes	No of not fertilized oocytes	Fertilization rate (%)	No of cultured zygotes	No of morulas on day 6-7	% of morulas on day 6-7	No of blastocysts on day 8	% of blastocysts on day 8
0 ng EGF/ml	7.8±0.8	5.7±0.7	2.1±0.4	73.8±5.1	4.6±0.4	1.9±0.4	39.1±7.7	0.6±0.2	13.4±4.3
10 ng EGF /ml	8.2±0.9	6.5±0.9	1.7±0.3	78.1±4.1	5.2±0.8	2.2±0.6	40.5±8.5	1.4±0.7	21.0±6.6
P value for 0 vs 10 ng of EGF	0.730	0.487	0.432	0.512	0.496	0.668	0.905	0.245	0.352
Overall (no EGF effects)	15.5±1.7	11.9±1.6	3.5±0.6	75.7±3.9	8.9±1.3	3.9±1.0	40.6±7.1	1.9±0.8	18.4±4.9

All parameters were similar ($P>0.05$) for no treated and EGF treated COC. However, the number of blastocysts on day 8 of culture tended ($P<0.25$) to be greater in the EGF-treated group. The rate of blastocyst formation (% of blastocysts on day 8) was positively correlated (0.490, $P<0.06$) with number of follicles/ewe.

DISCUSSION

Assisted reproductive technologies are powerful tools in animal industry for genetic improvement and also for enhancing reproductive efficiency. For ART methods to be efficient, the number of follicles and the number of oocytes and embryos obtained from animals must be optimized. In this regard, existing protocols for oocyte retrieval, maturation, and in vitro fertilization techniques need improvements especially in terms of consistency of the responses.

For ART, induction of multiple follicles is only effective if multiple oocytes or embryos can be collected (Gordon, 1997). In the present study, we stimulated follicular growth with FSH-treatment for two days which resulted in induction of about 25 follicles per ewe. This length of FSH-treatment has been shown to be beneficial for obtaining high number of oocytes and for high rates of fertilization (Stenbak et al., 1999).

In this experiment, the rate of in vitro fertilization was 76%, and the rate of morula and blastocyst formation was 41% and 18%, respectively. Similar rates of fertilization were reported by others for sheep (68%, Slavik, et al., 1992; 70%, Stenbak et al., 1999; 72%, Ledda, et al., 1997; 74%, Dattena et al., 2000; 80%, O'Brien, et al., 1996, 1997; 72-83%, Watson, et al., 1994). However, in other studies, the rate of morula and blastocyst formation ranged from 15 to 70% (Gardner et al., 1994; Watson et al., 1994; Thompson et al., 1995; O'Brien et al., 1996, 1997; Walker et al., 1996; Wang et al., 1998; Dattena et al., 2000). These differences probably are due to media composition, culture conditions, age of oocyte donor, and breed of ewes.

Numerous supplements of maturation, fertilization and/or culture media have been tested to improve production of embryos in vitro (Gardner et al., 1994; Watson et al., 1994; Thompson et al., 1995; Holm et al., 1996; O'Brien et al., 1996, 1997; Walker et al., 1996; Ledda et al., 1997; Wang et al., 1998). In addition to gonadotropins and estradiol, growth factors including EGF have been demonstrated to have some positive effects on oocyte maturation, IVF, and blastocyst formation in several species (Longergan et al., 1996; Park et al., 1997; Izadyar et al., 1998; Rieger et al., 1998; Lim and Hansel, 1999; Abeydeera et al., 2000; Guler et al., 2000). EGF is present in the ovaries of several species, and affects cellular functions through EGF receptors (Reeka et al., 1998; Yoshida et al., 1998; Qu et al., 2000). In the present experiment, EGF increased formation of blastocysts from 0.6 to 1.4/ewe. This demonstrates that in the presence of EGF, formation of blastocysts doubles, which confirms previously published reports. These results indicate and confirm previous reports that EGF is a very important supplement to maturation media and it should be recommended for use in in vitro embryo production in FSH-treated sheep. The results of this study could ultimately lead to improved and efficient methods for obtaining large numbers of high quality oocytes and embryos for transfer programs. Improvement in these techniques will enhance the overall efficiencies of ART for farm use.

ACKNOWLEDGEMNTS

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A Preliminary Report on Pregnancies from Transfer of In Vitro Generated Sheep Embryos at NDSU

J.T. CHOI, D.A. REDMER, D.R. ARNOLD, F.L. LOPES, C. NAVANUKRAW, J.J. BILSKI, K.C. KRAFT, R.M. WEIGL, J.D. KIRSCH, L.P. REYNOLDS, AND A.T. GRAZUL-BILSKA

Dept. of Animal and Range Sciences, North Dakota State University, Fargo

INTRODUCTION

The first embryo transfer (ET) in sheep was reported more than 60 years ago (Warwick et al., 1934). However, the application of embryo transfer in sheep has been more extensively developed in the past 10 years (Gordon, 1997). One obvious area of commercial significance has been employing ET to expand the population of a particular breed or genotype which is in demand (Warwick et al., 1934). Perhaps more importantly, the use of many of the modern biotechnologies that recently have been reviewed by Reynolds and Redmer (1998) require the use of embryo production, manipulation and transfer technologies. The development of specific culture regimes in the laboratory capable of supporting in vitro maturation (IVM) and in vitro fertilization (IVF) of eggs (oocytes) and subsequent development to a multicellular stage, the blastocyst stage, has continued unabated in recent years (Gardner, 1998; Krisher and Bavister, 1998) largely due to the importance of IVF to the ET industry. However, the current knowledge about the exact requirements for oocyte maturation and culture conditions for embryos through different developmental stages is not complete (Wang et al., 1998). For example, length of culture and culture conditions can greatly affect pregnancy rates after ET. The transfer of embryos at the 2-cell stage was shown to be low (Slavik et al., 1992). However, pregnancy rates can be increased by culturing embryos in vitro to the morula or blastocyst stage, which in turn would allow for selection based on embryo viability before transfer (Cognie, 1999). Unfortunately, growth becomes retarded or arrested in many embryos during extended culture. At NDSU, our goal in present studies is to begin to establish procedures for successful IVM and IVF of sheep oocytes (see Report by Grazul-Bilska et al. herein), as well as to examine pregnancy rates when IVF embryos are transferred shortly after fertilization (i.e., 2-4 cell stage) and after extended culture (morula/blastocyst stage). Herein we report, to the best of our knowledge, the first IVF pregnancies in sheep in North Dakota. These lambs will be born in spring of 2001. The use of superovulation, oocyte collection, in vitro oocyte maturation, in vitro fertilization, in vitro culture, and embryo transfer were used to culminate in the established pregnancies in this report.

MATERIALS AND METHODS

Briefly, oocytes were collected from FSH stimulated ewes and were matured and subjected to IVF as described by Stenbak et al. (2000) and a report herein (Grazul-Bilska et al.). Following IVF and culture, embryos were transported to a surgical facility and embryos were transferred to ewes under general anesthesia by laparotomy. Two-cell and 4-cell embryos were placed directly into the oviduct at the isthmus-ampulla junction in ewes that were on day 2 of the estrous cycle. Morula and blastocyst embryos were placed directly into the anterior portion of the uterine horn in ewes that were on day 7 of the estrous cycle. Embryos were always placed in the horn ipsilateral to the ovary containing a corpus luteum. Two or three embryos were transferred to the same location for each ewe. Pregnancy was verified by real-time ultrasonography after day 40 from ET.

RESULTS

Table 1. Established pregnancies from embryo transfer of in vitro generated sheep embryos.

Stage of Development	Number of Ewes Receiving IVF Embryos	Number of Pregnancies
2 or 4-cell	7	3
Morula/Blastocyst	12	6

DISCUSSION

Herein we report several pregnancies in ewes that were implanted with in vitro fertilized and developed embryos. This is significant because of the need for these techniques in the successful application of modern biotechnologies to the North Dakota livestock industry. Although this study is of a preliminary nature, much progress has been made in implementing these tools into the repertoire of techniques required for successful IVF and embryo transfer. Future studies will focus on optimizing each of the many steps required for in vitro fertilization and embryo transfer.

ACKNOWLEDGMENTS

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Influence of concentrated separator by-product (CSB) on intake, digestion, and nitrogen balance in wether lambs

S.M. Shellito, J.S. Caton, C. Navanukraw, H.B. Encinias, E.R. Loe and M.L. Bauer
Department of Animal and Range Sciences,
North Dakota State University, Fargo

INTRODUCTION

The northern Great Plains has growing conditions that support production of sugar beets. Molasses, one of the by-products of sugar beets known to stimulate intake in some animal diets, can now be further processed into a product of higher crude protein and ash. This product, known as concentrated separator by-product (CSB) results from the extraction of much of the remaining sugar present in molasses prior to the separation process. Concentrated separator by-product may increase feed consumption in ruminants and may be a valuable protein supplement in livestock feeds. Additionally, protein may be the first limiting nutrient in low quality forages, in which case, supplementation is needed. This trial was designed to compare feed intake, digestibility, and N balance in wether lambs fed CSB mixed with a basal hay diet or offered separately.

SUMMARY

An experiment was conducted to evaluate how sheep consuming low quality forage responded to CSB when mixed with forage or offered separately. Experimental design was a 5x5 Latin square where every wether received each of the five diets once. Dietary treatments were 0, 10, or 20% CSB mixed with hay as a proportion of diet dry matter (DM). Concentrated separator by-product was offered separate from hay in equal amounts with the 10% CSB mixed diet for the fourth treatment (10% separate) and urea was added to forage with N equivalent to the 10% CSB mixed diet as a positive control (fifth treatment). Dietary intake was greater in lambs fed CSB added diets ($P = .01$) compared with non-supplemented or urea-supplemented hay. Dry matter digestion increased with CSB ($P = .01$).

MATERIALS AND METHODS

Five wether lambs (97.0 ± 3.3 lb initial weight) were used to evaluate the effects of CSB on intake, digestion, and N balance. Lambs were housed in individual pens and placed in metabolism crates during collection periods. Feed and water intake were measured daily at 0700 for each animal and urine and feces were collected. At the end of each collection period, lambs were weighed and transferred to prior pens. Lambs had access to trace-mineralized salt during the trial and were offered ad libitum access to feed and water. Concentrated separator by-product for the fourth treatment was offered with fresh hay daily. The diet containing urea was similar in N content to the 10% CSB hay and was mixed with hay as a solution using a compression sprayer. Basal forage was 7.7% CP.

RESULTS AND DISCUSSION

Dry matter intake increased when CSB increased but forage dry matter intake between 0% and 10% CSB offered separate remained similar. Nitrogen balance as a percent of N digested and as a percent of N consumed increased linearly with CSB ($P < .03$). Additionally, N balance was greater when 10% CSB was offered separately compared with 10% and 20% CSB mixed diets ($P < .05$). Although lambs fed CSB separately had improved N balance compared with CSB mixed diets, DM and OM digestibility were greater when CSB was mixed with forage ($P < .02$). Digestion of NDF and ADF were similar among all treatments. Compared with molasses, CSB is higher in crude protein and may be considered a valuable supplement in less palatable feeds.

CONCLUSION

Data supports that CSB, either mixed or offered separately, stimulates intake and increases DM, OM, and N digestion when offered to lambs fed mature grass hay. When CSB is added to forage above 10%, fiber digestion may be reduced. The effects of CSB on intake and digestion are not completely explained by N addition, but when added in moderate proportions, CSB improves intake and N balance.

Table 1. Effect of CSB on Intake and N digestion

	Treatment					
	% CSB					
Item	0	10	20	10 separate	Urea	SEM
Intake						
Total DM, lb/day	1.8^{a}	2.4^{b}	2.8^{c}	2.1^{d}	1.9^{ad}	0.1
Forage DM, lb/day	1.8^{a}	2.2^{b}	2.2^{b}	1.9^{a}	1.9^{a}	0.1
Water, lb/day	4.2^{a}	7.0^{b}	9.0^{c}	6.4^{b}	4.3^{a}	0.3
Digestion, %						
DM	50.8^{ac}	52.3^{ac}	58.7^{b}	52.9^{a}	48.9^{c}	1.5
OM	52.4^{ab}	54.3^{b}	59.7^{c}	50.6^{ab}	49.3^{a}	1.9
N	35.1^{b}	38.6^{b}	49.8^{a}	50.0^{a}	36.5^{b}	2.4
NDF	56.3	57.6	60.3	58.1	54.8	1.9
ADF	52.0	52.1	55.3	54.5	50.5	1.6
N balance, % of						
N intake	3.2^{ab}	2.7^{ab}	12.6^{b}	17.1^{c}	-2.6^{a}	3.4
N digested	0.7^{ab}	6.4^{ab}	24.5^{bc}	34.4^{c}	-8.0^{a}	8.8

[a,b,c,d] Means within a row with different superscripts differ ($P<.10$).

EFFECTS OF PREPARTUM HIGH LINOLEIC SAFFLOWER SEED SUPPLEMENTATION FOR GESTATING EWES ON COLD TOLERANCE AND SURVIVABILITY OF LAMBS

H. B. Encinias[1], A. M. Encinias[1], T. C. Faller[2], M. L. Bauer[1], and G. P. Lardy[1]
[1]Department of Animal and Range Sciences, NDSU, Fargo
[2]Hettinger Research Extension Station, NDSU, Hettinger

INTRODUCTION

Mortality of lambs due to cold stress is a problem during winters and cold, wet springs in the Northern Great Plains. Lambs produce heat through shivering and non-shivering thermogenesis. Brown adipose tissue is the origin of the non-shivering portion. Research has shown that feedstuffs high in linoleic acid increases brown fat and increases cold tolerance of calves. High linoleic safflower seeds may be an economical source of linoleic acid.

Safflower is an oilseed crop that is becoming increasingly popular in this area. According to Farm Service Agency estimates, approximately 49,000 acres of safflower were raised in North Dakota in 1998. Seeds from the high linoleic varieties can contain up to 75% linoleic acid. In addition, the seed is a high energy feed and a good source of rumen degradable protein, making it an ideal winter feed.

The objectives of this study is to determine the effects of supplementing high linoleic safflower to gestating ewes 45 days prior to lambing on lamb performance and cold tolerance.

PROCEDURES

Experiment 1 was conducted at the Hettinger Research Extension Center. One hundred twenty-two gestating ewes (166.8 ± 16.7 lb initial weight) were allotted randomly to one of two dietary treatments (4 pens per treatment). Ewes received diets equal in calories and crude protein, containing either 4.6 (high fat; HF) or 1.9% (low fat; LF) dietary fat. Diets consisted of alfalfa and a supplement and were fed beginning approximately 45 days before lambing. Rolled safflower seeds (32% fat; 75% linoleic acid) served as the supplemental fat source in HF. Solvent extruded safflower meal was used as protein source in LF supplement and energy was balanced with corn. All pens were offered same amounts of feed throughout trial. Initial and final ewe body condition and weights were measured. In addition lamb birth weights, morbidity, and mortality were also measured.

In experiment 2, 20 gestating ewes (183.7 ± 0.9 lb initial weight) were housed individually at the NDSU Animal Research Center and assigned randomly to either the LF or HF treatment. All ewes received ad libitum access to the same basal diet (37.5 % grass hay, 37.5% alfalfa hay, 25% corn silage; DM basis) in addition to a supplement. Rolled safflower seeds were supplemented in HF while LF supplement contained 64.5% corn, 30.5% safflower meal, and 5.0% molasses. Diets were equal in protein and energy. Prepartum ewe performance was monitored by body weight. Lamb birth weights were recorded. One lamb from each ewe was selected randomly to be slaughtered. Perirenal and pericardial brown fat was excised and weighed, and carcass was frozen for compositional analysis.

RESULTS AND DISCUSSION

In experiment 1, initial ($P = 0.43$) and final ($P = 0.91$) body condition of ewes were similar; however, ewes fed LF supplement gained more weight ($P = 0.05$) during the 45 day supplementation period (Table 1). Birth weights of lambs (Table 2) were not different ($P = 0.47$). Numerically, lambs from HF dams had higher survivabilities. More LF lambs died due to starvation ($P = 0.06$) and pneumonia ($P = 0.14$).

In experiment 2, ewe body weight increased throughout the trial ($P < 0.001$) but was similar between treatments and basal diet dry matter intake decreased ($P < 0.001$) over the trial in both treatments (Table 3). Lamb birth weight was not different ($P = 0.51$). Brown fat weights were similar for the perirenal ($P = 0.88$) deposit and when the deposits were combined ($P = 0.37$). LF lambs tended to have more pericardial fat ($P = 0.12$). Lamb carcasses were similar in fat ($P = 0.92$) and crude protein ($P = 0.65$). HF carcasses tended to be higher in ash ($P = 0.18$)

CONCLUSIONS

High linoleic safflower seeds may be beneficial in improving lamb survivability and tolerance to cold. Supplementation does not seem to affect lamb birth weight, perirenal or pericardial fat mass, or carcass constituents. However, additional research in this area is needed before making strong conclusions and both trials are being repeated in the current year.

Table 1. Effect of safflower supplementation on ewe performance in Exp. 1

Item	Treatment		
	HF	LF	SEM
Weight, lb			
Initial	166.1	167.5	1.5
Final BW	202.8[a]	209.2[b]	2.2
Change	36.7[c]	41.7[d]	1.4
Body condition score*			
Initial BCS	3.3	3.4	0.1
Final BCS	3.9	3.9	0.1
BCS change	0.6	0.5	0.1

*1=emaciated, 5=obese
[a,b]Row means with different superscripts are different ($P = 0.10$)
[c,d]Row means with different superscripts are different ($P = 0.05$)

Table 2. Effect of safflower supplementation of birth weight and morbidity in Exp. 1

Item	Treatment HF	Treatment LF	SEM
Birth weight, lb	13.3	12.5	0.8
	----------------% of ewes----------------		
Lambs	165.48	149.40	0.16
Live	89.77	82.95	0.06
Dead	7.11	15.41	0.73
Born dead	5.39	2.63	0.84
Starvation	1.14[a]	8.28[b]	0.31
Pneumonia	0.00	1.27	0.46

[a,b]Row means with different superscripts are different ($P = 0.06$)

Table 3. Effect of safflower supplementation on ewe performance in Exp. 2

Item	Treatment HF	Treatment LF	SEM
Weight, lb			
Initial	183.7	183.8	1.5
Final	200.6	206.6	1.5
Dry matter intake			
Initial 7 days, lb	7.81	7.92	0.17
Final 7 days, lb	4.84	6.58	0.17
Initial 7 days, % BW	1.94	1.97	0.08
Final 7 days, % BW	1.11	1.43	0.08

Table 4. Effect of safflower supplementation on variables in lambs in Exp. 2

	Treatment		
Item	HF	LF	SEM
Birth weight, lb	11.6	11.9	0.3
Brown fat, g	0.194	0.209	0.011
Pericardial, g	0.032	0.036	0.003
Perirenal, g	0.162	0.164	0.005
Carcass composition, %			
Fat	15.17	15.11	0.45
Crude protein	69.24	69.71	0.72
Ash	21.33	17.43	1.95

LEVEL OF RUMEN DEGRADABLE INTAKE PROTEIN (DIP) IN HIGH-GRAIN DIETS FED TO FEEDLOT LAMBS

E. R. Loe, A. M. Encinias, M. L. Bauer, G. P. Lardy, and J. S. Caton
North Dakota State University, Fargo

Impact statement

Degradable intake protein does not appear to limit performance of feedlot lambs fed a corn based diet containing 7.3% (dry matter basis) undegradable intake protein.

Summary

Eighty Hampshire crossed ram lambs (85.0 ± 0.7 lb initial weight) were used to determine the degradable intake protein level in corn-based diets. Dietary treatments were 0% urea-0% SBM, 0.33% urea-3% SBM, 0.67% urea-6% SBM, and 1.0% urea-9% SBM. A quadratic ($P = 0.09$) response to dry matter intake occurred, lambs consuming the 0.33 and 0.67% diets had the highest intakes. A similar response (quadratic; $P = 0.10$) occurred when expressing intake as a percentage of body weight, peaking at 0.33 and 0.67% urea. There was a tendency (quadratic; $P = 0.12$) for hot carcass weight to decrease from a peak at the 0.33% diet. Rib-eye area linearly ($P = 0.05$) decreased as level of DIP increased. Leg score responded cubically ($P = 0.07$), lambs consuming 1.0% urea had the greatest leg score.

Introduction

Little research has been conducted to determine the metabolizable protein requirements for lambs. The Beef NRC (1996) came out with a metabolizable protein (MP) system where MP is the sum of microbial protein and rumen undegradable protein (UIP; bypass protein). Degradable intake protein (DIP) is incorporated into microbial protein; microbial protein and undegradable intake protein flow to the small intestine where digestion takes place. Research conducted at NDSU on lambs fed corn-based diets found that an increase in dietary UIP (5.4 to 7.3%) increased lamb feed efficiency; however, an increase in dietary DIP (8.9 to 11.0%) did not change performance leaving the optimal level of DIP in high-grain diets in question. The lack of response with additional DIP in high-grain diets is converse to the response generally seen in beef cattle fed high-grain diets. The objective of this study was to determine the optimal level of DIP in high-grain finishing lamb diets.

Materials and Methods

In determination of the optimal level of DIP in corn-based diets fed to finishing lambs, 80 Hampshire crossed ram lambs were fed for 38 days (3 pens/treatment) and 60 days (2 pens/treatment). Lambs were weighed on three consecutive days, blocked by weight, and allotted randomly to dietary treatment. Lambs (4/pen) were housed at the NDSU Animal Research Center in Fargo. Diets contained dried beet pulp pellets as the roughage source instead of hay to avoid feed sorting problems and insure intake of a balanced diet. Urea and soybean meal were the degradable intake protein sources; whereas, feathermeal and bloodmeal (4:1; feathermeal:bloodmeal) were the undegradable intake protein sources. Dietary treatments (Table 1) were formulated to contain a minimum 13.4% crude protein, 0.7% Ca, 0.3% P, 0.6% K, and 2.05 Ca:P. Level of UIP was held constant at 7.3% across all treatments. Final weights were an average of three consecutive day weights. Lambs were marketed for slaughter when they were thought to have approximately 0.2 inch fat thickness. Carcass data was taken on all lambs.

Results and Discussion
Feeding urea up to 1.0% in a high-corn diet did not appear to be detrimental to lamb growth (Table 2). Dry matter intake responded quadratically ($P = 0.09$) being greatest with 0.33% and 0.67% urea and lowest with 1.0% urea in the diet. A similar response (quadratic; $P = 0.10$) occurred when dry matter intake was expressed as a percentage of body weight. No other treatment affects on performance occurred; gain and feed efficiency were similar among treatments.

Rib-eye area decreased linearly ($P = 0.05$) with increase in level of DIP. Leg score responded quadratically ($P = 0.07$), with lambs consuming the 1.0% urea diet having the highest leg scores. There were no other affects on carcass characteristics (Table 3) with respect to treatment.

Conclusion
The optimal level of DIP fed to feedlot lambs with the ability to gain at least 1.06 lb/day does not appear to be greater than 6.1% of the diet dry matter; however, feeding levels between 6.1 and 11.0% does not affect gain or feed efficiency.

Table 1. Formulated dietary treatments

	Level of rumen degradable intake protein, % dry matter basis			
Item	6.1	7.7	9.4	11.0
Dry-rolled corn	74.0	71.5	69.0	66.5
Beet pulp pellets	12.5	12.5	12.5	12.5
Molasses	5.0	5.0	5.0	5.0
Soybean meal	0.0	3.0	6.0	9.0
Urea	0.0	0.33	0.67	1.00
Feathermeal	3.48	3.00	2.52	2.04
Bloodmeal	0.87	0.75	0.63	0.51
Supplement	4.15	3.92	3.68	3.45
Protein [a]				
Crude	13.4	15.0	16.7	18.3
Rumen degradable	6.1	7.7	9.4	11.0
Rumen undegradable	7.3	7.3	7.3	7.3
Metabolizable	8.6	8.7	8.7	8.8

[a] Calculated from book values

Table 2. Effect of treatment on performance.

Item	Level of rumen degradable intake protein, % dry matter basis				Error
	6.1	7.7	9.4	11.0	
Weight, lb					
Initial	84.8	85.2	85.0	84.8	0.7
Final	132.9	133.6	133.4	132.6	1.6
Dry matter intake					
lb/day [a]	3.71	3.79	3.80	3.63	0.07
% of body weight [a]	3.40	3.46	3.47	3.33	0.06
Average daily gain, lb	1.06	1.08	1.08	1.06	0.03
Gain:Feed	0.285	0.282	0.282	0.291	0.005
Feed:Gain [b]	3.51	3.54	3.54	3.44	--

[a] Quadratic response to treatment ($P < 0.10$)
[b] Feed:Gain calculated as Gain:Feed. Feed:Gain is a reciprocal of Gain:Feed

Table 3. Effect of treatment on carcass characteristics.

Item	Level of rumen degradable intake protein, % dry matter basis				Error
	6.1	7.7	9.4	11.0	
Hot carcass weight, lb	65.6	67.6	65.6	64.8	0.8
Fat thickness, in	0.19	0.18	0.19	0.17	0.02
Rib-eye area, in^2 [a]	2.67	2.59	2.51	2.50	0.06
Bodywall thickness, in	0.78	0.74	0.78	0.69	0.05
Marbling [b]	427	397	387	396	17
Flank streaking [b]	461	445	453	459	12
Yield grade	2.26	2.18	2.30	2.06	0.18
Leg score [c]	11.4	11.4	11.3	11.7	0.1
Conformation score	11.4	11.3	11.0	11.3	0.2

[a] Linear response to treatment ($P = 0.05$)
[b] Marbling or flank streaking score of 400 = small (low choice)
[c] Cubic response to treatment ($P = 0.07$)

EFFECTS OF MULTI-SPECIES GRAZING ON LEAFY SPURGE (Euphorbia esula L.) INFESTED RANGELAND USING ROTATIONAL GRAZING
(A Three-Year Summary)

[1]Luke Samuel, [1]Kevin K. Sedivec, [2]Timothy C. Faller, [2]Jack D. Dahl, and [3]Lyndon L. Johnson

[1]Animal and Range Sciences Dept., North Dakota State University, Fargo, ND 58105.
[2]Hettinger Research Extension Center, Hettinger, ND 58639.
[3]USDA, Forest Service, Eagle, CO 81631.

Introduction
Leafy spurge is a plant widely dispersed across the northern hemisphere, including the United States and Canada, with a distribution center in the Caucasus Region of Asia (Croizat 1945 in Noble and MacIntyre 1979). This plant is found on every continent except Australia (Lacey et al. 1985). Leafy spurge is believed to have been introduced into mainland North America before 1872 (Callihan et al. 1991). Leafy spurge now infests thirty-nine states in the United States including every northern state and every Canadian province except Newfoundland (Lacey et al. 1985). One million hectares (two and a half million acres) in North America are infested by leafy spurge (Noble et al. 1979 in Noble and MacIntyre 1979), with an estimated 400,000 hectares (one million acres) in North Dakota (N.D. Dept. of Agriculture 1996).

Traditional approaches for controlling leafy spurge, e.g. herbicides, are becoming cost prohibitive as this noxious weed continues to spread. Many forms of biological and cultural controls have come into practice over the past twenty years. Grazing sheep on leafy spurge infested rangeland is one such cultural control. Cattle do not graze leafy spurge and often avoid leafy spurge-infested communities, creating opportunities for multi-species grazing with sheep. Multi-species grazing is the concurrent use of rangeland by more than one kind of animal, and this approach utilizes more than one class of vegetation (Merrill et al. 1966). Cattle and sheep grazing has the potential to reduce leafy spurge density, increase plant species richness, and improve the economic viability of a cattle operation on leafy spurge infested rangelands.

Research Objectives
The objectives of the study were to determine if simultaneous grazing of leafy spurge infested rangeland with cattle and sheep employing a twice-over-rotational grazing system in concert with biological control will (1) reduce leafy spurge density compared to season-long grazing and (2) enhance livestock grazing efficiency compared to season-long grazing.

Study Area and Design
This project was conducted on leafy spurge infested rangeland in western North Dakota from 1998 through 2000. The study area is located approximately ten kilometers (six miles) north of Sentinel Butte or 240 kilometers (150 miles) west of Bismarck, North Dakota. Two tracts of rangeland of 257 and 160 hectares (635 and 395 acres) comprise the replicated multi-species grazing trial

in the Badlands vegetative region of North Dakota. Vegetation in this region is typical of northern mixed grass prairie and is classified as a wheatgrass-grama-needlegrass (Agropyron, Bouteloua, Stipa) plant community (Barker and Whitman 1989). Leafy spurge infested approximately forty to fifty percent of the land on these two study sites.

The research tested the effect of twice-over rotation (TOR) and season-long (SL) grazing on leafy spurge infested rangeland using multi-species grazing with cattle and sheep in conjunction with a biological control program. Each of two tracts of land were blocked into four cells with one cell randomly selected as SL treatment. The remaining three cells in each replicate were grazed using TOR grazing treatment. Two 0.40 hectare (one acre) exclosures were developed on each replicate by stratifying each treatment and randomly selecting points for development. The four exclosures, containing forty to fifty percent leafy spurge, were excluded from grazing and classified as biological control treatments.

Fifty permanent 100-meter line transects were systematically located in leafy spurge clumps (26 transects) and native range (devoid of leafy spurge) vegetation sites (24 transects) throughout the replicates to monitor changes in leafy spurge stem density and plant species richness. Barbour et al. (1999) defined density as the number of plants rooted within each quadrat. Species richness is simply the number of species per unit area; diversity is a combination of richness and evenness, i.e., species richness weighted by species evenness (Barbour et al. 1999). Peet (1974 in Ludwig and Reynolds 1988) termed this "the dual concept of diversity," i.e., diversity combines species richness and relative species abundance.

Four transects were located in each cell of the TOR grazing treatments, eight transects in each SL treatment, and two in each of the biological control cells (0.40 hectare exclosures). In addition, two permanent line transects designed to monitor effects of leafy spurge on rangeland without grazing, biological, or other management were located in areas dominated by leafy spurge adjacent to each replicate.

Leafy spurge density and graminoid species frequency is collected every five meters using a 0.10 square meter frame and forb and shrub density and frequency is collected every five meters using a 0.25 square meter frame on the 100-meter line transects.

Livestock performance and production data is collected for cattle and sheep for determination of average daily weight gain and gain per area. Livestock are weighed at the beginning and end of each grazing season.

Treatment and year effects for leafy spurge stem density, and livestock performance were analyzed using a general linear model (GLM) (SPSS 1999). A mean separation was performed when significant ($P < 0.05$) differences were found using Tukey's Honesty Significant Difference.

Grazing Treatments and Grazing Plan

Cattle grazed each treatment from 1 June through 15 September while stocked in accordance with the recommended carrying capacity of the land as outlined in USDA Natural Resources Conservation Service technical guidelines (1984). Sheep grazed from 15 May through 15

September while stocked at forty percent of carrying capacity without adjustments to cattle numbers.

Carrying capacity of the TOR grazing treatment is 142.4 animal unit months (AUMs) and 73.6 AUMs on replicates #1 and #2, respectively. Stocking rates of the TOR grazing treatments were 0.28 AUMs/acre for both replicates #1 and #2. Type of cattle grazed is Angus-Hereford cross cow/calf pairs with cows weighing approximately 545 kilograms (1200 pounds). Thirty-six cow/calf pairs grazed replicate #1 and 18 cow/calf pairs grazed replicate #2. Since sheep will be stocked at forty percent of carrying capacity, sheep will graze 57.5 AUMs (replicate #1) and 33 AUMs (replicate #2) on the TOR grazing treatments. Type of sheep was mature white-faced ewes of which 86 head grazed on replicate #1 and 45 head grazed on replicate #2.

Carrying capacity of the SL grazing treatment was 39.6 and 33.9 AUMs on replicates #1 and #2, respectively. Stocking rates of the SL grazing treatments were 0.31 and 0.32 AUMs/acre on replicates #1 and #2, respectively. Type of cattle grazed is Angus-Hereford cross cow/calf pairs with cows weighing approximately 545 kilograms (1200 pounds). Ten cow/calf pairs grazed replicate #1 while 8 cow/calf pairs grazed replicate #2. Since sheep will be stocked at forty percent of carrying capacity, sheep will graze 16 AUMs (replicate #1) and 15 AUMs (replicate #2) on the SL grazing treatments. Type of sheep grazed is mature white-faced ewes, with 23 head on replicate #1 and 20 head on replicate #2.

Livestock graze the SL treatment continuously throughout the grazing season. Livestock graze the TOR grazing treatment as one herd and rotate simultaneously. The entire herd of cattle and sheep graze one cell at a time, grazing forty percent of the available carrying capacity of the cell in the first rotation and sixty percent of available carrying capacity in the second rotation.

Results and Discussion

After three grazing seasons, leafy spurge stem densities were significantly reduced ($P<0.05$) on the TOR Upland and Lowland sites from 1998 to 2000. Significant ($P<0.05$) difference was also found when comparing stem densities at TOR vs. SL Upland and Lowland sites (Table 1).

Cow average daily gain (ADG) was not significantly ($P>0.05$) different between TOR and SL treatments. However, cow ADG was lower ($P<0.05$) in 1999 compared to 1998 and 2000 on the TOR treatment. Calf ADG was not ($P>0.05$) difference between TOR and SL treatments for all three years. However, Calf ADG was lower ($P<0.05$) in 1998 then 2000 on the TOR (Table 2).

There was no ($P>0.05$) difference in ewe ADG between TOR and SL treatments over the three years of the study. Ewe ADG was higher ($P<0.05$) on SL and TOR treatments in 1999 compared to 1998 and 2000 (Table 3).

Table 1. Leafy spurge stem densities on the season long (SL) and twice-over-rotation (TOR) grazing treatments in 1998, 1999, and 2000.

Treatment[1]		1998[2]	2000[2]	% Change from 1998 to 2000
		# Stems/ 0.10 m^2		
Seasonlong				
	Control	13.9 ± 1.3^{ax}	12.8 ± 1.4^{ax}	-7%
	Upland	9.7 ± 0.8^{ax}	10.8 ± 1.3^{ax}	11%
	Lowland	18.4 ± 1.1^{ax}	15.6 ± 1.3^{ax}	-15%
Twice-over				
	Control	8.8 ± 0.8^{ax}	8.9 ± 1.3^{ax}	1%
	Upland	9.1 ± 0.6^{ax}	6.3 ± 0.5^{bz}	-31%
	Lowland	18.2 ± 0.8^{ax}	9.2 ± 1.0^{by}	-49%

[1] Treatments with the same letter are not significantly different ($P \leq 0.05$) (a, b, and c).
[2] Years with the same letter within each treatment are not significantly different ($P \leq 0.05$) (x, y, and z).

Table 2. Cow and calf average daily gains (ADG) for the season long (SL) and twice-over-rotation (TOR) treatments from 1998, 1999, and 2000.

Treatment		1998	1999	2000
			lb/day	
Cows				
	Seasonlong	$1.13 \pm .12^{ax}$	$0.01 \pm .14^{ay}$	$1.21 \pm .13^{ax}$
	Twice-over Rotation	$0.80 \pm .08^{ax}$	$0.07 \pm .07^{ay}$	$0.78 \pm .10^{ax}$
Calves				
	Seasonlong	$2.23 \pm .08^{ax}$	$2.28 \pm .08^{ax}$	$2.43 \pm .06^{ax}$
	Twice-over Rotation	$1.99 \pm .05^{ax}$	$2.19 \pm .07^{axy}$	$2.22 \pm .04^{ay}$

[1] Treatments with the same letter, for the same class of livestock, are not significantly different ($P \geq 0.05$) (a, b, and c).
[2] Years with the same letter, for the same class of livestock, within each treatment are not significantly different ($P \geq 0.05$) (x, y, and z).

Table 3. Ewe average daily gains (ADG) for season long (SL) and twice-over-rotation (TOR) treatments during the 1998, 1999, and 2000 grazing seasons.

Treatment[1]	1998[2]	1999[2]	2000[2]
	lb/day		
Seasonlong	0.21 ± .01^{ax}	0.35 ± .02^{ay}	0.26 ± .02^{ax}
Twice-over	0.20 ± .003^{ax}	0.36 ± .009^{ay}	0.25 ± .005^{ax}

[1] **Treatments with the same letter are not significantly different ($P \leq 0.05$) (a, b, and c).**
[2] **Years with the same letter within each treatment are not significantly different ($P \leq 0.05$) (x, y, and z).**

Summary

The preliminary results from this multi-species grazing trial are encouraging. The addition of sheep to a cattle only grazing operation was shown to effectively reduce leafy spurge stem densities. To date, the TOR treatment had better control over the three years of the study, with both SL and TOR grazing treatments reducing leafy spurge stem densities. Stocking rates for the two replicates remained the same for the duration of the study with no treatment effects occurring on livestock performance. Overall, cattle and sheep grazing simultaneously did not adversely affect the ADG of cows, calves, or ewes. Multi-species grazing is a good alternative for leafy spurge control while allowing for an increased carrying capacity of the land with no adverse affects on livestock performance.

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INFLUENCE OF DIET TYPE AND MIXED MICROBIAL EXTRACT (MME) TREATMENT ON INTAKE, DIGESTION, AND NITROGEN RETENTION IN GROWING RAM LAMBS

T. L. Lawler, M. L. Bauer, V. I. Burke, T. C. Gilbery, G. P. Lardy, and J. S. Caton
Department of Animal and Range Sciences, NDSU, Fargo

Introduction

Yeast and fermentation products have been on the market and have been tested for several years. An increase in dietary IVOMD and soluble Nitrogen was found when Olson et al. (1994) supplemented beef cattle grazing mixed-grass rangeland with a yeast culture. These researchers also concluded that intake, in situ NDF and CP digestion increased at various times through the study. Caton et al. (1993) found intake and digestion measurements to be altered with *Aspergillus oryzae*, a fermentation product, when supplemented to steers on cool season grasses. The mixed microbial extract (Cilk; Enviro Consultants Service, Evergreen, CO) in this trial may be similar to other yeast and fermentation products, yet as a new product little information is available. The goal of this study was to examine MME and its results in the areas of intake, digestion and nitrogen retention.

Summary

Four diets were fed ad libitum to crossbred growing ram lambs. Two diets were forage-based and two diets were concentrate-based. One of each, forage and concentrate, included MME at company recommendations (0.125% of diet dry matter). Mixed microbial extract was found to have no effect on nitrogen intake or DM digestibility, but affected fecal DM and ADF digestion. Additional research seems warranted to follow up on these results.

Materials and Methods

Sixteen crossbred ram lambs (112.2 ± 3.3 lbs BW) were used in a completely randomized design. Lambs were housed at NDSU Ruminant Nutrition Research Center. There were four lambs per treatment. Lambs on the forage-based diet were fed alfalfa pellets and a corn-based supplement. The concentrate-based diet was 59% ground corn with beet pulp pellets, alfalfa pellets, and a premix supplement. MME was included in the totally mixed ration for the concentrate diet and as a component of the corn-based supplement for the forage-based diet. Forage-based lambs received their supplement daily just prior to receiving fresh alfalfa pellets daily at 0700. Concentrate-based lambs received fresh feed at 0700. Lambs were adapted to diets for 14 days followed by seven days of total fecal, urine and intake collections. Samples were analyzed for dry matter, ash, organic matter, crude protein, NDF, ADF, and starch by standard laboratory procedures. Data was analyzed by analysis of variance and P-values < 0.1 are considered significant.

Results

As shown in table 1, DMI was higher (4.07 vs 3.04 lbs/d; 3.6 vs 2.7 % of BW; $P < 0.02$) and DM digestibility lower (47.6 vs 81%; $P < 0.01$) in lambs fed alfalfa pellets compared with concentrate. The low digestion coefficients associated with alfalfa pellets are likely due to high intakes and high rates of passage. Mixed microbial extract did not affect DMI or DM digestion ($P > 0.60$). Mixed microbial extract increased ($P < 0.01$; 31.2 vs 26.1 %) fecal DM and resulted in less ($P=0.09$) total fecal water excretion (4.94 vs 3.23 lbs/d for MME and control, respectively). Dry fecal output was not affected ($P=0.64$) by MME. Mixed microbial extract increased ADF Digestion (48 vs 53%; $P = 0.05$) when included in the diet. Diet type increased ($P<0.01$) both NDF (37 vs 64% for forage and concentrate respectively) and ADF digestion (31 vs 54% for forage and concentrate respectively). Table 2 indicates nitrogen intake (61.8 vs 34.4 g/d) was greater ($P < 0.01$) in alfalfa- compared with concentrate-fed lambs. Feeding MME had no influence ($P > 0.30$) on nitrogen intake or digestibility.

Conclusion

These data suggest that form of diet alters intake and DM digestion while MME does not. However, ADF digestion was improved with MME. In addition, MME did increase fecal DM, which may have waste management implications.

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Table 1: Influence of diet type and MME on intake and digestion in growing ram lambs.

	Diet		Cilk			P-Values		
Item	Alfalfa	Conc	Without	With	SE	Diet	Cilk	Diet + Cilk
Body wt, lbs	112.2	112.2	110.0	116..6	3.3	0.98	0.17	0.72
DMI, lbs	4.07	3.04	3.66	3.46	0.26	0.02	0.59	0.74
DMI, % BW	3.6	2.7	3.4	2.7	0.22	0.02	0.23	0.80
Digestion								
DM	48	81	63	65	2.3	0.01	0.42	0.69
NDF	37	64	48	53	2.4	0.01	0.15	0.88
ADF	31	54	38	46	2.6	0.01	0.05	0.40
Starch	90	99	94	95	0.4	0.01	0.21	0.57
Fecal DM, %	25	32	26.1	31.2	0.01	0.01	0.01	0.45
Fecal Output DM, lbs	2.14	0.60	1.44	1.30	0.13	0.01	0.48	0.64
Fecal Output Water, lbs	6.81	1.36	4.94	3.23	0.67	0.01	0.09	0.21

Table 2: Influence of diet type and MME on Nitrogen metabolism in growing ram lambs.

	Diet		Cilk			P-Values		
Item	Alfalfa	Conc	Without	With	SE	Diet	Cilk	Diet + Cilk
N Intake, g	62	34	49	47	3.8	0.01	0.72	0.57
Fecal N, g	27	11	20	18	1.7	0.01	0.48	0.53
Apparent N Digestion, %	56	69	62	63	1.3	0.01	0.48	0.78
Urine N, g	25	15	19	21	1.4	0.01	0.30	0.21
N balance, g	10	9.0	10.4	8.0	2.4	0.86	0.49	0.22
N balance, % N Digestion	24	38	35	28	5.9	0.13	0.41	0.17
N retention, % N intake	14	25.9	21	18	3.4	0.03	0.55	0.16

Nutrient Composition, Productivity, and Growth of Selected Warm-season Grasses: Preliminary Report

Donovan Craig[1], Kevin Sedivec[1], Dwight Tober[2], Irwin Russell[2], and Timothy Faller[3]

[1]Graduate Student and Extension Rangeland Specialist, Animal and Range Sciences Dept., NDSU, Fargo; [2]Plant Materials Center Supervisor and District Conservationist, Natural Resources Conservation Service; [3]Director, Hettinger Research Experiment Center, Hettinger, ND.

Cooperators: North Dakota State University, Animal and Range Sciences, Fargo, ND; USDA, Adams County Soil Conservation District, Hettinger, ND; USDA, Plant Materials Center, Bismarck, ND; North Dakota State University, Hettinger Research Experiment Center, Hettinger, ND.

Introduction

Warm-season grasses are planted in North Dakota for mid to late summer pastures, hay land, wildlife habitat, roadside right-of-ways, and set aside acres. However, warm-season plantings are somewhat atypical in North Dakota due to dominating cool-season species. New varieties/cultivars of warm and cool-season grasses have been established and released by plant materials centers around the country. Grasses of the same species can take on different growth forms due to their point of origin. These ecotypical species, or cultivars, have great potential for adding more diversity to a producer's forage supply. Whatever a producer desires from a grass species, evaluation of cultivars can have great importance to decision-making.

Meeting the nutritional requirements of domestic livestock is the key to optimizing performance on and off pasture. Crude protein (CP) content, acid detergent fiber (ADF), and total digestible nutrients (TDN) comprise the majority of values needed to develop feed requirements for domestic livestock (Nutrient Requirements of Beef Cattle 1996). It is generally accepted that as grasses mature, they decline in nutritional quality. Knowledge of the nutritional concentrations of these warm-season grasses can be used by livestock producers to obtain optimum performance through best-use management and timely supplementation during the grazing season when nutritional requirements are deficient.

Many ranchers in the northern Great Plains have an overabundance of cool-season forage and would benefit from a complementary system involving high quality warm-season grasses in July and August (Tober and Chamrad 1992, Conard and Clanton 1963, Krueger and Green 1976). Likewise, many cost cutting measures are focused on the mechanical side of ranching, when more attention should be directed towards cutting feed costs (Ricketts 1994). To best suit these needs, nutritional content of the grasses, production potential, and best use based on plant maturity and production are needed to address these concerns. With the advent of such knowledge and the potential to improve cattle performance on a regional basis, a need has developed to determine the nutrient content and production potential of selected warm-season grasses in the Northern Great Plains region.

The primary objectives of this study are to 1) determine and compare the nutrient content by date and phenological growth stage of 16 selected warm-season grasses, 2) determine and compare herbage production levels of these selected 16 warm-season grasses, and 3) develop management recommendations on proper use of these grasses.

Study Area

Two locations were selected for this study, one near Hettinger, ND and a second near Pierre, SD. The Hettinger site is located on private land approximately 3 kilometers south of Hettinger, ND. It lies on the Verbar-Flasher-Parshall soil association, with a sandy loam soil texture (Ulmer and Conta 1987). The Pierre site is located north of Ft. Pierre, SD, on land managed by the U.S. Army Corps of Engineers. Soil on the Pierre site is a Promise clay with nearly level slope, a high shrink-swell potential, and restrictive root growth (Bismarck PMC, 1992).

The climatic condition in both sites is a continental climate characterized by continuous air movement and large annual, daily, and day-to-day temperature changes. Relative humidity is low and precipitation tends to be irregular in time and cover (Jensen 1972). Average annual precipitation in the Hettinger and Pierre study sites is approximately 40.6 cm. Most precipitation occurs during the growing season. Seventy-seven percent of the annual precipitation falls during the summer months, with 50 percent falling during May, June, and July (Bavendick 1952). On average for the year, the temperature is 44 to 48 degrees F with a 130 to 160 day freeze-free period.

Temperatures were normal to above normal during the field season during the summer of 1999. From mid to late July, extreme temperatures occurred throughout much of the country, with temperatures reaching 100+ degrees F in the Pierre area for consecutive days. Precipitation was variable throughout the summer at both locations. The Pierre area received above average precipitation for the year (23 in or 46.6 cm) while the Hettinger area was relatively dry receiving 80 percent of its normal precipitation. The 2000 study year was similar to 1999 with warm temperatures and normal to below normal precipitation.

Grasses Studied

Sixteen grasses were selected to be analyzed for nutrient and forage production in 1999 and 2000. A total of eight grass species were tested encompassing 16 cultivars (Table 1).

Table 1. List of grass species and cultivar of each warm-season grass tested near Hettinger, ND, and Pierre, SD 1999.

Grass Species	Common Name	Cultivar	Origin
Andropogon gerardii	Big bluestem	Bison	ND
Andropogon gerardii	Big bluestem	Sunnyview	SD
Andropogon hallii	Sand bluestem	Garden*	NE
Andropogon hallii	Sand bluestem	Goldstrike*	NE
Bouteloua curtipendula	Sideoats grama	Butte	NE
Bouteloua curtipendula	Sideoats grama	Pierre	SD
Bouteloua gracillis	Blue grama	Bad River*	SD
Bouteloua gracillis	Blue grama	Willis*	ND
Calamovilfa longifolia	Prairie sandreed	Goshen	WY
Calamovilfa longifolia	Prairie sandreed	ND-95	ND
Panicum virgatum	Switchgrass	Dacotah	ND
Panicum virgatum	Switchgrass	Forestburg	SD
Schizachyrium scoparium	Little bluestem	Badlands*	SD, ND
Schizachyrium scoparium	Little bluestem	Camper	NE
Sorghastrum nutans	Indiangrass	Holt	NE
Sorghastrum nutans	Indiangrass	Tomahawk	SD, ND

* Grass cultivar was not sampled at Pierre, SD site.

Methods and Materials

Nutritional quality and herbage production were determined from ungrazed, non-mowed warm-season grass clippings. An array of 16 warm-season grass cultivars were seeded in 2m by 8m plots at the Hettinger site on 20 May 1997. An array of 33 warm-season cultivars were seeded in 3.5m by 15m plots at the Pierre site on 20-21 May 1986; however, only 11 of these 33 cultivars were analyzed in this study. Seeding rate varied with species but followed recommended seeding rates as specified in the North Dakota Natural Resource Conservation Service Technical Guide. Species with no specified seeding rates were planted at 20-25 seeds/0.1m^2. Three replicated arrays were developed and each grass cultivar randomly seeded in each array to create a randomized complete block design (RCBD).

This nutritional quality and forage production trial began in June 1999. Six sample collection dates were selected at three-week intervals beginning in June and ending in October of 1999. In 2000, seven collections dates were selected at three-week intervals beginning in May and ending in October. Samples from both locations were collected from each plot using a 0.5 m2 frame placed in its designated quadrant as randomly selected for each clipping period. Grasses were clipped to 1 cm stubble with plant tissue placed into a paper bag for future preparation. Clipping date and phenological growth stage was recorded for all grass cultivars at each clipping period. Forage production was determined for the Pierre, SD and nutritional quality determined for both sites in 1999. Each of the grass cultivars were analyzed for crude protein (CP), in vitro dry matter digestibility (IVDMD), acid detergent fiber (ADF), neutral detergent fiber (NDF), phosphorus (P), calcium (Ca), copper (Cu), zinc (Zn), magnesium (Mg), sodium (Na), iron (Fe), potassium (K), and manganese (Mn).

All samples were oven dried at 60 degrees Celsius, measured for production, ground through a 1 mm screen in a Wiley mill, and analyzed for dry matter, ash, minerals, CP, IVDMD, ADF, and NDF at the North Dakota State University, Animal and Range Sciences nutritional laboratory. Dry matter, ash, minerals, and ADF were determined following standardized procedures (AOAC 1990), NDF using procedures described by Robertson and Van Soest (1982), CP using the Kjeldahl Auto System II (AOAC 1990), and IVDMD using methods outlined by Tilley and Terry (1963).

Data was analyzed to determine differences at the 0.05 percentile ($P<0.05$) between time periods and grass species and cultivars. Analysis comparing differences in nutrient quality and herbage production between time periods will be conducted using one-way analysis of variances as performed using Statistical Procedures for Social Sciences (1999). When significant differences occurred, means were separated using Tukey's Honesty Significant Difference (Steel and Torrie 1980).

Results and Discussion

Production

Most varieties reached peak herbage productivity by early August, with some exceptions occurring in July or September. Species or cultivars that matured earliest included blue grama, sideoats grama, and 'Dacotah' switchgrass. Sand bluestem, little bluestem, and 'Sunnyview' big bluestem were species or cultivars that tended to mature later. In addition, cultivars of a northern origin can be expected to mature earlier than southern varieties; therefore, one might expect southern cultivars to produce more herbage. However, this is highly dependent on site characteristics such as soil and microclimatic influence. The north-south origin difference among selected cultivars ranges from North Dakota to Nebraska (Table 1). One of the main limiting factors to production in the northern Great Plains is the soil moisture deficit common in late August and September (Rogler and Haas 1947).

The highest producing grasses at Pierre were 'Forestburg' and 'Dacotah' switchgrass, with cumulative production (peak production plus regrowth) 4,065 and 3,320 pounds per acre respectively (Table 2). Overall productivity did not differ between the two study locations ($P=0.756$). However, there was a variety by location interaction effect ($P<0.05$). Sideoats grama varieties had different levels ($P<0.05$) of production based on location. At Hettinger, 'Butte' and 'Pierre' sideoats grama achieved peak production levels of nearly 3000 pounds per acre; however, the Pierre location had levels closer 200 pounds per acre (Tables 3 and 4). Varieties of big bluestem, Indiangrass, and prairie sandreed produced more herbage at the Pierre location, where stands of Indiangrass were poor to nonexistent at the Hettinger site. Consequently, it must be stressed that soil type and characteristics such as water holding capacity be determined prior to seeding a grass species or cultivar. Shorter grasses like sideoats grama and blue grama produce more in upland sandy sites similar to the Hettinger location; whereas, taller species prefer low to midland sites similar to the Pierre location.

A significant year effect was detected for the Pierre location. 'Forestburg', 'Bison', 'Sunnyview', 'Goshen', and 'Holt' were cultivars that produced more herbage ($P<0.05$) in 2000 than 1999. Other cultivars showed no difference ($P>0.05$) between 1999 and 2000. Sideoats grama cultivars were the only grasses that had a reduction ($P<0.05$) in 2000. Although production was not evaluated at Hettinger in 1999, it is the belief of the investigators that production in 1999 was similar to that in 2000.

Table 2. Production levels at each date (dry lbs/acre) among 11 select warm-season grasses at Pierre, SD in 1999.

	Date					
Species (Variety)	6/23	7/13	8/5	8/24	9/15	10/6
Big bluestem (Bison)	1158	2198	2420	1343	1940	1381
Big bluestem (Sunnyview)	874	2103	2192	1446	1691	862
Sideoats grama (Butte)	116	228	353	340	378	257
Sideoats grama (Pierre)	270	485	615	329	775	462
Prairie sandreed (Goshen)	626	1234	1306	1034	1168	1125
Prairie sandreed (ND-95)	1200	1813	2834	1419	1458	1437
Switchgrass (Dacotah)	1877	2716	2548	2421	3193	2084
Switchgrass (Forestburg)	851	1855	2997	1939	3002	1798
Little bluestem (Camper)	394	1157	1915	932	1989	1114
Indiangrass (Holt)	270	915	1909	717	1405	702
Indiangrass (Tomahawk)	302	1389	2065	791	1278	953

Table 3. Production levels at each date (dry lbs/acre) among 11 select warm-season grasses at Pierre, SD in 2000.

	Date						
Species (Variety)	5/30	6/20	7/10	8/2	8/23	9/12	10/3
Big bluestem (Bison)	1311	2466	3495	3906	3060	2444	2341
Big bluestem (Sunnyview)	1104	2665	3842	3805	4590	4292	3472
Sideoats grama (Butte)	53	114	139	137	253	218	202
Sideoats grama (Pierre)	150	218	227	413	240	244	249
Prairie sandreed (Goshen)	845	1489	1683	1961	2176	2753	2270
Prairie sandreed (ND-95)	1007	1468	2318	3145	2791	2136	2392
Switchgrass (Dacotah)	1252	2179	3107	3164	2644	2925	2845
Switchgrass (Forestburg)	941	2156	3666	5360	4757	4196	3655
Little bluestem (Camper)	364	1044	1430	2622	1731	1682	1806
Indiangrass (Holt)	490	1607	1734	2105	2269	1947	1871
Indiangrass (Tomahawk)	409	1104	1334	1223	1297	1451	1735

Table 4. Production levels at each date (dry lbs/acre) among 14 select warm-season grasses at Hettinger, ND in 2000.

Species (Variety)	Date						
	5/31	6/20	7/11	8/1	8/22	9/13	10/3
Big bluestem (Bison)	936	2322	2728	3175	1728	1512	987
Big bluestem (Sunnyview)	580	658	1444	2788	1556	2382	1535
Sideoats grama (Butte)	1116	2373	2699	3934	2518	2810	2453
Sideoats grama (Pierre)	1016	2143	2293	3372	2177	2983	2484
Prairie sandreed (Goshen)	169	1072	812	1066	894	1365	1185
Prairie sandreed (ND-95)	294	734	1110	1006	1456	1854	1030
Switchgrass (Dacotah)	683	2534	3362	3611	4140	3513	3111
Switchgrass (Forestburg)	614	1491	4208	5464	3794	4267	3856
Little bluestem (Camper)	162	605	934	701	2119	1356	1279
Little bluestem (Badlands)	160	446	710	925	900	858	1050
Blue grama (Willis)	640	1171	1191	2350	1897	2648	1754
Blue grama (Bad River)	770	928	1307	2722	2622	2071	1677
Sand bluestem (Garden)	216	1149	1380	2178	2260	3353	1874
Sand bluestem (Goldstrike)	228	693	1483	2579	1680	2447	2177

Nutritional Quality

Crude Protein:

Sixteen warm-season grass varieties were analyzed for nutritional quality in 1999 and 2000. To optimize livestock performance, ranchers would like the nutrient content of the grass to remain at or above the minimum requirements of the livestock throughout the grazing season or in harvested feeds for hay. These goals can be achieved if knowledge of nutrient content is determined and correlated with the production parameters.

All grass cultivars showed a decline in crude protein (CP) content from June to October 1999 (Table 5). Initially, no differences ($P>0.05$) were found between varieties. As cultivars matured, they began to exhibit larger differences in percent CP. Species that maintained a higher percentage of CP included blue grama and prairie sandreed cultivars. Cultivars of switchgrass and big bluestem declined to the lowest levels among the species. Sideoats grama tended to have higher CP at Pierre than Hettinger.

The phenological stage contrast between cultivars of the same species indicated nutritional differences. 'Sunnyview' big bluestem maintained a vegetative state longer than 'Bison' throughout the study and tested slightly higher CP levels. All grass species initially met the minimum nutrient requirements of a 1200 lb lactating cow, but dropped below requirements by mid-summer.

Overall, varieties at the Pierre location had a lower level of crude protein ($p<0.05$) when compared to Hettinger; however, there were no variety by site interactions ($p=0.206$). All varieties exhibited similar trends regardless of location. Due to a large amount of standing litter, the grass at the Pierre site had some obvious interference that may have contributed in reducing quality in 1999.

When reviewing the nutritional quality results of these warm-season grasses, quality can only be assessed for hay quality and not actual grazing quality for pasture. Livestock can selectively graze for higher quality than shown in this data; however, hay quality will be accurate as shown since clipping was conducted similar to a haying operation. Comparison among grass species can be conducted and selection for grazing or haying use since all grass species were collected and analyzed the same.

Table 5. 1999 Crude protein (%) content by date for selected warm-season grasses in Hettinger, ND and Pierre, SD.

	Date					
Plant Species	6/21	7/12	8/4	8/23	9/14	10/5
Hettinger, ND						
Big bluestem (Bison)	13.27	9.97	7.79	6.59	5.90	3.41
Big bluestem (Sunnyview)	14.95	10.36	7.55	9.05	7.88	5.41
Sand bluestem (Garden)	14.07	10.81	8.09	8.24	7.32	5.82
Sand bluestem (Goldstrike)	14.59	10.87	8.54	8.55	7.63	6.05
Blue grama (Bad River)	15.49	12.07	8.92	9.34	8.75	6.89
Blue grama (Willis)	15.99	12.51	9.22	9.94	9.12	7.46
Sideoats grama (Butte)	14.85	11.18	8.68	7.73	6.30	4.84
Sideoats grama (Pierre)	15.12	10.97	7.78	7.48	6.57	4.75
Prairie sandreed (Goshen)	13.53	10.80	7.99	7.92	8.74	7.48
Prairie sandreed (ND-95)	14.90	11.56	9.44	9.02	9.77	8.07
Switchgrass (Dacotah)	15.89	10.49	7.05	6.71	5.61	4.24
Switchgrass (Forestburg)	15.88	11.42	7.84	7.77	6.88	3.92
Little bluestem (Badlands)	13.73	10.75	6.50	5.60	6.56	5.24
Little bluestem (Camper)	14.18	10.60	7.95	8.20	6.89	6.67
Indiangrass (Holt)	13.46	10.35	8.18	7.89	7.14	6.21
Indiangrass (Tomahawk)	14.27	9.84	7.14	5.81	5.05	4.22
Pierre, SD						
Big bluestem (Bison)	9.58	5.95	5.24	3.85	3.64	3.38
Big bluestem (Sunnyview)	9.82	6.23	5.41	4.34	4.58	3.76
Sideoats grama (Butte)	12.09	8.83	7.48	6.42	7.41	7.28
Sideoats grama (Pierre)	11.06	9.02	6.75	5.51	6.45	5.87
Prairie sandreed (Goshen)	10.28	7.78	6.53	5.56	6.60	5.99
Prairie sandreed (ND-95)	10.46	7.72	6.07	4.96	6.23	5.50
Switchgrass (Dacotah)	8.31	5.17	4.17	2.83	3.27	2.29
Switchgrass (Forestburg)	11.16	6.74	4.95	4.20	3.47	2.95
Little bluestem (Camper)	8.94	6.25	5.22	4.41	4.43	4.25
Indiangrass (Holt)	11.05	6.42	5.58	4.88	5.13	5.03
Indiangrass (Tomahawk)	11.10	7.18	5.99	4.67	5.08	3.34

In Vitro Dry Matter Digestibility:

The in vitro dry matter digestibility (IVDMD), like crude protein, declined with advancing maturity of the grasses (Table 6). The cultivars at Hettinger had a higher digestibility than Pierre throughout the entire 1999 season ($p<0.05$); however, there was not a variety by location interaction (p=0.274) suggesting similar trends in cultivars. Big bluestem, sideoats grama, sand bluestem, and indiangrass cultivars tended to be highest in digestibility throughout the season, regardless of location. Fibrous grasses like prairie sandreed and 'Badlands' little bluestem were relatively low among the cultivars. Switchgrass exhibited some variability by location with extremely low late season values at Pierre compared to Hettinger.

Table 6. In Vitro Dry Matter Digestibility (%) by date for 16 select warm-season grasses near Hettinger, ND and Pierre, SD 1999.

Plant Species	Date					
	6/21	7/12	8/4	8/23	9/14	10/5
Hettinger, ND						
Big bluestem (Bison)	72.25	71.70	57.21	55.33	48.81	46.30
Big bluestem (Sunnyview)	77.72	71.70	60.07	64.38	55.45	55.44
Sand bluestem (Garden)	74.00	70.53	59.59	61.05	52.32	51.88
Sand bluestem (Goldstrike)	73.68	71.15	61.79	58.24	51.60	52.51
Blue grama (Bad River)	74.55	72.18	56.86	51.88	47.90	45.46
Blue grama (Willis)	73.20	69.88	56.14	48.14	49.31	44.85
Sideoats grama (Butte)	71.26	68.38	59.21	54.79	48.72	50.15
Sideoats grama (Pierre)	71.99	69.37	56.64	49.93	47.44	47.04
Prairie sandreed (Goshen)	72.03	69.89	58.31	46.28	44.63	41.27
Prairie sandreed (ND-95)	72.95	70.59	58.83	49.81	43.42	41.80
Switchgrass (Dacotah)	75.84	68.61	53.85	50.79	46.34	49.26
Switchgrass (Forestburg)	76.28	73.10	54.84	49.80	47.44	49.26
Little bluestem (Badlands)	72.17	69.59	53.18	41.90	37.98	38.49
Little bluestem (Camper)	72.58	66.36	54.52	49.44	40.28	45.54
Indiangrass (Holt)	77.83	72.84	61.42	59.06	52.18	52.86
Indiangrass (Tomahawk)	79.76	72.63	59.69	51.47	44.45	47.50
Pierre, SD						
Big bluestem (Bison)	64.42	53.98	50.17	47.57	35.63	41.17
Big bluestem (Sunnyview)	65.12	54.46	49.89	51.15	41.66	45.59
Sideoats grama (Butte)	60.24	59.14	50.55	51.16	42.13	46.43
Sideoats grama (Pierre)	61.73	59.65	49.26	47.80	42.11	43.01
Prairie sandreed (Goshen)	59.12	55.74	45.44	42.94	36.57	36.69
Prairie sandreed (ND-95)	62.27	56.16	46.27	44.61	38.46	38.44
Switchgrass (Dacotah)	59.82	42.52	38.67	32.99	31.65	30.87
Switchgrass (Forestburg)	67.79	46.54	38.61	34.39	31.11	33.45
Little bluestem (Camper)	58.38	49.94	43.78	46.22	35.28	44.31
Indiangrass (Holt)	67.70	58.21	52.30	49.23	40.98	47.00
Indiangrass (Tomahawk)	67.64	61.01	51.34	47.97	41.73	44.08

Summary

Herbage production and nutrient content differed between warm-season grasses and between cultivars for some species. Production differences were most likely due to soil characteristics and climate. Peak yields were generally obtained in early August for each year regardless of location. Grasses such as prairie sandreed and blue grama were able to maintain relatively high levels of crude protein throughout the growing season; however, prairie sandreed tested low in digestibility and high in fiber. Grasses that produced the most biomass (i.e. switchgrass) typically had lower levels of crude protein but variable levels of digestibility and fiber. Phenological development differences between cultivars of big bluestem indicate the effect of morphology on nutritional characteristics. Least matured plants were highest in nutritional quality. Great potential exists for many of these grasses as a forage source in mid summer when cool-season grasses are less productive.

A full report will be published at a later date showing results of all minerals and statistical analysis for production, crude protein, IVDMD, ADF, and NDF among all grass species and cultivars.

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EFFECTS OF MULTI-SPECIES GRAZING AND SINGLE SPECIES GRAZING ON LEAFY SPURGE INFESTED RANGELAND (A Five-Year Summary)

J.D. Dahl[1], K.K. Sedivec[2], T.C. Faller[1] D. Stecher[1], J.F. Karn[3], P.E. Nyren[4], and L. Samuel[2]

[1]NDSU Hettinger Research Extension Center, Hettinger
[2]Animal and Range Sciences Department, North Dakota State University, Fargo
[3]Northern Great Plains Agricultural Research Center, Mandan
[4]Central Grasslands Research Center, Streeter

Introduction

Multi-species grazing is an important idea in rangeland management because rangelands usually consist of one or more classes of vegetation (Merrill et al. 1966). By using more than one livestock species on a given rangeland containing various vegetative communities provides the potential of increasing red meat production, species diversity, vegetative production, and revenue for a given ranching operation, with proper management plans. Although multi-species grazing provides the above benefits, the introduction of leafy spurge and its consistency of infesting grasslands in the mid-west exploits the importance of using a multi-species grazing approach. Research has shown that sheep or goats will reduce leafy spurge stem densities and increase grass and grass-like disappearance, and there are significant benefits in using multi-species grazing to manage leafy spurge infested rangelands (Prosser 1995)

The objectives of this study were to test the effects of multi-species and single species grazing treatments using cattle and sheep on: 1) differences in leafy spurge control, plant species richness and density, plant species diversity, 2) evaluate differences in utilization levels by plant type and herbage production, and 3) evaluate differences in livestock weight gain.

Study Area

This study was conducted on Section 32, T139N, R81W of Morton County owned by the North Dakota State Correction Center in south central North Dakota, approximately two miles southwest of Mandan, and on the north half of Section 9 T138N, R81W of Morton county on native rangeland operated by the Northern Great Plains Research Laboratory, approximately three miles south of Mandan. The study area was located in the Missouri Slope Prairie region. Vegetation in this region is typical of northern mixed grass prairie (Barker and Whitman 1989) and classified as a wheatgrass-grama-needle grass (*Agropyron, Bouteloua, Stipa*) plant community (Shiflet 1994).

Grazing treatments were multi-species and single species grazing on three replicated 20 acre blocks. Replicate one and two were within the North Dakota State Correction Center land and replicate three on the Northern Great Plains Research Laboratory. Each of the replicates were subdivided into 5 acre plots and treated with either a cattle only treatment (CO), sheep only treatment (SO), cattle and sheep treatment (CS) or a non use control (NU). Treatments were randomly selected within each block. The experimental design was a randomized complete block design (RCBD).

Sheep were placed on treatments approximately 15 May and cattle 1 June when native cool season grass species reach grazing readiness (3-4 leaf stage). Livestock species were removed from treatments when 50 to 60 percent degree of grass and grass-like species use or before 15 September.

Each replicated research block had one plot grazed by yearling steers (CO), one grazed by mature ewes (SO), and one grazed by yearling steers and mature ewes (CS). Stocking rates include two yearling steers for the CO from 1996 to 1999; twelve mature ewes in 1996, ten-mature ewes 1997 and 1998, and seven mature ewes in 1999 for the SO; one yearling steer and six mature ewes in 1996 and one yearling steer and five mature ewes for the CS from 1997 to 1999. Stocking rates were about 1.5 AUMs/acre for the CO, SO, and CS treatments. Stocking rates for this trial were designed for 3.5 months of grazing for the steers and 4 months of grazing for the ewes. The flexible stocking rates on the SO and CS in sheep was due the adjustment in leafy spurge control and range condition.

Methods

Leafy spurge stem density counts were obtained by using a permanent 109 yard line transect and counts collected approximately every 5 ½ yards using a 12 inch^2 quadrat. One transect was systematically placed in each of the four treatments (CO, SO, CS, and NU) for each replicate. Transects were selected based on leafy spurge location within the treatments to assure full length of transect comprised leafy spurge. Leafy spurge densities were monitored over the five years to detect effectiveness of sheep grazing to control. Leafy spurge densities will be collected annually, around the end of May, for the duration of the study.

Leafy spurge vigor was monitored in 2000 by collecting the height of the plant and growth stage of the plant on 1 May, 22 May, and 15 June. Twenty leafy spurge plants were randomly selected from each treatment. Leafy spurge plants were measured in inches and the growth stages were broke down into, as follows: seedling, vegetative, formation of bracts, flowering, and formation of seed pods. Vigor of leafy spurge will be collected throughout the duration of the study to detect any changes within and among treatments.

Forb and shrub species diversity and densities were determined using a 24 inch^2 quadrat. Nested within the 24 inch^2 quadrat was a 12 inch^2 quadrat used to determine graminoid species diversity. Data was collected from 109 yard transects with readings conducted approximately every 5 ½ yards. Data was collected on all treatments and replicate from the leafy spurge transect developed to monitor leafy spurge stem density counts. One native (non-infested) 109 yard transect was located within each replicated treatment to monitor species diversity and density changes that may naturally occur due to treatment. Readings were collected from the native transects annually, except 1997. The leafy spurge transects were monitored annually and will continue to be monitored annually throughout the ten-year trial.

Leafy spurge, graminoid, shrub, and forb herbage production was determined by clipping in late July on the NU treatment when vegetative species reached peak production (Whitman et al. 1952). The NU was stratified into 7 ½ by 7 ½ yard plot. A 7 ½ yard buffer's strip was implemented to prevent edge effect. Twenty-five plots were randomly selected and clipped within each NU using a 24 inch^2 quadrat.

Degree of disappearance of leafy spurge, graminoids, forbs, and shrubs were determined for each treatment at the end of the grazing season by stratifying each treatment into 7 ½ by 7 ½ yard quadrats in 1996, 1997, 1998, and 1999. Twenty-five quadrats were randomly selected and clipped using 24 inch^2 quadrat on each grazed and non-use treatment to determine the degree of disappearance. The method of determining degree of disappearance was change in 2000 due to the change in herbage production on the grazing treatments. Degree of disappearance was monitored using the pair-plot technique in 2000, two frames within the cage and two out were clipped after the removal of livestock species. Five cages were systematically placed within each grazing treatment (CO, SO, and CS) in leafy spurge infested sites. This method allowed use to monitor the herbage production on the grazing treatments and the degree of disappearance of grass and grass-like species, forbs, shrubs, and leafy spurge.

Livestock performance and production were collected for both cattle and sheep by determining average daily gain and gain per acre, respectively. Both classes of livestock were weighed prior to pasture turn out and monthly to follow performance throughout the grazing season. Final livestock weights were collected at the end of grazing season.

Treatment and year effects for leafy spurge stem density, forb and shrub density, herbage production, degree of disappearance, and livestock performances were analyzed using a general linear model (GLM) (SPSS 1999). A mean separation was performed using Tukey's Honesty Significant Difference when significant ($P \leq 0.05$) differences were found. The Shannon Wiener Index was used to calculate species diversity indices for both leafy spurge infested and non-infested range sites. Treatment and year effects of species diversity were analyzed using a non-parametric test (Krushal-Wallis Test) (SPSS 1999).

Results and Discussion

A significant ($P \leq 0.05$) reduction in leafy spurge stems occurred after one grazing season on the SO treatment and in three grazing seasons on the CS treatment. Leafy spurge was reduced from 10.4 stems/12 inch^2 in 1996 to 0.6/ inch^2 stems in 2000, a reduction of 36% after one grazing season and 98% after four on the SO. Leafy spurge stem densities were not affected after two grazing seasons on the CS treatment, however, by the third year the CS treatment had a significant ($P \leq 0.05$) reduction and results showed that a significant ($P \leq 0.05$) change between year three and four. Leafy spurge stems were reduced ($P \leq 0.05$) from 11.6 stems/12 inch^2 in 1996 to 2.1 stems/12 inch^2 in 2000, a reduction of 82% after four grazing seasons. There was no significant ($P > 0.05$) change in leafy spurge stem density on the CO and NU treatments after three years of grazing (Table 1).

Leafy spurge vigor results showed that the growth stage during the three collection periods on the SO and CS treatments never made it past vegetative stage. The average height of the plants on the SO and CS was less than eight inches in height. By the third collection 46.7% and 73.3% of the leafy spurge plants measured were in the formation of seed pods on the NU and CO treatments and the average heights of the plants were more than 19 inches (Table 2).

Leafy spurge and non-infested range sites were significantly ($P \leq 0.05$) different in forb and shrub density on the NU treatment throughout four grazing seasons. Non-infested range sites had a higher ($P \leq 0.05$) forb and shrub density/24 inch^2 than leafy spurge range sites. Results after two grazing seasons showed that there were no differences (P>0.05) between non-infested and leafy spurge range sites on the CO, SO, and CS grazing treatments in forb and shrub densities (Table 3). By the third year of grazing, however, forb and shrub density on treatments CO and SO showed that there was a difference between the non-infested and leafy spurge range sites. Non-infested sites were significantly higher (P≤0.05) than leafy spurge range sites on both CO and SO treatments. Forb and shrub density results also suggested that after the forth grazing season the only treatment that showed no differences between the non-infested and leafy spurge sites were the CS grazing treatment (Table 3).

Species diversity results showed that there were significant (P≤0.05) differences between leafy spurge and non-infested range sites in all treatments. In all of the treatments non-infested range sites were higher (P≤0.05) in species diversity than leafy spurge infested sites. Results also showed that species diversity did not change (P>0.05) after four grazing seasons and there was no treatment or year effect present after the four years of grazing (Table 4).

Herbage production was different (P≤0.05) between growing seasons in grass and grass-like lb/acre. Results showed that graminoid grass and grass-like lb/acre was lower (P≤0.05) in 1998 than 1996, 1999 and 2000, however, were similar (P>0.05) to 1997. Leafy spurge production was significantly higher (P≤0.05) in 2000 than 1998, however, similar to production in 1996, 1997, and 1999. (Table 5).

Leafy spurge degree of disappearance increased on all sheep treatments form 1996 to 2000. The SO treatment went from 76% to 99% leafy spurge disappearance from 1996 to 2000, and the CS treatment went from 62% to 97% from 1996 to 2000. There was an increase (P≤0.05) in leafy spurge disappearance in the CO treatment with 23% disappearance in 1996 compared with 50% in 1997 and 1998; however, reduced again to 23% in 1999. These results in leafy purge disappearance on the CO treatment would suggest that steers were consuming leafy spurge; however, due to the design and location of watering facilities, the leafy spurge disappearance was more likely due to a trampling effect. As graminoid disappearance increased on CO treatment, so did leafy spurge disappearance, suggesting more use of the graminoids, more grazing and trampling occurs. Graminoid degree of disappearance was similar (P>0.05) throughout the grazing seasons within and between grazing treatments for all years except 1999, where graminoid disappearance was reduced on the sheep treatments

Steer average daily gain (ADG) was not different (P>0.05) between treatments (CO and CS) after four grazing seasons of the study (Table 6). There was no change (P>0.05) in steer ADG between years on the CO and CS treatment. Ewe ADG was not different (P>0.05) between treatments (SO and CS) for either years of the study. There was a decrease (P≤0.05) in ewe ADG between years 1996 and 1998 on both SO and CS treatments, however, ADG was significantly higher (P≤0.05) in 1999 than the 1998 grazing season (Table 6). These results would suggest multi-species grazing had no negative or positive impact on sheep or cattle performance compared with single species grazing.

Table 1. Leafy spurge stem densities per 12 inch^2 quadrat (standard errors in parentheses) on the cattle only (CO), sheep only (SO), cattle and sheep (CS), and control (NU) treatments for 1996, 1997, 1998, 1999, and 2000.

	CO[2]	SO[2]	CS[2]	NU[2]
	# of Stems/12 inch^2 quadrat			
1996[1]	9.8 (1.2)^{abx}	10.4 (0.9)^{ax}	11.6 (1.0)^{ax}	9.8 (1.1)^{ax}
1997[1]	12.0 (1.2)^{ax}	6.7 (0.7)^{by}	12.3 (1.0)^{ax}	11.4 (1.3)^{ax}
% Change 1996 to 1997	+22	-36	+6	+16
1998[1]	10.8 (1.0)^{ax}	2.5 (0.6)^{cy}	11.6 (1.0)^{ax}	11.1 (1.2)^{ax}
% Change 1996 to 1998	+10	-75	0	+13
1999[1]	11.1 (0.8)^{ax}	0.8 (0.2)^{cy}	6.5 (0.8)^{bz}	10.5 (1.0)^{ax}
% Change 1996 to 1999	+13	-92	-44	+7
2000[1]	6.2 (0.8)^{bx}	0.6 (0.2)^{cy}	2.1 (0.3)^{cy}	8.1 (0.8)^{ax}
% Change 1996 to 2000	-37	-94	-82	-17

[1]Years with the same letter within each treatment are not significantly different (P>0.05) (a, b, and c).
[2]Treatments with the same letter are not significantly different (P>0.05) (x, y, and z).

Table 2. Growth stage of leafy spurge on treatments non-use (NU), cattle only (CO), sheep only (SO), and cattle and sheep (CS) during the 2000 growing season. The table is broken down by collection data's and summarized by percentage (%) of samples during that collection period occurred in the growth stage and the height of the leafy spurge plant in inches (inch).

	Seedling		Vegetative		Formation of Bracts		Bracts		Flowering		Formation of Seed Pods	
	%	inch	%	inch	%	inch	%	inch	%	inch	%	inch
NU												
5/01/00	--	--	62.5	6.9 (0.3)	37.5	9.2 (0.6)	--	--	--	--	--	--
5/22/00	--	--	48.3	9.9 (0.8)	--	--	16.7	14.8 (0.4)	35	16.7 (0.7)	--	--
6/15/00	--	--	43.3	11.0 (0.7)	--	--	10	15.1 (1.1)	--	--	46.7	19.1 (0.7)
CO												
5/01/00	2.5	3.2 (NA)	52.5	6.5 (0.4)	45	9.1 (0.3)	--	--	--	--	--	--
5/22/00	--	--	60	10.7 (0.7)	--	--	11.7	16.3 (2.1)	28.3	18.4 (1.0)	--	--
6/15/00	--	--	25	14.5 (0.7)	--	--	1.7	18.5 (NA)	--	--	73.3	22.7 (0.5)
SO												
5/01/00	95	2.9 (0.2)	5	4.3 (0.04)	--	--	--	--	--	--	--	--
5/22/00	--	--	100	4.2 (0.2)	--	--	--	--	--	--	--	--
6/15/00	--	--	100	4.1 (0.2)	--	--	--	--	--	--	--	--
CS												
5/01/00	90	2.6 (0.2)	10	4.4 (0.2)	--	--	--	--	--	--	--	--
5/22/00	--	--	100	4.7 (0.2)	--	--	--	--	--	--	--	--
6/15/00	--	--	100	7.1 (0.3)	--	--	--	--	--	--	--	--

Table 3. Forb and shrub species density/24 inch^2 quadrat on the cattle only non-infested (CON), cattle only leafy spurge infested (COS), sheep only non-infested (SON), sheep only leafy spurge infested (SOS), cattle and sheep non-infested (CSN), cattle and sheep leafy spurge infested (CSS), control non-infested (NUN), and control leafy spurge infested (NUS) treatments for 1996, 1997, 1998, 1999, and 2000. (SE in parentheses.)

	1996[1]	1997[1]	1998[1]	1999[1]	2000[1]
			Density/24 inch^2 quadrat		
CON[2]	6.7 (1.0)^{abxz}	----	4.1 (0.1)^{ax}	7.8 (1.1)^{bxz}	9.5 (1.5)^{bz}
COS[2]	1.8 (0.4)^{ay}	1.5 (0.4)^{ax}	1.3 (0.3)^{ax}	1.0 (0.3)^{ay}	1.1 (0.3)^{ay}
SON[2]	5.8 (1.1)^{axz}	----	2.1 (0.5)^{bx}	7.0 (1.5)^{ax}	6.0 (0.9)^{ax}
SOS[2]	1.1 (0.3)^{ay}	0.5 (0.2)^{ax}	0.8 (0.2)^{ax}	2.2 (0.5)^{ay}	1.7 (0.2)^{ay}
CSN[2]	4.5 (0.4)^{ax}	----	2.3 (0.4)^{ax}	3.0 (0.4)^{ay}	3.5 (0.5)^{ay}
CSS[2]	0.9 (0.2)^{ay}	0.3 (0.1)^{ax}	0.8 (0.3)^{ax}	1.4 (0.4)^{ay}	0.9 (0.4)^{ay}
NUN[2]	7.8 (0.9)^{az}	----	6.9 (0.8)^{az}	5.8 (0.7)^{az}	6.1 (0.7)^{ax}
NUS[2]	1.1 (0.4)^{ay}	0.9 (0.3)^{ax}	1.0 (0.3)^{ax}	1.9 (0.5)^{ay}	1.6 (0.4)^{ay}

[1] Years with the same letter within each treatment are not significantly different (P>0.05) (a and b).
[2] Treatments with the same letter are not significantly different (P>0.05) (x, y, and z).

Table 4. Shannon Weiner diversity index on the cattle only non-infested (CON), cattle only leafy spurge infested (COS), sheep only non-infested (SON), sheep only leafy spurge infested (SOS), cattle and sheep non-infested (CSN), cattle and sheep leafy spurge infested (CSS), non-use control non-infested (NUN), and non-use control leafy spurge infested (NUS) treatments for 1996, 1997, 1998, 1999, and 2000. (SE in parentheses.)

	1996[1]	1997[1]	1998[1]	1999[1]	2000[1]
			Species Diversity Index		
CON[2]	2.73 (0.17)^{ax}	---	2.60 (0.10)^{ax}	2.60 (0.05)^{ax}	2.65 (0.14)^{ax}
COS[2]	2.30 (0.07)^{ay}	2.23 (0.26)^{ay}	2.12 (0.13)^{ay}	2.11 (0.19)^{ay}	2.26 (0.13)^{ay}
SON[2]	2.62 (0.04)^{ax}	---	2.42 (0.25)^{ax}	2.58 (0.25)^{ax}	2.69 (0.19)^{ax}
SOS[2]	2.31 (0.13)^{ay}	2.17 (0.21)^{ay}	2.24 (0.15)^{ay}	2.23 (0.18)^{ay}	2.37 (0.10)^{ay}
CSN[2]	2.66 (0.17)^{ax}	---	2.46 (0.06)^{ax}	2.46 (0.08)^{ax}	2.63 (0.12)^{ax}
CSS[2]	2.15 (0.12)^{ay}	1.91 (0.07)^{ay}	1.92 (0.21)^{ay}	2.19 (0.07)^{ay}	2.17 (0.04)^{ay}
NUN[2]	2.57 (0.11)^{ax}		2.76 (0.12)^{ax}	2.67(0.15)^{ax}	2.76 (0.17)^{ax}
NUS[2]	2.08 (0.04)^{ay}	1.92 (0.27)^{ay}	2.02 (0.29)^{ay}	1.90 (0.47)^{ay}	2.21 (0.28)^{ay}

[1]Years with the same letter within each treatment are not significantly different (P>0.05)(a,b and c).
[2] Treatments with the same letter are not significantly different (P>0.05) (x, y, and z).

Table 5. Herbage production (lb/acre) on the non-use control treatment in 1996, 1997, 1998,1999, and 2000. (Standard errors in parentheses.)

	1996[1]	1997[1]	1998[1]	1999[1]	2000[1]
			lb/acre		
Grass & Grass-Like	1527 (146)[a]	1317 (168)[ab]	1060 (139)[b]	1609 (202)[a]	1652 (143)[a]
Forb	118 (43)[ab]	87 (29)[ab]	46 (23)[a]	171 (59)[b]	93 (53)[ab]
Shrub	82 (76)[a]	14 (13)[a]	14 (14)[a]	14 (12)[a]	10 (8)[a]
Leafy Spurge	407 (139)[ab]	446 (77)[ab]	350 (81)[a]	410 (92)[ab]	624 (173)[b]

[1] Years with the same letter within each treatment are not significantly different (P>0.05) (a, b, and c)

Table 6. Livestock average daily gains (standard errors in parentheses) for individual livestock classes on the (CO) cattle only, (SO) sheep only, and (CS) cattle and sheep treatments for 1996, 1997, 1998, 1999, and 2000.

Treatment & Livestock Class[1]	1996[2]	1997[2]	1998[2]	1999[2]	2000[2]
			lb/day		
CO Steer	1.76 (0.07)[ax]	1.61 (0.13)[ax]	1.23 (0.06)[ax]	1.80 (0.25)[ax]	1.96 (0.24)[ax]
CS Steer	1.53 (0.32)[ax]	1.12 (0.16)[ax]	0.96 (0.13)[ax]	1.44 (0.22)[ax]	2.02 (0.10)[ax]
SO Ewe	0.16 (0.02)[ax]	0.07 (0.02)[bx]	0.04 (0.02)[bx]	0.09 (0.02)[abx]	0.20 (0.02)[ax]
CS Ewe	0.16 (0.02)[abx]	0.09 (0.03)[abx]	0.07 (0.02)[bx]	0.18 (0.02)[abx]	0.22 (0.03)[ax]

[1] Years with the same letter within each treatment are not significantly different (P>0.05) (a, b, and c).
[2] Treatments with the same letter within each livestock class are not significantly different (P>0.05) (x, y, and z).

CONCLUSIONS

Sheep grazing, either as a sole enterprise or mixed with cattle, will provide and effective tool in controlling leafy spurge by reducing stem densities. When replacing cattle AUM's with sheep AUM's, leafy spurge stem density counts were reduced by 94% in four years of grazing. When grazing sheep and cattle together, leafy spurge was reduced by 82% in four years. There were no negative or positive effects on species diversity grazing sheep or cattle alone or together after three grazing seasons. Grass and grass-like disappearance was similar among all grazing treatments, showing replacing cattle with sheep would not affect graminoid disappearance while reducing leafy spurge. There was no difference in livestock performance when grazing cattle and sheep separately or in combination, suggesting multi-species grazing had no negative or positive effects on livestock performance as it relates to weight gain in this study.

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EFFECT OF MULTI-SPECIES GRAZING ON LEAFY SPURGE INFESTED RANGELAND USING TWICE-OVER ROTATION AND SEASONLONG GRAZING TREATMENTS
(A Five-Year Summary)

J.D. Dahl[1], K.K. Sedivec[2], T.C. Faller[1],
D. Stecher[1], J. Karn[3], P.E. Nyren[4], and L. Samuel[2]

[1]*Hettinger Research Extension Center. Hettinger, ND 58639.*
[2]*Animal and Range Science Dept., North Dakota State University, Fargo, ND 58105.*
[3]*Northern Great Plains Agricultural Research Center, Mandan, ND 58554.*
[4]*Central Grasslands Research Center, Streeter, ND 58483*

Introduction

Multi-species grazing, the concurrent use of rangeland by more than one kind of animal, has been advocated to maximize animal production on native rangeland (Merrill and Miller 1961). It is an important concept in rangeland management because rangelands usually consist of one or more classes of vegetation (Merrill et al. 1966). However, no published reports have documented the potential use of sheep and cattle in a multi-species grazing approach to improve graminoid species use, increase plant species richness and diversity, and to control leafy spurge on leafy spurge infested rangeland.

The objectives of this study were to: 1) determine effects of multi-species grazing using twice-over rotation grazing system (TOR) and seasonlong grazing treatments (SL) in leafy spurge control and changes in plant species diversity 2) evaluate the degree of disappearance of herbage and livestock performance on TOR and SL using a multi-species grazing program.

Study Area

The research was conducted on two separate tracts of land in Morton County. The first tract was Sections 31 and 32, T139N, R81W, in south central North Dakota, approximately two miles southwest of Mandan. This tract consisted of 603 acres of native rangeland owned by the North Dakota State Correctional Center. The second tract was on the north half of Section 9, T138N, R81W on 237 acres of native rangeland operated by the Northern Great Plains Research Laboratory, approximately three miles south of Mandan. Both tracts are found in the Missouri Slope Prairie Region and associated with the Heart River Watershed drainage. Vegetation in this region is typical of northern mixed grass prairie (Barker and Whitman 1989) and classified as a wheatgrass-grama-needle grass (*Agropyron, Bouteloua, Stipa*) plant community (Shiflet 1994). Leafy spurge infestations were mapped before the study and estimated to cover 30 percent of each tract of rangeland.

The TOR consisted of four pastures grazed from 15 May to 1 October by one heard of cow/calf pairs and mature dry ewes. A total of 96 animal units of cattle (85 - 1200 lb. cows with calves) and 33 animal units of sheep (200 - 135 lb. mature white-face ewes without lambs) or a total 532 AUMs grazed the TOR treatment in 1996 and 1997. Cattle animal units were reduced to 85 animal units of cattle (76 - 1200 lb. cows with calves) in 1998; however, sheep animal units remained the same and a total 491 AUMs grazed the TOR in 1998. The overall stocking rate was 0.88 AUMs/acre in 1996, 1997, 1999, and 2000; and 0.82 AUMs/acre in 1998 on the TOR treatment. Stocking rates were decreased due to below average winter snow cover and rain fall in the spring 1998.

The SL treatment was grazed moderately light in 1996 due to lack of range evaluation data and unknown carrying capacities. Twenty-seven animal units of cattle (35 - 700 lb. Yearling steers) and 8 animal units of sheep (48 - 135 lb. mature white-face ewes without lambs) or a total 144 AUMs grazed the SL treatment in 1996. The overall stocking rate was 0.68 AUMs/acre in 1996 on the SL treatment. The SL treatment was grazed by yearling steers and mature ewes and stocked with 37 animal units of cattle (49 - 705 lb. yearling steers) and 13 animal units of sheep (78 - 135 lb. mature white-face ewes without lambs) or a total 207 AUMs grazed in 1997 and 1998. The overall stocking rate was 0.88 AUMs/acre in 1997, 1998, 1999, and 2000 on the SL treatment.

Sheep were placed on pasture approximately 15 May each year when leafy spurge was ready for grazing and cattle placed on pasture 1 June when native cool season grass species reach grazing readiness (3-4 leaf stage). Livestock species were removed from the treatments when 50 to 60 percent degree of graminoid disappearance was reached or 1 October. During all three years livestock grazed until 1 October.

Methods

Objective 1

Leafy spurge density was counted in six 32 ft by 16 ft exclosures. Three exclosures were systematically placed in each of the TOR and SL treatments. Each 32 ft by 16 ft exclosure was subdivided in two 16 ft by 16 ft plots with one plot randomly assigned a grazed treatment (TOR or SL) and second plot an ungrazed treatment (NU). A 2.5 ft buffer was placed along the inside border of each grazed and ungrazed plot to prevent an edge effect. Each plot was further stratified into 12 $inch^2$ ($0.1 \ m^2$) quadrats and each quadrat assigned a number. Ten 12 $inch^2$ quadrats were randomly selected in each treatment for leafy spurge density counts. Leafy spurge densities were collected in the first week of June throughout the duration of the study.

Objective 2

Forage production and degree of disappearance for leafy spurge, graminoid, shrubs, and other forbs were determined using a pair-plot clipping technique (Milner and Hughes 1968). Eight cages were dispersed in each of the four pastures of the TOR. Four of the cages were systematically placed in leafy spurge infested sites and four in non-infested sites. Twelve cages were systematically placed in the SL, six cages placed on leafy spurge infested sites and six cages on non-infested sites. Two plots were clipped from each cage using a 24 $inch^2$ ($0.25 \ m^2$) frames.

Livestock performance and production were determined for both cattle and sheep and expressed as average daily gain. Weights were taken when animals were allocated to and removed from each treatment.

Data Analysis
Treatment and year effects for leafy spurge stem density, species richness, forb and shrub density, herbage production, degree of use, and livestock performances were analyzed using a general linear model (GLM) (SPSS 1999). A mean separation was performed using Tukey's Honesty Significant Difference when significant ($P \leq 0.05$) differences were found. The Shannon Wiener Index was used to calculate species diversity indices for both leafy spurge infested and non leafy spurge infested range sites. Treatment and year effects of species diversity were analyzed using a non-parametric test (Krushal-Wallis Test) (SPSS 1999).

Results and Discussion
Leafy spurge stem densities were significantly reduced ($P \leq 0.05$) on the SL treatment after 3 grazing seasons and after 4 grazing seasons on the TOR treatment. Leafy spurge stem density was reduced on the SL from 14.4 ± 1.9 stems/0.12 $inch^2$ to 5.7 ± 0.6 stems/0.12 $inch^2$ in three years of treatment, a 60.4% reduction in leafy spurge stem density. Twice-over rotation grazing treatment reduced ($P \leq 0.05$) leafy spurge density by 31.8% in four grazing seasons, 13.2 ± 1.5 stems/0.12 $inch^2$ to 9.0 $\pm$ 1.3 stems/0.12 $inch^2$ (Table 1). These results followed similar trends found by Lym et al. (1997) comparing multi-species grazing with cattle and angora goats. They reported SL grazing reduced leafy spurge stem density faster than TOR grazing. Results of this study would support Lym et al. (1997) in that SL grazing using a multi-species approach would reduce leafy spurge stem density faster than TOR grazing. Long term, however, the TOR grazing treatment would provide comparable control to the SL treatment and be beneficial to the plant community.

Forb and shrub densities results showed that there were significant changes ($P \leq 0.05$) in density/0.24 $inch^2$ in both the SL and TOR grazing treatments (Table 2). Results showed that forb and shrub densities increased ($P \leq 0.05$) on the shallow native range sites in the TOR grazing treatment, from 1996 to 2000. The SL on the other hand saw a significant decrease ($P \leq 0.05$) after one year of grazing. Forb and shrub density was also higher ($P \leq 0.05$) on the SL shallow native range sites than the TOR shallow native range sites. By the third grazing season, however, the TOR shallow native range sites were significantly higher ($P \leq 0.05$) than the SL native range sites (Table 2). Leafy spurge infested range sites were generally lower ($P \leq 0.05$) than native range sites for both the SL and TOR grazing treatments throughout four grazing seasons. Results also suggested that there were no significant changes ($P \leq 0.05$) on leafy spurge infested sites through four grazing seasons on both the grazing treatments (Table 2).

Species diversity was significantly higher ($P \leq 0.05$) on native range sites than leafy spurge infested range sites on the seasonlong treatment, except the silty sites in 1998 (Table 3). There were no differences ($P > 0.05$) between native and leafy spurge infested range sites on these silty range sites. The TOR grazing treatment, however, results showed that there were no differences ($P > 0.05$) between native and leafy spurge infested range sites after four grazing seasons, except the silty sites in 1996 where the native sites were higher ($P \leq 0.05$) than leafy spurge infested sites (Table 3). Results also indicated that the SL native shallow range sites were significantly higher ($P \leq 0.05$) in species diversity than the TOR native shallow range sites (Table 3). There were no differences ($P > 0.05$) between the SL and TOR grazing treatments on the native silty range sites.

Table 1. Leafy spurge stem densities on the seasonlong and twice-over rotation grazing treatments in 1996, 1997, 1998, 1999, and 2000 (standard errors in parentheses).

	Seasonlong	Twice-Over Rotation
	# of Leafy Spurge Stems /12 inch^2	
1996	14.4 (1.9)[a]	13.2 (1.5)[a]
1997	12.5 (1.0)[a]	15.9 (1.4)[a]
% change 1996 to 1997	-13.2	+20.5
1998	11.5 (1.5)[a]	12.8 (1.1)[ac]
% change 1996 to 1998	-20.1	-3.0
1999	5.7 (0.6)[b]	13.4 (1.4)[a]
% change 1996 to 1999	-60.4	+1.0
2000	1.1 (0.3)[b]	9.0 (1.3)[c]
% change 1996 to 2000	-92.3	-31.8

[1] Years and treatments with the same letter within treatments are not significantly different (P>0.05).

Degree of leafy spurge disappearance on both treatments was similar throughout the four grazing seasons 1996, 1997, 1998, and 1999. The degree of leafy spurge disappearance varied from 41% to 89% over four grazing seasons in both treatments. Grass and grass-like species degree of use within leafy spurge infested communities increased on both treatments after the first grazing season. Grass and grass-like plant species disappearance in leafy spurge infested sites was 1% on the SL and 2% on the TOR treatment, however, by the forth grazing season, grass and grass-like degree of disappearance increased to 30% on the SL and 20% on the TOR on leafy spurge infested communities. In the third and forth year, degree of grass and grass-like species disappearance showed a slight increase again on leafy spurge communities compared with 1996 and 1997 (Table 5).

Cow average daily gains (ADG) were higher (P<0.05) on the TOR treatment in 1997 and 2000 than 1996, 1998, and 1999. Results also showed that cow ADG was higher (P≤0.05) in 2000 than 1997 (Table 6). Calf ADG was similar (P>0.05) throughout three grazing seasons, however, ADG significantly increased (P≤0.05) during the forth grazing season (Table 6). Steer ADG was higher (P≤0.05) in 1996 and 1999 than 1997 and 1998 grazing seasons (Table 6).

Ewe ADG on the TOR treatment was lower (P<0.05) in 1997, 1998, and 1999 compared with 1996 and 2000, dropping from 0.32 lb/day in 1996 to 0.25 lb/day and 0.26 lb/day in 1997 and 1998, respectively (Table 6). Seasonlong ewe ADG increased (P<0.05) from 1996 to 1997; however, there was a significant decrease (P<0.05) in ewe ADG from 1997 to 1998 with 1996 and 1998 not different

(P>0.05). Ewe performance results also showed that ewe ADG was higher (P<0.05) on the TOR in 1996, 1997, 1999, and 2000 than the SL, with no treatment differences (P>0.05) occurring in 1998 (Table 6).

Table 2. Forb and shrub density on the twice-over rotation and seasonlong treatments for 1996, 1997, 1998, 1999, and 2000 (standard errors in parentheses).

Treatments & Sites	1996	1997	1998	1999	2000
			Density/24 inch² quadrat		
Twice-Over					
Native Shallow	8.9 (0.9)^{ax}	---	4.4 (0.5)^{ax}	25.9 (2.4)^{cx}	20.2 (1.8)^{bx}
Leafy Spurge Shallow	1.1 (0.3)^{ay}	0.8 (0.2)^{ay}	0.6 (0.2)^{ax}	2.0 (0.6)^{ay}	3.4 (1.1)^{ay}
Native Silty	8.0 (0.9)^{abx}	---	5.5 (0.7)^{ax}	11.4 (1.6)^{bx}	4.1 (0.6)^{ax}
Leafy Spurge Silty	0.8 (0.2)^{ay}	1.2 (0.8)^{ay}	0.8 (0.2)^{ax}	1.3 (0.3)^{ay}	0.8 (0.3)^{ax}
Seasonlong					
Native Shallow	22.7 (2.1)^{cz}	---	7.8 (0.8)^{abx}	13.0 (1.1)^{bz}	7.2 (0.6)^{az}
Leafy Spurge Shallow	0.1 (0.1)^{ay}	0.2 (0.1)^{ay}	0.2 (0.1)^{ay}	0.6 (0.2)^{ay}	0.3 (0.1)^{ay}
Native Silty	6.9 (0.9)^{ax}	---	6.2 (0.5)^{ax}	6.6 (0.6)^{ax}	7.3 (0.6)^{ax}
Leafy Spurge Silty	0.0 (0.0)^{ay}	0.0 (0.0)^{ay}	0.3 (0.2)^{ax}	0.3 (0.1)^{ax}	1.0 (0.4)^{ax}

[1] Years with the same letter within each treatment are not significantly different (P>0.05) (a, b, and c).
[2] Treatments with the same letter within each year are not significantly different (P>0.05) (x, y, and z).

Table 3. Shannon Weiner diversity index on the twice-over rotation and seasonlong treatments for 1996, 1997, 1998, 1999, and 2000 (standard errors in parentheses).

Treatments & Sites	1996	1997	1998	1999	2000
	------------Species Diversity Index------------				
Twice-Over					
Native Shallow	2.55 (0.13)[ax]	---	2.36 (0.22)[ax]	2.36 (0.08)[ax]	2.04 (0.10)[ax]
Leafy Spurge Shallow	2.25 (0.18)[ax]	2.09 (0.15)[ay]	2.19 (0.17)[ax]	2.39 (0.26)[ax]	2.15 (0.40)[ax]
Native Silty	2.62 (0.09)[ax]	---	2.44 (0.08)[ax]	2.34 (0.21)[abx]	2.07 (0.09)[bx]
Leafy Spurge Silty	2.19 (0.06)[ay]	2.09 (0.04)[ay]	2.39 (0.24)[ax]	2.31 (0.29)[ax]	2.28 (0.17)[ax]
Seasonlong					
Native Shallow	2.98 (0.11)[abz]	---	3.01 (0.09)[abz]	2.65 (0.25)[ax]	3.06 (0.10)[bz]
Leafy Spurge Shallow	2.12 (0.02)[ay]	1.99 (0.17)[ay]	1.94 (0.11)[ay]	2.14 (0.24)[ay]	2.04 (0.39)[ay]
Native Silty	2.69 (0.13)[abx]	---	2.52 (0.09)[ax]	2.69 (0.09)[abx]	2.83 (0.08)[bz]
Leafy Spurge Silty	2.15 (0.01)[ay]	2.04 (0.13)[ay]	2.22 (0.09)[ax]	2.15 (0.06)[ay]	2.00 (0.02)[ay]

[1] Years with the same letter within each treatment are not significantly different (P>0.05) (a, b, and c).
[2] Treatments with the same letter within each year are not significantly different (P>0.05) (x, y, and z).

Table 4. Degree of disappearance on native range sites on the twice-over rotation (TOR) and seasonlong (SL) grazing treatments, through five grazing seasons.

	TOR					SL				
	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
	% Disappearance									
Grass and Grass-like	34	37	24	18	38	21	32	37	43	34
Forbs	+2	51	36	69	42	+34	71	32	61	63
Shrubs	100	0	0	0	0	55	100	20	0	0

Table 5. Degree of disappearance on leafy spurge infested range sites on the twice-over rotation (TOR) and seasonlong (SL) grazing treatments, through five grazing seasons.

	TOR					SL				
	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
	% Disappearance									
Grass and Grass-like	2	20	27	25	11	1	33	40	39	47
Forbs	0	89	83	22	1	0	0	0	85	0
Shrubs	0	0	0	0	0	0	100	0	0	0
Leafy Spurge	41	61	62	73	41	47	47	46	89	100

Table 6. Livestock average daily gains (standard errors in parentheses) for individual classes of livestock on treatments: twice-over rotation (TOR) and seasonlong (SL) for 1996, 1997, 1998, 1999, and 2000 (standard errors in parentheses).

Treatment & Livestock Class[1]	**1996**[2]	**1997**[2]	**1998**[2]	**1999**[2]	**2000**[2]
			-----------lb/day ----------		
TOR					
Cow	0.78 (0.05)[a]	1.00 (0.05)[b]	0.01 (0.04)[c]	0.67 (0.05)[a]	1.39 (0.05)[d]
Calf	2.33 (0.03)[a]	2.32 (0.03)[a]	2.42 (0.03)[a]	2.64 (0.03)[b]	2.86 (0.02)[b]
Ewe	0.32 (0.01)[ax]	0.25 (0.01)[bx]	0.26 (0.01)[bx]	0.24 (0.01)[bx]	0.30 (0.004)[ax]
SL					
Steer	1.99 (0.04)[ac]	1.84 (0.03)[a]	1.54 (0.04)[b]	2.09 (0.04)[c]	1.91 (0.22)[a]
Ewe	0.23 (0.03)[aby]	0.28 (0.03)[by]	0.22 (0.01)[ax]	0.17 (0.01)[cy]	0.19 (0.006)[acy]

[1] Years with the same letter within each treatment are not significantly different (P>0.05) (a, b, c, and d).
[2] Sheep (ewe) treatments with the same letter within each year are not significantly different (P>0.05) (x, y, and z).

Conclusion

Multi-species grazing with cattle and sheep in a seasonlong grazing treatment will reduce leafy spurge quicker than a twice-over rotation grazing treatment. The trend of this study, however, would show that in time the twice-over rotation would provide similar control than the seasonlong in a long term management plan. The continuation of this project will allow use to detect which treatment will increase plant species diversity on leafy spurge infested sites. At this time it is too soon to make any conclusion on species diversity. Livestock performance results showed that the twice-over rotation has provided greater average daily gains than the seasonlong for the ewes, however, this may be related to the amount of leafy spurge remaining in the twice-over rotation treatment. Leafy spurge stem counts on the twice-over are still much higher than the seasonlong, which would suggest that the ewes on the twice-over are receiving a higher quality diet than the seasonlong throughout the growing season with the presence of leafy spurge. Livestock results have also shown that the twice-over rotation has increased calf average daily gains over five grazing seasons.

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ND 1709 Objective: 2
GENETIC AND ENVIRONMENTAL STRATEGIES TO IMPROVE THE EFFICIENCY OF LEAN TISSUE ACCRETION IN LAMBS

P.T. Berg and T.C. Faller

The need for objective value-based market pricing structures has never been more apparent. Meat animal production systems must become more efficient if they are to compete with other protein sources. Producing fat is not efficient. Paying a producer for fat lambs is counterproductive. Since 1994, lambs of known ancestry which have been slaughtered at the NDSU Meat Laboratory have been evaluated for carcass characteristics under the NCR 190 regional umbrella project "Increasing efficiency of sheep production." Data from over 500, mostly Columbia, lambs has been presented in past Western Dakota Sheep Day Reports. All of the prediction formulas have never been presented in a single document. This project is now in its final stage, that of testing the prediction formulas through progeny testing the selected sires. Interest has been expressed in how these formulas might be used by a producer in either a selection program or as a pricing scheme.

Formulas for predicting proportion of trimmed retail product (TRP) have been developed from standard carcass measurement data and from electronic evaluation using bioelectrical impedance (BEI) of both carcasses and live lambs. The accuracy of the prediction formulas was verified by actual cutout data.

An "anatomical" prediction formula, using carcass weight, ribeye area, 12[th] rib fat thickness, and body wall thickness was developed after summarizing data on 217 lambs slaughtered at the NDSU Meat Lab. All carcasses were processed into wholesale cuts according to North American Meat Purveyors Specifications (NAMPS). Each wholesale cut was weighed, trimmed of external fat, and reweighed. The sum of the trimmed wholesale cuts for each carcass served as the dependant variable. The carcass measurement information which contributed to the prediction of the dependant variable (pounds of trimmed retail product) were identified through the Statistical Analysis System procedure of General Linear Models stepwise regression. The most variation in pounds of retail product was explained by the formula:

(Pounds TRP = 4.80 + (0.58*cold carc.wt.) + (1.39*ribeye area) - (7.36*12th rib fat) -(5.87*bodywall thickness)

which accounted for 95% of the variation in trimmed retail product. As can be deduced from the component cells of the formula, as carcass weight and ribeye become larger, more pounds TRP are predicted. As carcasses become fatter, as expressed by either 12[th] rib fat or body wall thickness, pounds of predicted TRP decreases. The development of this anatomical prediction formula was very labor intensive because of the need to physically separate the subcutaneous fat from each wholesale cut.

A trimmed retail product prediction formula was developed from BEI analysis of cold carcasses of the same 217 lambs used for the anatomical formula. A BEI transmitter emits a low voltage electrical current into muscle tissue. The amount of resistance to the electrical energy is proportional to the volume or mass of the tissue. Random dispersion of the electrical energy (reactance) is also proportional to mass. The shape of the mass is also important in the amount of resistance and reactance recorded; but since all lambs are roughly the same geometric shape, a formula based on a relatively large sample should be accurate for all lamb carcasses. A formula using carcass weight, resistance, reactance, length (distance) between the detector electrodes and carcass temperature accounted for nearly 93% of the variation in pounds of trimmed retail product.

[Pounds TRP = 6.72 + (.4818*cold carc.wt.) - (.0314*resist.) - (.0481*react.) +(.254*length) + (.0223*temp)]

The component cells in this formula also reflect the fact that larger carcasses produce more pounds of TRP. As temperature decreases, resistance to electrical flow increases. Warmer carcasses generate a larger cell value. The negative mathematic sign for both resistance and reactance indicates that at cold carcass temperatures, carcasses which have greater muscle mass will have less resistance to electric impulse and less reactance. (In terms of electrical conductance, a larger gauge wire has less resistance to current flow than does a smaller gauge wire.) The length measurement is a reflection of a larger volume so the longer distances between the electrodes indicate more muscle. A second set of readings from the BEI analysis was taken using a constant distance between the electrodes, simulating robotic application. This formula also produced an R^2 of nearly 93%. Either the measured length or the constant length method would have easy adaptation to "on-line, chain-speed" carcass evaluation systems.

BEI is one of only two electronic evaluation techniques (the other is ultrasound) which lend itself to live animal adaptation. While ultrasound has received much attention, it only measures estimators (components) of cutability, such as fat thickness and ribeye area. BEI estimates lean tissue directly. A BEI-based prediction formula was developed from 182 live lambs which were slaughtered and processed immediately after BEI evaluation. This formula:

(Pounds TRP = .0973 +(.3318*live wt) + (.017*resist) + (.1739*react) + (.0102*length)

accounted for 79% of the variation in TRP in this set of lambs. As with carcass-based formulas, the mathematic sign associated with live weight and length is "plus" indicating larger animals have more muscle mass than smaller ones. At normal, live body temperature, larger readings for both resistance and reactance result in greater cell values for predicted TRP. That the math sign is opposite between carcass-generated formula and live based may be a function of the different electrolytes present in the live animal versus their carcass.

The percentage of variation explained by each of the formulas was very acceptable when checked against TRP of the same animal carcasses from which the data was gathered. A more definitive test of these formulas was to predict TRP from another slaughter group. The formulas were used to predict TRP on forty-eight lambs slaughtered and processed to trimmed wholesale cuts. The anatomical based formula (cold carc. wt., ribeye, fat and body wall) explained 82% of the variation in this independent set of lambs carcasses. The carcass BEI formula had an R^2 of 84% and the live animal BEI formula explained 79.5% of the variation in TRP.

The development of these formulas has direct application for sheep producers of the state in that either the anatomically-based or the BEI-based prediction formulas could be used for value-based market pricing. The Dakota Lamb Producers Cooperative is currently evaluating the potential to include one or both formulas in their payment program. The live animal BEI prediction formula is currently being evaluated in a feedlot setting under a Hatch Project at NDSU (Fargo and Hettinger). The first 150 lamb carcasses have been evaluated. The BEI generated estimate of "pounds of retail product per day age" EPD for the sires of these lambs accounted for 32% of the variation in retail product of their offspring carcasses. While the 32% is less than we had hoped, it is a major step in improving sire selection efficacy.

EASY SHEEP

T. C. Faller, D. J. Nudell, J. D. Dahl

Hettinger Research Extension Center, Hettinger ND

Introduction

The availability of labor on the average North Dakota farm has declined due to; smaller family size, increased participation in jobs off the farm by family members, and increased mobility which allows family members to be more participatory in educational, social and recreational events away from the farm. Currently minimum wage forty hour per week jobs off the farm are competitive with smaller supplemental income on-farm enterprises. Reduced family farm labor available to the operation has forced farm operations to become more specialized and supplemental income farm enterprises have had to be eliminated. These thoughts may in part explain declines in some of the more labor intensive sources of supplemental income to the average North Dakota family farm, such as; poultry production, dairying, swine production and sheep production, etc.

The Hettinger Research Extension Center (HREC) has recently collected data (Nudell et al. 1999) that indicated some economic favor for pasture lambing systems as compared to more traditional rearing systems. Traditional animal husbandry favors a very strong connection between the caretaker and the animal for mutual survival. Reduced labor systems of sheep production may be more acceptable to today's farm family life styles. The reduced care levels afforded to the animals may not be acceptable to the caretaker. Increasing sheep numbers because of new flocks based on reduced input sheep production may assist the North Dakota sheep industry to rebuild to satisfactory numbers. Regrowth of the industry would help to help support necessary industry infrastructure.

In the spring of 1999 the HREC provided three small flocks of pregnant ewes to three instate producers. The attempt was to collect information on producer response to pasture rearing of sheep with a major emphasis on reduced inputs and especially labor. Attempts will be made to compare production from these units to more traditional systems of production.

Procedure
(1999)

On April first a small flock of five and six year old Montadale x Rambouillet ewes was ultra-sounded for pregnancy at the HREC and seventy six head were found to be pregnant. The seventy six head were divided according to what each producer could handle and fifteen head was delivered to a first time producer at Fort Yates , North Dakota, thirty head were delivered to a long time sheep producers at Wolcott North Dakota and thirty one head were delivered to a dairy producer at Towner, North Dakota On April fifteenth. The ewes were bred to lamb between the period of May fifteenth and June eighteenth. The lambs and ewes were picked up, counted and weighed on September twenty fourth through October fourth when the lambs would have averaged approximately one hundred twenty days of age. There was very little similarity of conditions between the three operations.

(2000)

The same procedure was followed in the spring of 2000 with 104 pregnant five through seven year old Montadale cross Rambouillet ewes. Thirty-eight were delivered to the previous year producers at Towner and Walcott and 28 to a producer at Antler, North Dakota. Similar to the previous year, ewes were randomly sorted specific to what location might be their destination. The grazing period was shortened by 29 days in 2000 as opposed to 1999 because of drier growing conditions.

Producer responsibilities included; ear-tagging and counting the lambs and ewes at the end of the anticipated lambing period, documenting any happenings on an as per event status, documenting any personal feelings throughout the course of the project, and filling out surveys at the end of the lambing period and again at the conclusion of the summer season. Producers would be afforded the opportunity to participate a second year if they wanted and if they did not wish to it was anticipated that they respond as to why for the sake of the project.

An Economic Model of EZ Sheep Results

Four cooperators, located in different areas of North Dakota, tested the EZ sheep system on their farms in 1999 and 2000. A total of six lambing groups were observed over the two years. Two cooperators lambed twice and two cooperators lambed once each. The results of the six lambing groups were combined and an economic model (Sheepbud) was constructed to compare the projected financial results from the EZ cooperators and a more traditional North Dakota lambing system.

Table 1 shows the actual production results achieved by the EZ Sheep cooperators, their average results and an estimated set of North Dakota results under a more typical production scenario. In the comparison analysis, EZ SHEEP average production results to weaning were carried through the model to an expected sell weight of 125 pounds. The North Dakota comparison flock modeled a typical winter lambing flock with early weaning and lambs going directly to feed till they reached a 125 pound market weight.

Table 1. Flock Summaries

Flock	W99	W00	T99	T00	FY99	A00	EZ Ave	ND*
No Ewe	30	38	31	38	15	30	182	100
Ewe Die	1	1	2	1	2	0	7	4
% Die	3.3	2.6	6.5	2.6	13	0	4	4
Lambs Wean	39	41	29	43	20	0	172	130
% Lamb	130	108	97	113	133	0	95	130
Wean Wt	2669	2140	2610	2540	1545	0	11504	5850
Sell Wt							21500	16520
Ave Wean Wt	68	52	90	59	77	0	67	45
# Lamb/Ewe	89	56	84	67	103	0		

***Composite numbers based on Financial records from ND Sheep Development Project (1988-1994).**

In a comparison of projected economic results a number of assumptions were used. They are:

- All lambs sold for $75/cwt at 125 pounds.
- Wool is assumed to be 8 lb per ewe and is valued at $0.25/lb.
- Replacement rate is 20% and all replacements are purchased at $110/hd.
- Ewe death rate is 4%.
- Traditional scenario assumes a barn valued at $5000.
- EZ assumed winter shelter to be a windbreak valued at $500.
- Equipment value is $1000 for traditional and $500 for EZ.
- Traditional scenario markets a 130% lamb crop
- EZ Sheep markets a 95% lamb crop.
- Marketing and trucking cost per head is same for both
- Traditional scenario adds 25 lb of creep feed per lamb and slightly higher vet expense.
- Fuel and utility expense are 2.5 times higher per head in traditional scenario
- Labor and management time is valued at $10 per hour.
- Labor and management is 3 hours per ewe in traditional scenario and 1 hour in EZ.
- traditional assets are valued at $17,750 (Includes value of ewes).
- EZ assets are valued at $22,520 (Includes value of ewes).
- Both assume 50% debt on the ewes.
- Return on Assets is calculated as Net Cash Income + Interest Paid - Value of Labor and management divided by Total Asset Value

Table 2. Projected Financial Results of Comparisons

	Flock Net	Net/Ewe	Interest Paid	Labor Charge	Asset Value	ROA
EZ Sheep	($615)	($3)	$655	$1,820	$22,520	-7.9%
Traditional System	$164	$2	$36	$3,000	$17,750	-14%

The traditional winter lambing scenario shows a positive net cash return. However, the higher labor requirements and the greater per ewe investment required means that the Return on Assets used is -14%. EZ Sheep shows a negative cash flow based on the average results of the six cooperators in the study. The much lower investment per ewe and the substantially lower labor requirements do mean that the Return on Assets is higher for EZ Sheep.

A key finding of this study is the difference in return on assets used between EZ Sheep and more traditional management scenarios. While the combined results of the EZ Sheep cooperators did not project a positive cash flow, the average was substantially affected by poor results in one location. An EZ Sheep operation with results production similar to the other five cooperators is expected have a positive cash return and a positive return on assets (See 2000 Sheep Day Report)

EZ Sheep has potential to be an efficient use of assets available on many North Dakota farms. The reduced labor requirements and the potential to enter the enterprise with a reduced debt load (lower shelter and equipment costs) make the operation more feasible for many farms. There is a risk of failure under the system, see results of flock A00, however a well thought out plan for EZ Sheep has been demonstrated to be viable in many locations of the state.

Results of Cooperator Surveys: (Lambing and Weaning/1999 and 2000)

A questionnaire was sent to cooperators after lambing and weaning each year. The questionnaires asked animal production questions and also to respond to the concepts of EZ Sheep as a system of production. Questions pertained to estimates of major causes of lamb loss, ewe loss, incidences of predation and associated problems. Other questions centered on producer's feeling in relation to the production system and what their perceptions were of processes and ideas that would enhance this form of low input/labor livestock production.

At lambing time primary causes of lamb and ewe losses were ewe body condition and fetal size at birth. While the ewes were of similar genetic makeup and age there were some differences in numbers of birthing problems associated with fetal size especially in year one. In year two fetal size was not mentioned as a problem. Terminal sire breeds was changed in year two with the intent of selecting for lighter birth weights. The ewes were not originally selected for teat size and this was indicated as a problem for lambs to commence suckling on their own and was listed as a cause of baby lamb loss. All cooperators were appreciative of the labor reduction at lambing time associated with the EZ Sheep system of production. One producer in year one indicated that while he/she had good success that it was preferred to lamb under a conventional system because of the ability to have better control of outcomes. Two producers participated both years of the study with acceptable results. The new producer in year two of the study had acceptable birthing performance but EZ Sheep failed completely for him as predation pressures wiped out the complete lamb crop in short order. All producers involved in the study feared the potential of predation problems.

The weaning time survey indicated problems associated with lamb livability from birth to weaning ranked from greatest to least were:

1. Predators
2. Ewe age and associated body condition
3. Teat size
4. Fetal size

There may have been other minor problems that went undetected, however, the four major problems were great enough that they could be positively documented. Fetal size problems were reduced in the second year as a direct affect of targeted attempts to do so by changing terminal sire breeds. Ewe age was years five and six in year one of the study and 6 and 7 in year two and documented as somewhat of a problem by cooperators. The ewes in the study were non-selected other than soundness at shearing time and pregnancy by ultra-sound.

Conclusions

It is difficult at best to fairly compare this system of production by an average North Dakota flock situation. The complete loss of lamb crop at one site in the second year of the study negatively influenced outcome of the study when all numbers were merged. Five of the six cooperator experiences were deemed as positive and more profitable than an average North Dakota flock situation (Sheep Day Report #41). It would appear that the four major documented constraints for conducting a successful EZ Sheep production system would favorably respond to management without greatly increasing inputs. Easy sheep should offer opportunity to new producers with minimal facilities and practical experience. It is fully recognized that EZ Sheep is not for everyone. It would appear to not fit well for extremely high performance ewes or purebred operators. While predation at one site greatly influenced return on assets as a whole it was still most favorable for the EZ Sheep system. At the Hettinger Research Extension Center a historic flock of one hundred ewes will be developed to investigate what level of performance can be achieved when a flock of ewes is bred, selected and managed to perform under a minimal labor/input system. It is believed that it will be critical to the future of the sheep industry to adapt sheep production to our changing lifestyles.

ND 1709 Objective: 1
OUT OF SEASON REPRODUCTIVE POTENTIAL OF WESTERN WHITE FACED RAMBOUILLET TYPE SHEEP UNDER NORTH DAKOTA CONDITIONS

T. C. Faller, P. T. Berg

INTRODUCTION

The seasonal fertility of sheep continues to be a biological puzzle. Unlocking the puzzle offers much opportunity to the sheep industry. Many earlier studies indicate acceptable levels of success in getting sheep to conceive and lamb in non-traditional seasons, however, it usually has involved light control and or hormonal therapy. Many times there still has been some level of failure. Occasionally the level of management employed has confused the level of success of or predictability of out of season lambing schemes. The inability of sheep to consistently lamb according to chosen season severely restricts the development of a constant, dependable supply of lamb meat to consumers. If sheep were able to conceive consistently in April and subsequently lamb in mid to late September it would reduce necessity of quality facilities to maintain a breeding sheep operation under North Dakota climatic conditions . This production scheme would open opportunity to the most economically attractive markets for North Dakota producers as well. Similarly mature ewes involved in a fall lambing scheme would be available as leafy spurge grazers during typical summer months without the presence of lambs to reduce potential of predation. This would be extremely attractive insight of the level of problems associated with the presence of leafy spurge in North Dakota.

PROCEDURE

Starting in 1986, Rambouillet ewes were randomly mated to Rambouillet rams and evaluated in a lambing system that anticipated the ewes to lamb three times in a two year period. In the spring of 1992 the flock was closed and the ewes were being evaluated based on the anticipation of breeding in April with a July clean up mating. The ewes were exposed each time with a 51 day breeding period starting April 4 and July 15. Ram to ewe ratios were one ram to twenty ewes. This closed flock was able to maintain consistent breeding success in April of 80-90 percent of the mature ewes. Replacement ewes were selected randomly from the September born ewe lambs similar to the selection of replacement rams. Poor growth or structurally incorrect individuals were removed from the population prior to making random selections. A control set of similar background ewes mated in November for April lambing has been maintained for the duration of the trials. Replacement ewes were exposed their first time in July along with the mature ewe flock and then re-exposed the following April regardless if they had conceived in the previous July. Ewes that did not maintain a lambing sequence that included every twelve month period starting with their first anticipated lambing time were eliminated from the flock.

In the fall of 1997 one hundred May born ewe lambs of similar wool grade and structural size were selected from a commercial sheep operation in Wyoming. The purpose was to compare breeding success when subjected to the exact same breeding strategy as the one hundred ewe lambs selected from the September born closed flock ewes. Similar selections were made in the fall of 1998 and 1999 with the same intent. Rams from outside flocks were also purchased each year to service a 2x2 factorial design that included closed flock ewes mated to closed flock rams, closed flock ewes mated to purchased rams, purchased ewes mated to closed flock rams and purchased ewes mated to purchased rams. Ram to ewe ratios were maintained to be similar for all breeding groups. All ewes included in the project will be weighed and condition scored annually in the month of April. A five point condition scoring system will be employed with 1 being emaciated and 5 being obese. Routine performance measures will be recorded for the duration of the studies. A strict regimen of isolation of ewes from rams will be maintained other than during the desired mating periods to take advantage of any positive effects of the presence of the ram in enhancing the onset of estrus. Similar data will be collected for the original closed ewe flock that originated in 1986.

RESULTS AND DISCUSSION

(Progress Report)

Table 1 indicates performance of the mature brood ewe flock that has been maintained as a closed fall lambing flock since 1986. All ewes were exposed to mate in April with clean-up mating in July-August. Table 1 indicates success of mating naturally without light control or hormonal therapy. Success would be categorized to be quite similar to traditional fall mating for spring lambing.

Table(1999) and 2000 Mature Flock Fall Lambing Performance

Birth Year of Ewes	1993	1994	1995	1996
Ewes Exposed	(55)	(56) 42	(62) 51	(96) 84
Ewes Lambing	(55)	(53) 38	(60) 50	(87) 81
Percent Bred to Fall Lamb	(100)	(95) 90	(97) 98	(91) 96

Table 2 indicates ewe body weights and condition scores for ewes exposed to lamb their first time in the fall . These measures would represent purchased ewes at 22 months of age and those from the closed flock being 17 months of age at breeding time in April. The data would indicate that the purchased ewes perform very similar to the ewe flock that has been selected for fall lambing.

Table 2 Yearling ewe April Body Weights and Condition Scores

	Closed flock ewes		Purchased ewes	
	1999	2000	1999	2000
Shorn Ewe Body Weights (lbs)	113.2	112.8	113.6	122.7
Ewe Body Condition Scores	2.64	2.51	2.72	2.73

Table 3 indicates reproductive performance of the four breeding schemes described in the procedure. Numbers of ewes available at time of breeding were reduced from the original one hundred closed flock ewes and one hundred purchased ewes because of predation, loss of ear tags and other natural causes. Early indications are that the purchased ewes and rams performed at a level higher than anticipated for first exposure for fall lambing. Initially there appeared to be a positive influence when using closed flock rams on purchased ewes, this effect diminished in the second year of production.

Table 3. Fall Lambing Performance of Purchased vs Closed Flocks

	1999	2000	
Ewe Birth Year	1997	1997	1998
Closed Ewes x Closed Rams			
Ewes exposed	42	38	35
Ewes Pregnant	33	30	24
Fall Breeding Percent	79	79	97
Closed Ewes x Purch Rams			
Ewes Exposed	43	40	31
Ewes Pregnant	28	32	27
Fall Breeding Percent	65	80	87
Purch. Ewes x Closed Rams			
Ewes Exposed	43	37	34
Ewes Pregnant	33	31	31
Fall Breeding Percent	72	84	91
Purch.Ewes x Purch Rams			
Ewes Exposed	44	39	35
Ewes Pregnant	23	31	33
Fall Breeding Percent	52	79	94

Summary

This being the second year of a multiple year trial no attempt was made to analyze the data for differences. It will be especially important to evaluate year two through four and to see if the purchased ewes breeding performance improves at similar rates as closed flock individuals as they mature in the system. They will continue to be measured as a comparison to the base closed flock.

Montadale Regeneration Project: Progress Report.

NDSU (ARS) Personnel Involved:

Dr. Bert Moore
Mr. Wes Limesand
Ms. Millie Brown

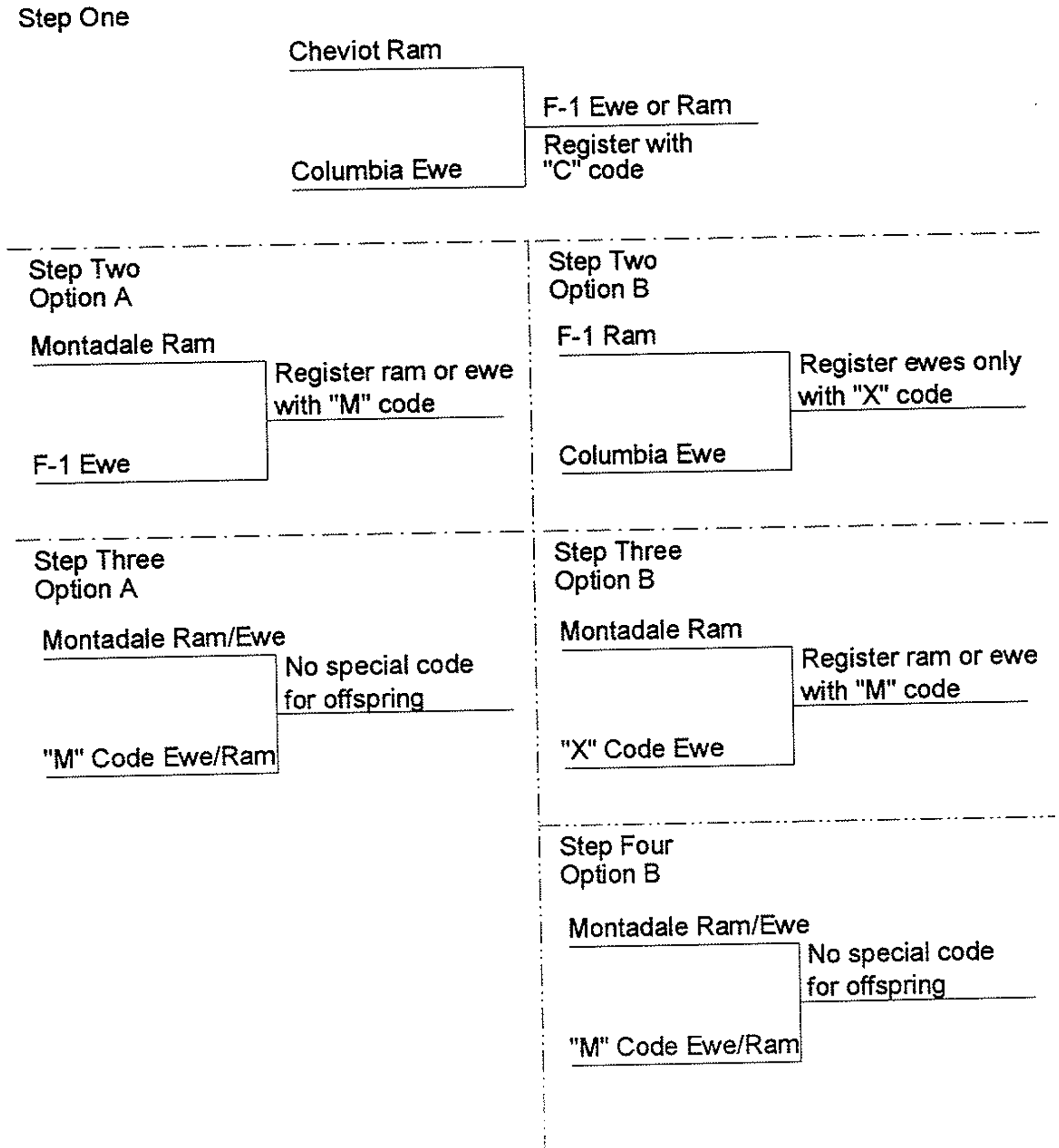
The Montadale Sheep Breeders Association endorsed a regeneration project in 1997. Reports of this project have been detailed in previous Sheep Day Reports (1998 and 1999). NDSU made matings of Columbia ewes to a Border Cheviot ram in the fall of 1997. The F_1 progeny were displayed at the National Montadale Show in Springfield, Illinois, and at the Midwest Stud Ram Sale in Sedalia, Missouri. The F_1 ewe lambs were mated to a purebred Montadale ram in the fall of 1998 and 13 of these ewe lambs lambed a total of 18 lambs, for a 138 percent lambing rate. Average birth weight of these lambs was 11.8 pounds. Fourteen of the 18 F_2 lambs reached 90 days of age and had average adjusted 90 day weights of 94.7 pounds. Both F_1 and F_2 progeny of this project were again exhibited at the previously listed show and sale events.

The F_1 progeny were again mated in the fall of 1999, but this time artificially to one of the top Montadale artificial insemination sires available, a former national champion. Results of these artificial insemination matings arrived in February. Because of the young age, the F_2 ewe lambs were not bred to lamb in the spring of 2000.

Future Projections:

The Mating Scheme for steps in the Regeneration Project is outlined on the following page. This year, lambs which will be considered "purebreds" are born. An attempt will be made to keep this entire group of sheep together by a single breeding establishment

MATING SCHEME FOR STEPS IN REGENERATION PROJECT



Evaluation of Katahdin and Wiltshire Horn (Hair Sheep Breeds): Their Effectiveness in Low Input Management Schemes.

NDSU (ARS) Personnel Involved:

Dr. Bert L. Moore
Dr. Paul T. Berg
Mr. Roger Haugen
Mr. Wes Limesand
Dr. Dale A. Redmer
Dr. Anna Grazul-Bilska

Objectives:

1. Evaluate production parameters of two hair sheep breeds (Katahdin and Wiltshire Horn).

    a. growth to weaning
    b. feedlot gains
    c. carcass characteristics

2. Investigate propensity for fall lambing in hair breed females.

3. Determine generations required to "breed the wool off" conventional sheep breeds.

4. Compare economics of "wool less" sheep and wool producing breeds.

5. Establish semen and embryo inventories for different hair and hair x wool cross populations.

Justification:

U.S. sheep numbers are currently at an all-time low of 7.2 million head. This is the lowest total since census numbers of sheep have been kept (USDA, 2000). World wool supply remains extremely high and a subsequently low price is being realized for wool. In many cases, wool stores are simply being warehoused because of the extremely low market prices. Many sheep producers are finding it impossible to cover shearing costs from the total revenue received from the wool clip. This is in severe contrast to the situation fifteen years ago when approximately one-third of the total revenue from sheep in the United States was obtained from wool receipts (USDA, 1984).

Some of the decline in numbers can be attributed to a decline in the amount of and the high cost of labor involved at specific times in a sheep operation. Hair sheep breeds seem to have potential in establishment of low input, less labor intensive sheep programs which can complement other farm and ranch enterprises.

Background – Katahdin Sheep Breed:

Work on establishment of the Katahdin breed started in 1957 through the efforts of Michael Piel of Maine. Three "African Hair Sheep" were imported from St. Croix and crossed with several breeds which existed in the United States at that time. The Wiltshire Horn influence was added in the 1970's (Katahdin Breed Assn., 1999).

Katahdins are described in the breed literature as hardy, adaptable, low maintenance sheep. They do not produce a fleece and, therefore, do not require shearing. Most animals are white, but can also be tan or multi-colored.

Other traits which seem to offer potential from the Katahdin include resistance to parasites, potential for accelerated or out of season lambing, and acceptable fertility. Katahdin sheep did, however, exhibit lower average daily gain than some other breeds (Wideus, 1997).

Background – Wiltshire Horn:

The Wiltshire Horn is an ancient British breed from the Chalk Downs region of England. Both rams and ewes are horned, but a polled line has been established. Both sexes are white with occasional dime-sized black spots on the undercoat. They are described as medium sized sheep that do well in either heat or cold. Current interest is due, in part, to their lack of wool and need for shearing (Thwaites, 1993).

There has been no research done to characterize the Wiltshire Horn for their use in American production schemes. Their value may come from not only their lack of wool, but also from resistance to external parasites, foot rot resistance from a black hard hoof, and lamb vitality. They, however, are probably suspect in growth rate. They are also said to be seasonal breeders and somewhat late in maturity.

Procedures:

The ewe flock used at the Ekre property for leafy spurge grazing demonstrations will be divided; one group bred to a Katahdin ram, another group to a Wiltshire Horn ram, a third group to Columbia and Hampshire rams.

Breed of sire effect on lamb birth weights, weaning weights, and feedlot gains will be measured. Male lambs will be evaluated for carcass traits. Female lambs will be kept as flock replacements and evaluated over three to four years for puberty, out of season lambing ability, and reproductive performance. Economic impacts of wool versus no wool will be evaluated.

Results:

Results of lambing are given in table 1. All groups had high lambing percents. Death losses were greatest in the Columbia and Hampshire sired lambs. There is no particular explanation for this. As expected, these lambs were heavier at birth than were the hair-sired lambs. All hair-sired lambs showed exceptional vigor at birth. Again, this was to be expected because of the heterotic affect on vigor.

Table 1. Lambing results.

Sire Group	K	W	CH
Percent Lambs Dropped	195	182	167
Lamb Birth Weight (lbs.)	11.1	10.8	13.5
Death Loss	0	12.5	22.2

Two groups of lambs were placed on feeding trials and carcass data gathered. Because of management procedures and marketing decisions, the first group of lambs were placed on trial and marketed after a 45-day feeding trial. A 16 percent protein complete mixed ration containing 12 percent alfalfa pellets as a roughage source was fed free choice. Lambs were weighed every 2 weeks. Growth and feed consumption data were gathered.

A second group of April born lambs were placed on a compatible feeding regime after the first group. Again, because of management and marketing decisions, these lambs were placed on test at lighter weights and slaughtered at heavier weights.

Results of the finishing trials are listed in tables 2 and 3. In the first trial, the CH lambs gained the most rapidly. In the second trial, there was negligible difference between the average daily gains of the lambs. Because it was later in the year and there was substantially more hot weather, lambs on the second trial ate less and, consequently, grew less rapidly.

Table 2. Finishing data – Trial 1.

Sire Group	K	W	CH
ADG (lbs.)	.718	.806	.863
Feed Intake/d (lbs.)	3.76	4.14	4.96
Feed/Gain (lbs.)	5.24	5.14	5.75
Dry Matter/Gain (lbs.)	4.65	4.56	5.11

Table 2. Finishing data – Trial 2.

Sire Group	K	W	CH
ADG (lbs.)	.673	.651	.644
Feed Intake/d (lbs.)	3.17	3.32	3.18
Feed/Gain (lbs.)	4.71	5.10	4.94
Dry Matter/Gain (lbs.)	4.18	4.53	4.39

Slaughter data is presented in tables 4 and 5. In both data sets, K sired lambs had less fat measured at the ribeye and by body wall thickness. This accounts for the fact that K sired lambs had the highest percent boneless closely trimmed retail cuts (percent BCTRC). Ribeye areas were similar within each trial and larger in the second trial where the carcasses were slightly heavier. In both trials, W sired lambs had the highest (but not significant) conformation scores. This was easily observable visually in these W lambs.

Table 4. Carcass data – Trial 1 (45 d).

Sire Group	K	W	CH
Hot Carcass Weight (lbs.)	59.98	56.13	63.13
ERA (in. sq.)	2.43	2.47	2.46
Conformation Score[1]	10.56	11.13	10.67
Lean Color	2.99	2.72	2.83
Fat (in.)	.13	.20	.18
Body Wall Thickness (in.)[2]	.61	.76	.68
Percent BCTRC	48.10	47.46	47.35

Table 5. Carcass data – Trial 2 (99 d).

Sire Group	K	W	CH
Hot Carcass Weight (lbs.)	63.57	67.29	65.68
ERA (in. sq.)	2.65	2.59	2.55
Conformation Score[1]	11.40	11.44	10.85
Lean Color	3.18	3.01	3.25
Fat (in.)	.13	.18	.18
Body Wall Thickness (in.)[2]	.75	.87	.77
Percent BCTRC	47.63	46.69	46.89

[1] 10 = Ch^-, 11 = Ch^o, 12 = Ch^+
[2] Percent boneless closely trimmed retail cuts

<u>Conclusions</u>:

- Although smaller at birth, both K and W sired lambs showed exceptional vigor and recorded very low death loss.
- Lambs gained more rapidly in the first trial when they were less stressed by heat and humidity with CH sired lambs gaining the fastest. No differences in gains by sire groups were recorded in the second trial.
- Growth and feed efficiency measures for all lambs were acceptable.

- Recorded carcass data indicates that the carcass value of hair sired lambs is very acceptable and comparable to that of some of our popular breeds.

Progress and Future Plans:

Two additional Katahdin rams were purchased in 2000 to be bred to the F_1 females as well as the crossbred foundation ewes. These rams originated from one of the most highly regarded flocks in the breed. Some of the females sired by a Katahdin x Wiltshire Horn ram were also exposed to lamb in the spring of 2001. F_1 Katahdin females will be bred in April to lamb in the fall to one of the two newly purchased rams.

F_1 Wiltshire Horn ewes will, likewise, be bred in April to the polled Wiltshire Horn x Katahdin ram for the production of one-half Wiltshire Horn, one-quarter Katahdin, one-quarter crossbred progeny. This is done for several reasons. First, purebred Wiltshire Horn rams are very difficult to find and acquire because of the very low population of this breed of sheep. Second, the polled factor is desirable; and it is hoped that this polled ram will help incorporate this trait into higher percentage progeny. Third, the Katahdin reportedly has a higher propensity for out of season (fall) lambing than does the Wiltshire Horn, so incorporation of this trait is also desirable.

Two purebred Katahdin ewes were acquired from the Fortmeyer flock in Kansas. Both of these ewes were super ovulated, flushed, and embryos transferred to recipient ewes. The goal of this process is to use the new embryo transfer techniques developed at NDSU in the expansion of this purebred Katahdin flock.

Most one-half and three-quarter hair-sired male lambs will again be evaluated through feed trials and carcass data will be gathered. A few outstanding three-quarter ram lambs which show the desirable shedding traits may be retained for use in the expanding flock.

Contact has been established with several other universities and agricultural experiment stations throughout the country, all of which have on-going interest and research activities with hair sheep. Grant applications for funding have been made which are currently pending.

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SECTION II
MANAGEMENT SECTION

TIMOTHY C. FALLER
DIRECTOR
HETTINGER RESEARCH EXTENSION CENTER

MR. ROGER HAUGEN
EXTENSION LIVESTOCK SPECIALIST
NORTH DAKOTA STATE UNIVERSITY

42ND ANNUAL SHEEP DAY

HETTINGER RESEARCH EXTENSION CENTER
HETTINGER, NORTH DAKOTA

FEBRUARY 14, 2001

EKRE PROJECT - THE EWE FLOCK

ECONOMIC SUMMARY FOR 2000

Roger G. Haugen, Extension Sheep Specialist
NDSU , Fargo

2000 FLOCK OF 68 EWES

Ewes lambed in Feb-March; Lamb Drop = 179%; Death Loss = 12.0%
122 lambs born; 107 lambs weaned

- **19 Ewes lambed Bred to Katahdin; Lamb Drop = 195%; Death Loss = 0.0%**
  - ***average lamb birth weight was 11.1 lbs***
- **22 Ewes lambed Bred to Wiltshire Horn; Lamb Drop = 182%; Death Loss = 12.5%**
  - ***average lamb birth weight was 10.8 lbs***
- **27 Ewes lambed Bred to Hampshire or Columbia; Lamb Drop = 167%; Death Loss = 22.2%**
  - ***average lamb birth weight was 13.5 lbs***

1999 FLOCK OF 76 EWES

Ewes lambed in Feb-March; Lamb Drop = 178%; Death Loss = 8.9%
135 lambs born; 123 lambs weaned

1998 FLOCK OF 50 EWES

Ewes lambed in Feb-March; Lamb Drop = 178%; Death Loss = 12.4%
89 lambs born; 78 lambs weaned

Feed expenses by the ewes:

Nov/May 15 - Forage and grain fed. **200 days TOTAL ~ $25 /ewe**
May 15/Oct - Grazing on Ekre Property **(value versus 165 days @ 4 lbs hay/ day =$19.80)**

Lamb Marketing Income - 2000

51 lambs marketed at $0.84/lb; averaged 124 lbs. Gross $5312.16 ($104.16/head)
12 ewe lambs sold at $100/head. Gross $1200.
44 ewe lambs retained at a market value of $100/head. Gross value $4400.
Total gross $10,912.16 ($101.98/head) or ***$160.47/ewe***.

*In 1999, lambs grossed $12,894.00 ($105.40/head) or **$170.58/ewe**.*
*In 1998, lambs grossed $8553.36 ($112.55/head) or **$171.07/ewe**.*

Lamb feed costs til August.

Lambs conversions were ~ 4.5 pounds of feed per pound of gain for a total of ~ 333 pounds of feed per lamb (weaning-50 lbs to 124 lbs). The ration cost approximately 5 cents a pound. Total feed cost per lamb was $16.65. (At a feed cost of 6 cents, the feed cost/lamb would have been $19.98)
Total lamb feed costs - $1,781.55 (@5 cents) or ***$26.20/ewe***.
Total lamb feed costs - $2,137.86 (@6 cents) or ***$31.44/ewe***.

FLOCK CALENDAR OUTLINE

The following guidelines are neither inclusive nor intended to fit every sheep operation. Each operation is different, therefore, each "calendar of events" should be tailored to each flock's needs.

PRIOR TO BREEDING

1. Bag and mouth ewes and cull those that are not sound.

2. Replace culled ewes with top-end yearlings or ewe lambs.

3. Keep replacement ewe lambs on growing ration.

4. Evaluate sires:

   a. Be sure they are vigorous, healthy and in good breeding condition.

   b. Rams should be conditioned at least a month before the breeding season. Flush rams in poor condition.

   c. Allow at least two mature rams (preferably three) or four buck lambs per 100 ewes.

   d. Utilize production records to evaluate anticipated breeding ability.

5. Flush ewes:

   a. One pound grain/day two to five weeks before breeding (usually 17 days).

   b. If ewes are over-conditioned, the effect of flushing will be lessened.

6. Vaccinate ewes for vibriosis and enzootic abortion (EAE).

7. Identify all ewes and rams with ear tags, paint brands or tattoos.

BREEDING

1. The ovulation rate of a ewe tends to be lowered at the first part of the breeding season. Vasectomized or teaser rams run with the ewes through the first heat period tend to stimulate them and increase the ovulation rate at the second heat period.

2. Use a ram marking harness or painted brisket to monitor breeding. Soft gun grease with paint pigment mixed in works well for painting the brisket. A color sequence of orange, red and black is recommended with colors being changed every 17 days.

3. Leave rams in NO LONGER than 51 days (35 days is more desirable).

   a. An exception may be with ewe lambs. Allowing them four heat cycles or 68 days may be beneficial.

4. Remove rams from ewes after the season (don't winter rams with ewes).

PRIOR TO LAMBING — EARLY PREGNANCY (First 15 Weeks)

1. Watch general health of ewes. If possible sort off thin ewes and give them extra feed so they can catch up.

2. Feed the poor quality roughage you have on hand during this period, saving the better for lambing.

3. An exception to the above is feeding pregnant ewe lambs. They should receive good quality roughage and grain (about 20 percent of the ration) during this period.

LAST SIX WEEKS BEFORE LAMBING

1. Trim hooves and treat for internal parasites.

2. Six to four weeks before lambing feed 1/4 to 1/3 pound grain/ewe/day.

3. Shear ewes before lambing (with highly prolific ewes at least a month before is preferred). Keep feeding schedule regular and watch weather conditions immediately after shearing (cold).

4. Vaccinate ewes for enterotoxemia.

5. Control ticks and lice immediately after shearing.

6. Four weeks before lambing increase grain to ½ to 3/4 pound/ewe/day (usually done immediately after shearing).

7. Give A-D-E preparations to ewes if pastures and/or roughage are or have been poor quality.

8. Feed selenium-vitamin E or use an injectable product if white muscle is a problem. **Caution** — Don't do both.

9. Check facilities and equipment to be sure everything is ready for lambing.

10. Two weeks before lambing increase grain to 1 pound per ewe per day.

LAMBING

1. Be prepared for the first lambs 142 days after turning the rams in with the ewes, even though the average pregnancy period is 148 days.

2. Watch ewes closely. Extra effort will be repaid with more lambs at weaning time. Saving lambs involves a 24-hour surveillance. Additional help at this time is money well spent.

3. Put ewe and lambs in lambing pen (jug) after lambing (not before).

4. Grain feeding the ewes during the first three days after lambing is **not** necessary.

5. Be available to provide assistance if ewe has troubles.

6. Disinfect lamb's navel with iodine as soon after birth as possible.

7. Be sure both teats are functioning and lambs nurse as soon as possible.

8. Use additional heat sources (heat lamps, etc.) in cold weather.

9. Brand ewe and lambs with identical number on same sides. Identify lambs with ear tags, tattoos or both.

10. Turn ewe and lambs out of jug as soon as all are doing well (one to three days).

11. Bunch up ewes and lambs in small groups of four to eight ewes and then combine groups until they are a workable size unit.

12. Castrate and dock lambs as soon as they are strong and have a good start (two days to two weeks of age). Use a tetanus toxoid if tetanus has been a problem on the farm (toxoids are not immediate protection. It takes at least ten days for immunity to build).

13. Vaccinate lambs for soremouth at one to two weeks of age if it has been a problem in the flock.

14. Provide a place for orphaned lambs. Make decision on what lambs to orphan as soon after birth as possible for the best success. Few ewes can successfully nurse more than two lambs.

END OF LAMBING TO WEANING

1. Feed ewes according to number of lambs suckling. Ewes with twins and triplets should receive a higher plane of nutrition.

2. Provide creep feed for lambs (especially those born during the winter and early spring).

3. Vaccinate lambs for overeating at five weeks and seven weeks of age.

WEANING

1. Wean ewes from lambs, not lambs from the ewes. If possible, remove ewes from pen out of sight and sound of lambs. If lambs have to be moved to new quarters, leave a couple of ewes with them for a few days to lead the lambs to feed and water locations.

2. Lambs should be weaned between 50 and 60 days of age or when they weigh at least 40 pounds and are eating creep and drinking water. The advantage of early weaning is that the ewe's milk production drops off to almost nothing after eight weeks of lactation.

3. Grain should be removed from the ewe's diet at least one week prior to weaning and low quality roughage should be fed. Restriction of hay and water to the ewe following weaning lessens the chance of mastitis to occur. Poorer quality roughage should be fed to the ewes for at least 10 to 14 days following weaning.

4. Handle the ewes as little as possible for about 10 days following weaning. Tight udders bruise easily. If possible, bed the area where the ewes will rest heavily with straw to form a soft bed for the ewes to lay on.

WEANING TO PRE-BREEDING

1. If ewes go to pasture, treat for internal parasites.

2. Feed a maintenance ration to the ewes. Put ewe lambs that lambed back on a growing ration once they have quit milking.

3. Adjust ewe's conditions so they can be effectively flushed for next breeding season. Don't get ewes too fat prior to breeding.

REARING LAMBS ARTIFICIALLY (ORPHANS) — MANAGEMENT TIPS

Within 2 to 4 hours after birth, decide which lambs among those from multiple births you should remove. Look for the weaker, or smaller ones to choose for artificial rearing. It is important to make this decision early. Relatively weak lambs remaining with the ewes can experience more stress than those reared artificially. Consider the following tips:

- It is essential that newborn lambs receive colostrum milk. Cow's colostrum will work if ewe's milk is not available. Do not dilute with water or warm too quickly if colostrum is frozen.
- Lambs should be removed from sight and hearing distance of ewe.
- Provide a warm, dry, draft-free area to start lambs.
- Use a good milk replacer that is 30% fat and at least 24% protein. Each lamb will require from 15 to 20 pounds of replacer to weaning.
- Use good equipment. Self priming nipple and tube assemblies have been found to be excellent for starting lambs.
- Lambs may require some assistance the first day or two to teach them to nurse on whatever feeding device is used.
- Start on nurser quickly. Young lambs start easier.
- Self feed cold milk replacer after lambs are started. Milk replacers should be mixed with warm water for best results and then cooled down. Lambs fed cold milk grow well with less problems from scours and other digestive disturbance. Cold milk keeps better too.
- There is a Formaldehyde solution commercially available that retards bacterial growth in milk (1 cc/gallon milk).
- Hang a light over the milk replacer feeding device and dry ration feeder.
- Avoid placing young lambs with older lambs, as they may be pushed aside and not be able to obtain milk replacer. Remember that lambs nursing ewes drink 25 to 40 times per 24 hours. Best results have been obtained when lambs are fed in groups of 3 to 4 initially. After lambs are successfully trained, they can be handled in groups of 25.
- Inject lambs in the first few days with Iron Dextran, Vitamin A-D-E, and Selenium-Vitamin E. At 15 days of age, vaccinate for overeating (Colostridum perfringen type C & D).

- Provide lambs a high-quality creep feed as soon as possible. Provide ample fresh water in front of lambs at all times. Do not feed hay or oats the first three weeks of age as it encourages bloat. Caution! Do not feed leafy alfalfa until two weeks after weaning, as it may encourage bloat.

- Wean lambs abruptly at 21-30 days of age. When to wean depends upon whether lambs are eating creep feed and drinking water. Newly weaned lambs will go backwards for several days. Don't be alarmed, they will make compensating gains later on.

SHEEPBARNS AND EQUIPMENT PLANS

Timothy C. Faller
Hettinger Research Extension Center
North Dakota State University

NOTE: These and other plans are available through county agents or from Extension Agricultural Engineering, NDSU, Fargo, ND. The drawings show construction details and include a materials list for estimating. Due to changes in lumber sizes, lumber grades, plywood quality, and other developments in building materials, some adjustments are required for older plans. (Present charge is shown or $1.00 per sheet.)

CORRALS AND BARNS

Plan No.	Plan Title	Sheets
MW 72050	Pole Utility Buildings	$2.00
MW 72505	Slatted Floor, 40'x72', Feeder Lamb Barn	3.00
MW 72506	240 Ewe and Lambing Barn, 40'x104'	3.00
MW 72507	500 Ewe and Lamb Feeding Barn, 74'x256'	3.00
MW 72508	12' x 16' Portable Lamb Feeding Shed	2.00
MW 72509	40 Ewe and Lambing Barn, 24x32'	2.00
ND Plan	Confinement Sheep Barn & Hay Storage (at Hettinger)	1.00
Reprint #759	Practical Sheep Housing for North Dakota	No Charge
USDA 6096	Shearing Shed & Corral Arrangement	1
USDA 6236	Portable Handling Corral for Sheep (Metal Wood)	1
AE-683	Sheep Barn Layout	No Charge
AED-13	Insulation and Heat Loss	No Charge
AED-19	Slip Resistant Concrete Floors	No Charge
AED-25	Earth Tube Heat Exchange System Planning	No Charge
MWPS-3	Sheep Housing and Equipment Handbook (This 90 page booklet was revised in 1994. It includes barn and layout planning plus plans for fences and sheep equipment.)	10.00
MWPS-9	Designs for Glued Trusses	5.00

FEED HANDLING & FEEDERS

USDA 5917	Fencing, Feeding, and Creep Panels	1
Reprint #409	Chopped Hay Feeder for Sheep	No Charge
Reprint	16 ft. Collapsible Fenceline Feedbunk for Sheep	No Charge
ND 872-1-1	Stationary Roughage Self Feeder for 70 Ewes or 160 Lambs	No Charge
ND 872-1-2	Portable Roughage Self Feeder for 40 Ewes or 80 Lambs	No Charge

Plan No.	Plan Title	Sheets
MW 73110	24 ft. wide Clearspan Pole Frame Hay Shed	$ 3.00
MW 73111	36 ft. wide Clearspan Pole Frame Hay Shed	3.00
MW 73112	48 ft. wide Clearspan Pole Frame Hay Shed	3.00
MW 73113	32 ft. & 48 ft. Wide Pole Frame Hay Shed (Interior Poles)	3.00
MW 73210	Moveable Grain Storage Walls, 6' to 12' High	2.00
MW 73217	20, 45, 170, and 340 Bu. Hoppered Grain Bins	3.00
MW 73220	48 ft. Wide Pole Frame Grain Storage	2.00
MW 73250	Grain Storage Buildings, 600, 1000, 1200, 1500 or 2000 Bu.	3.00
MW 73293	Grain-Feed Handling Center, Work Tower Across Drive	4.00
MW 73294	Grain-Feed Handling Center, Work Tower Beside Drive	4.00
APA	10 Ton Hoppered Feed Bin	No Charge
APA	4 Compartment Bin for Feed Mill	No Charge
AED-15	Horizontal Bunker Silos, Concrete Tilt-up	No Charge
USDA 6090	5500 Bushel Wooden Grain Bin	2
MWPS-13	Planning Grain-Feed Handling Handbook	5.00