COLLEGE OF AGRICULTURE AND EXTENSION

RESEARCH REPORT

College of Agriculture

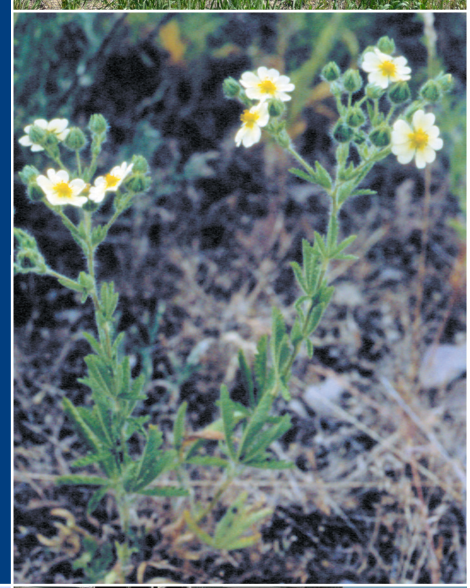
Extension Service

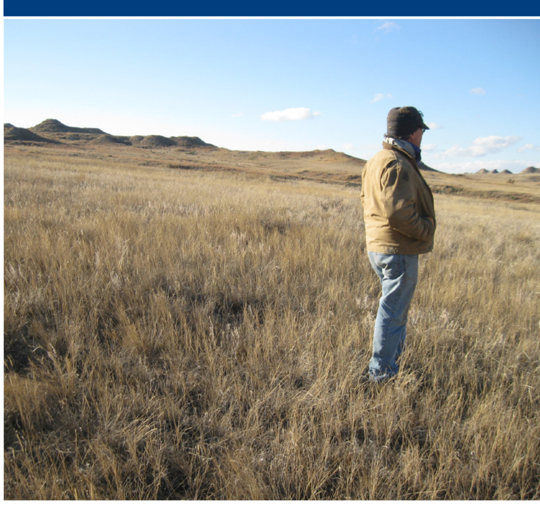
Montana State University
Report No. 1

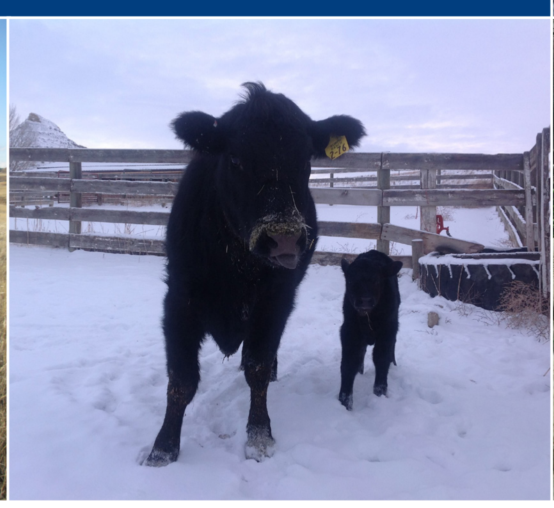
July 2015

MONTANA STATE UNIVERSITY
College of
AGRICULTURE

MONTANA STATE UNIVERSITY
EXTENSION







Welcome, to the first edition of the Montana State University College of Agriculture and MSU Extension Research Report.

The MSU College of Agriculture, Montana Agricultural Experiment Station and MSU Extension are committed to investigating challenges facing our state's agriculture producers and stakeholders. We are pleased to provide this report to Montana's agriculture industry, which highlights recent MSU research conducted throughout Montana.

This report provides a snapshot of research results that provide the knowledge and technology to improve management, efficiency, production, and sustainability of agriculture in Montana.

I encourage you to contact the scientists involved in these projects if you have questions or would like additional information. Our faculty are always glad to speak with producers and stakeholders. Our connections with you provide the means for us in the College, MAES and Extension to collectively honor the land-grant mission through continued service to the state and support for our agriculture industry – the largest economic driver in Montana.

We thank all of the sponsors who support our research programs. Without the support of sponsors – federal, state, private industry and partners across the state who support us in myriad ways – this research would not be possible. We also thank the faculty, staff, and graduate and undergraduate students who have contributed to this work.

Sincerely,

Charles Boyer

Charles Boyer, VP, Dean, and Director

Greetings,

I hope you find this important document as interesting and useful as I do. As part of the land-grant university in Montana, it is an integral part of our mission to disseminate the work being done by our excellent Extension and Montana Agricultural Experiment Station faculty. We must be accountable to our stakeholders and demonstrate to them the value of the research being conducted on agricultural issues important to the state.

This report will provide producers, processors, researchers and Extension agents valuable information on which to base production decisions, future research needs and educational programming.

I want to thank all of the scientists and students that have contributed to this first issue. The administration is committed to making this report a regular publication and to see it grow in participation and distribution.

Sincerely,

Jeff Bader
Director of Extension

TABLE OF CONTENTS

Acronyms/Abbreviations

ADG – average daily gain
ADF – acid detergent fiber
BW – body weight
CP – crude protein
Cr_2O_3 dosing – Chromium Oxide
CV – coefficient of variation
DM – dry matter
DMI – dry matter intake
HCW – hot carcass weight
ISDMD – in-situ dry matter disappearance
KPH – kidney, pelvic, and heart fat
LSD procedure – least significant difference
NDF – neutral detergent fiber
NEg – net energy of gain
NEl – net energy of lactation
NEm – net energy of maintenance
OM – organic matter
PGF2a – prostaglandin F2 alpha
REA – rib-eye area
RFI - residual feed intake
RFV – relative feed value
TDN – total digestible nutrients
SD – statistical differences
YG – yield grade

Creating Grazing Habitat Management Strategies for a National Wildlife Refuge

by

S.C. Davis[1] and K.A. Cutting[2]

[1] Department of Animal and Range Sciences, Montana State University, Bozeman,
and [2] Red Rock Lakes National Wildlife Refuge, Lima, MT

IMPACT STATEMENT

This report should be useful for land managers interested in using prescriptive cattle grazing to create desired habitat states. It can aid in understanding the process of developing grazing-related habitat management strategies.

CREATING GRAZING HABITAT MANAGEMENT STRATEGIES FOR A NATIONAL WILDLIFE REFUGE

by S.C. Davis and K.A. Cutting

SUMMARY

A habitat management plan for grazing serves to guide the management of conservation lands and explains how prescriptive cattle grazing can be used to prevent a decline in rangeland quality and maintain or improve wildlife habitat. Habitat management strategies developed for a National Wildlife Refuge focus on using stocking rate, period of rest, timing of grazing, invasive species control, and prescribed fire and grazing to help meet wildlife habitat objectives. Adaptive management and future monitoring are keys to ensuring the success of this habitat management plan.

INTRODUCTION

Land managers have the ability to create and modify wildlife habitat by utilizing various management tools. Prescriptive cattle grazing has been used as a management tool for maintaining or creating wildlife habitat at Red Rock Lakes National Wildlife Refuge (RRLNWR) in southwest Montana. Grazing predominately occurs in three habitat types at RRLNWR- wet meadow, grassland, and shrub-steppe.

Prescriptive grazing could be used to meet habitat objectives that have been defined in the RRLNWR Comprehensive Conservation Plan (CCP, a 15-year vision used to direct land management). CCP objectives are based on habitat type to create a desired habitat state for target wildlife species. Target wildlife species for wet meadows include northern pintail, short-eared owl, long-billed curlew, sandhill crane, and greater sage-grouse. Target species for grasslands include Swainson's hawk and Ferruginous hawk, while Brewer's sparrow and greater sage-grouse represent target species for shrub-steppe. The overarching management goal for RRLNWR is to provide a mosaic of habitats that meet the life history requirements of the target species.

Despite several scientific studies and targeted management actions, little has been done to synthesize this existing knowledge for a more comprehensive assessment of grazing management across the refuge. The objective of developing a habitat management plan (HMP) for grazing is to guide the management of refuge habitat and provide managers a decision-making framework. Grazing habitat management strategies are developed through the utilization of existing studies done at RRLNWR, monitoring data, scientific literature, and staff expertise (Figure 1).

PROCEDURES

Red Rock Lakes National Wildlife Refuge is located in the Centennial Valley of Beaverhead County in southwest Montana. The elevation ranges from 6,670 to 9,400 feet above sea level. Management takes place within grazing units that range from 25 to 2,789 acres and occupy 34,684 of ~60,000 acres of total RRLNWR land. Vegetation surveys were conducted in 2014 in all grazing units (35 total) at RRLNWR. We randomly selected one sampling point within each habitat type per grazing unit for permanent monitoring (63 points total).

As defined in the CCP, certain vegetation attributes (e.g., vegetation height, forb cover, etc.) are important habitat components that influence wildlife populations. To examine

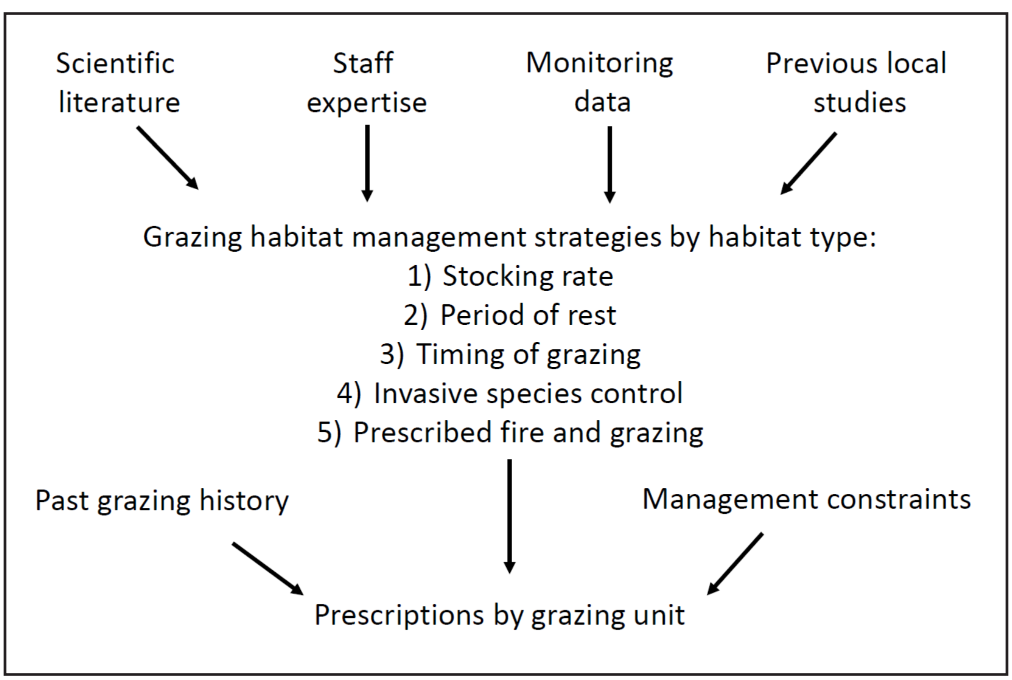


FIGURE 1: Conceptual diagram of the process of developing grazing habitat management strategies and prescriptions

if habitat requirements for target species are being met, we sampled 1) vegetation height using averages, 2) canopy cover of various groups (i.e., native graminoid, exotic graminoid, forb, litter, and bare ground) using a 7.87 in x 19.69 in Daubenmire frame (Daubenmire, 1959), and 3) shrub canopy cover using a line intercept technique (Bauer, 1943). Stocking rates were updated for each grazing unit based on useable forage production data collected in 2014. We also established two permanent photopoints at each sampling point to assess long-term changes and revisited historic transects to understand 40-year trends in native versus exotic grasses.

Interpreting the current habitat state will give an assessment of grazing management and if the habitat requirements are being met for target species. Assessing monitoring data by grazing unit will allow land managers to understand how the grazing history may have led to current habitat attributes and allow for focused prescriptive grazing plans.

RESULTS AND DISCUSSION

Grazing habitat management strategies by habitat type and prescriptions by grazing unit were developed through the process outlined in Figure 1. Achieving desired habitat objectives for target species can occur through altering components of the grazing regime such as stocking rate, period of rest, and timing of grazing.

For each habitat management strategy we provide a definition, how it can be implemented as a management tool in this type of environment, and current usage at RRLNWR. To balance the sometimes conflicting habitat requirements of target species, management strategies are recommended by habitat type and prescribed by grazing unit to create a mosaic of habitat attributes across the refuge. Prescriptions by grazing unit take into account the past grazing history of the unit and management constraints (e.g., consideration of wilderness, management flexibility, climatic conditions, and budgeting). Examples of grazing habitat management strategies are given below:

Stocking rate: A mixture of conservative and moderate updated stocking rates should be followed in wet meadow dominated grazing units to provide habitat for a variety of target species with conflicting habitat requirements.

Period of rest: Continue following a three year rest-rotation, but give a minimum of five years rest in grazing units in which there is less than 5% exotic graminoid cover in order to prevent potential spread of exotic graminoids into fairly pristine units. Longer periods of rest may be required for riparian willow recovery (3+ years) and temporary electric fencing should be used to protect a portion of sensitive riparian areas from heavy grazing.

Timing of grazing: Limit early season grazing (prior to mid-July) in known key areas for bird nesting and brood-rearing in order to help mediate grazing impacts on target species that require forbs and Hemiptera as a food source in June (Davis et al., 2014).

Invasive species control: Experiment with prescribed burning at the time of smooth brome tiller elongation in units where there are more than 20% of tall, native grasses (Willson and Stubbendieck, 2000). Preventative measures to limit the spread of invasive species can also include restricting travel by ATVs to established roads and trails and avoiding moving livestock from weedy areas into weed-free areas (Goodwin et al., 2012).

Prescribed fire and grazing: Conduct prescribed burns before the onset of grassland bird nesting or in the fall to avoid potential negative effects on grassland birds. Increased stocking rates for 1-2 years after controlled fire has been suggested as a potential way to reduce vegetative cover, allow re-initiation of active blowouts, and increase the proportion of early seral vegetation in the Centennial Sandhills (Lesica and Cooper, 1999). This strategy should be tested and monitored in grazing units with sandhill areas.

A key point to this HMP is the importance of adaptive management and an emphasis on future monitoring of wildlife populations and habitat. Grazing management needs some flexibility, especially in a high-elevation system with varying climatic conditions. Additionally, some grazing management strategies may need to be further examined and tested before implementing across large areas (e.g., prescribed burning to target invasive species). Therefore, monitoring habitat conditions before and after treatment, with replication, will be key to understanding the success of the strategy.

REFERENCES

Daubenmire, R. 1959. *A canopy-coverage method of vegetational analysis.* Northwest Sci. 33:43-64.

Bauer, H.L. 1943. *The statistical analysis of chaparral and other plant communities by means of transect samples.* Ecology 24:45-60.

Davis, S.C., L.A. Burkle, W.F. Cross, and K.A. Cutting. 2014. *The effects of timing of grazing on plant and arthropod communities in high-elevation grasslands.* PLoS ONE 9:1-14. doi:10.1371/journal.pone.0110460

Goodwin, K., R. Sheley, J. Jacobs, S. Wood, M. Manoukian, M. Schuldt, E. Miller, and S. Sackman. 2012. *Cooperative Prevention Systems to Protect Rangelands From the Spread of Invasive Plants*. Rangelands 34:26-31. doi: 10.2111/1551-501X-34.1.2

Lesica, P. and S.V. Cooper. 1999. *Succession and disturbance in sandhillsvegetation: constructing models for managing biological diversity*. Conserv. Biol. 13: 292-302.

Willson, G. D., and J. Stubbendieck. 2000.*A provisional model for smooth brome management in degraded tallgrass prairie*. Ecol. Restor. 18:34-38.

ACKNOWLEDGEMENTS

Inventory and Monitoring: U.S. Fish & Wildlife Service; Bok Sowell, Montana State University.

Gene Expression of Skeletal Muscle of Red-Faced Hereford Steers

by

B. Engle, M. Hammond, J. A. Boles, and J.M. Thomson

Department of Animal and Range Sciences, Montana State University, Bozeman, MT

IMPACT STATEMENT

This research provides insight into the growth and developmental differences in meat quality grade. This may enhance our ability to control variation in meat quality, as well as understand that underlying genetic mechanisms control muscle growth and fat deposition.

GENE EXPRESSION OF SKELETAL MUSCLE OF RED-FACED HEREFORD STEERS

by B. Engle, M. Hammond, J. A. Boles, and J.M. Thomson

SUMMARY

The objective of this study was to evaluate the relationship between quality grade and genetic growth patterns on meat tenderness. The research aimed to evaluate the impacts of gene expression on quality grade. Muscle samples from 16 different Hereford cross steers were taken following harvest and RNA was extracted from these samples to evaluate which genes were being actively transcribed in the muscle at time of harvest. Loin samples were collected and allowed to age for 1, 3, 7, 14, and 21 d postmortem and frozen. After harvest, carcasses were quality graded by an experienced grader. RNA samples were pooled and sequenced based upon carcass quality grade. Gene set enrichment analysis, transcription factor analysis and network and pathway analysis was used to identify genes and gene networks that relate to growth rate and carcass quality.

Grading of carcasses resulted in six carcasses grading Choice and five carcasses each for Select and Standard. Standard carcasses were significantly lighter, having less fat with smaller loin muscle area than the Select and Choice carcasses. This suggests the steers yielding Standard carcasses were not at the same growth phase as the steers yielding Choice or Select carcasses, despite belonging to the same cohort. Shear force measurements unexpectedly indicated that there was no difference in the tenderness of steaks from Choice and Standard carcasses, while steaks from Select carcasses were significantly less tender. Upon analysis of differentially expressed genes, a significant number of differences were observed between Choice and Standard carcass pools (1258 genes, $P < 0.01$). A functional analysis was run using DAVID bioinformatics software, which revealed differences in the underlying pathways regulating muscle cell growth and proliferation. This suggests that the previously observed differences in the growth patterns between Choice and Standard cattle were due to identifiable differences in the regulation of cellular processes and growth.

Meat quality and tenderness are two of the most important traits for beef production, and this research helps to identify the genetic and molecular basis of these traits, and how selection and growth may interact in these economically significant characteristics.

INTRODUCTION

Meat quality and tenderness are two of the most consumer-valued characteristics of a steak. Tenderness is one of the most important palatability attributes of meat (Shackelford et al., 2001). Consequently, providing this high-demand product becomes a major concern for beef cattle producers. However, despite this issue being on the forefront of improvement initiatives, the industry still experiences difficulties producing a tender product. The findings of the National Beef Tenderness Survey (Morgan et al., 1991) suggest that approximately 20% of rib and loin steaks are not acceptably tender. Ongoing research is required in order to gain a better understanding of the genetic expression of these traits, and how selection plays a role in the transmission and expression of these economically significant characteristics.

PROCEDURES

Sixteen Red-Faced Hereford steers were fed at Fort Keogh Agricultural Research Station. Birth weight, weaning weight, feedlot growth data, and fatness measurements were collected. Animals within the same cohort that produced carcasses that graded standard, select and choice were sampled.

The animals were harvested after all steers had been fed a minimum of 270 days in the feedlot. Animals were harvested at a federally-inspected facility. Carcass data was collected, as was a muscle sample from the loin, which was snap frozen in liquid nitrogen and stored for subsequent RNA extraction. Loin samples were collected and aged for 1, 3, 7, 14, and 21 days. These samples were used to determine tenderness as measured with Warner Bratzler shear. The extracted RNA was depleted of ribosomal RNA using an Invitrogen Ribominus kit and then will be used to create individual cDNA libraries that were then randomly allocated to one of two pools for each quality grade of standard, select and choice. These pools were then sequenced on an Ion Proton next-generation sequencing platform according to manufacturer instructions. The sequencing reads generated were aligned to the known bovine consensus sequence and a normalized count of reads were generated to determine expression of each known gene and gene isoforms using CLC Bio Genome Workbench software. Differentially expressed genes and transcripts were calculated using Golden Helix RNA seq. Module and gene set enrichment analysis, transcription factor analysis and network and pathway analysis were used to identify genes and gene networks that relate to growth rate and carcass quality. This also helped elucidate the mechanisms underlying muscle development, which may provide valuable information for beef meat quality improvement. The raw data will be made publically available to the Gene Expression Omnibus. A functional analysis was run using DAVID bioinformatics software.

Shear force was determined using previously published methods (Boles et al., 2008). Steaks were thawed at 4°C for 24 hours. Each steak was weighed before and after cooking to determine cook loss. Eight to ten samples (1.27 x 1.27 x 2.54 cm) for shear force evaluation were removed parallel to the fiber direction from each steak that was cooked and cooled. Samples were sheared once perpendicular to the fiber direction with a TMS 30 Food Texturometer fitted with a Warner-Bratzler shear attachment. The average of the samples sheared were used for statistical analysis in relation to the differentially expressed genes and transcripts.

RESULTS AND DISCUSSION

The carcasses were placed into categories by quality grades–Standard, Select and Choice–and were evaluated for statistical differences between carcass traits and shear force. The carcass traits evaluated included HCW, fat thickness, REA, KPH, YG and marbling. There was a significant difference in REA, KPH and marbling between all the categories. Choice carcasses had the largest REA, KPH and marbling scores whereas Standard measured the lowest in each category (Boles et al., 2009) also reported larger rib-eye areas with larger carcass weights. When comparing steaks from Select and Choice carcasses, Obuz et al. (2004) reported increased marbling scores decreased the shear force value, as also reported by Tatum et al. (1982).

Steaks from Standard carcasses had the lowest shear force values, but weren't significantly different from Choice ($P > 0.05$). Select, having the highest shear force value was significantly different from the other two categories ($P < 0.0001$). A report from Obuz et al. (2004) confirmed our findings of Select being tougher than Choice. Standard carcasses were significantly heavier with less fat than Select and Choice carcasses ($P < 0.0001$). As fat thickness increased, shear force values decreased, as also found by Tatum et al (1982). Select and Choice carcasses had significantly different yield grades.

Every carcass had a steak that was aged for 1, 3, 7, 14 and 21 days. The longer a steak is aged, the more tender it will become (Marino et al, 2013). Steaks aged 1 d were toughest. With longer aging, the shear force decreased, so those that aged 21 d were most tender. These values correlate directly to the study done by Marino et al (2013), having the shear force values decrease with aging, with 1 d measuring the highest and 21 d measuring the lowest values.

As expected, we found Choice carcasses had a lower shear value then Select carcasses. However, Standard carcasses had a lower shear force value than Select. This is potentially due to the physiological age of the animals that were Standard. This is supported by the lighter carcass weights, lower marbling values, and less fat on the carcasses. To get the most tender product possible, Standards need to be utilized or the animals need to be fed long enough to reach Choice.

Upon analysis of differentially expressed genes, a significant number of differences were observed between Choice and Standard carcass pools (1258 genes, $P < 0.01$). A functional analysis was run using DAVID bioinformatics software, which revealed differences in the underlying pathways regulating muscle cell growth and proliferation. Biological processes such as growth, muscle hypertrophy, protein kinase activity, and lipid biosynthetic pathway were found to be enriched in the differentially expressed gene set. This data will provide new insight into the molecular and genetic basis of meat quality grade.

REFERENCES

Boles, J.A., Boss, D.L., Neary, K.I., Davis, K.C., and Tess, M.W. (2009). *Growth implants reduced tenderness of steaks from steers and heifers with different genetic potentials for growth and marbling*. J Anim Sci. 87:269-274.

Marino, R., Albenzio, M., dell Malva, A., Santillo, A., Loizzp, P., and Sevi, A. (2013). P*roteolytic pattern of myofibrillar protein and meat tenderness as affected by breed and aging time.* Meat Sci. 95:281-287.

Morgan, J.B., Savell, J.W., Hale, D.S., miller, R.K., Griffin, D.B., Cross, H.R., Shackelford. (1991) *National Beef Tenderness Survey*. J Anim Sci. 69:3274-3283.

Obuz, E., Dikeman, M.E., Grobbel, J.P., Stephans J.W., and Loughin, T.M. (2004). *Beef longissimus lumborum, biceps femoris, and deep pectoralis Warner-Bratzler shera force is affected differently by endpoint temperature, cooking method, and USDA quality grade.* Meat Sci. 68:243-248.

Shackelford, S. D., Wheeler, T.L., Meade, M.K., Reagan, J.O., Byrnes, B.L., Koohmaraie, M.. (2001) *Consumer impressions of Tender Select beef.* J Anim Sci. 79:2605–2614.

Tatum, J.D., Smith, G.C., and Carpenter, Z.L. (1982). *Interrelationships between marbling, subcutaneous fat thickness and cooked beef palatability.* J Anim Sci. 54:777-784.

ACKNOWLEDGEMENTS:

This study was supported by the Montana Agricultrual Experiment Stations, and is a contributing project to Multistate Research Project, W2010, Integrated Approach to Enhance Efficiency of Feed Utiliization in Beef Production Systems.

Recovery and Viability of Sulfur Cinquefoil Seeds from the Feces of Sheep and Goats

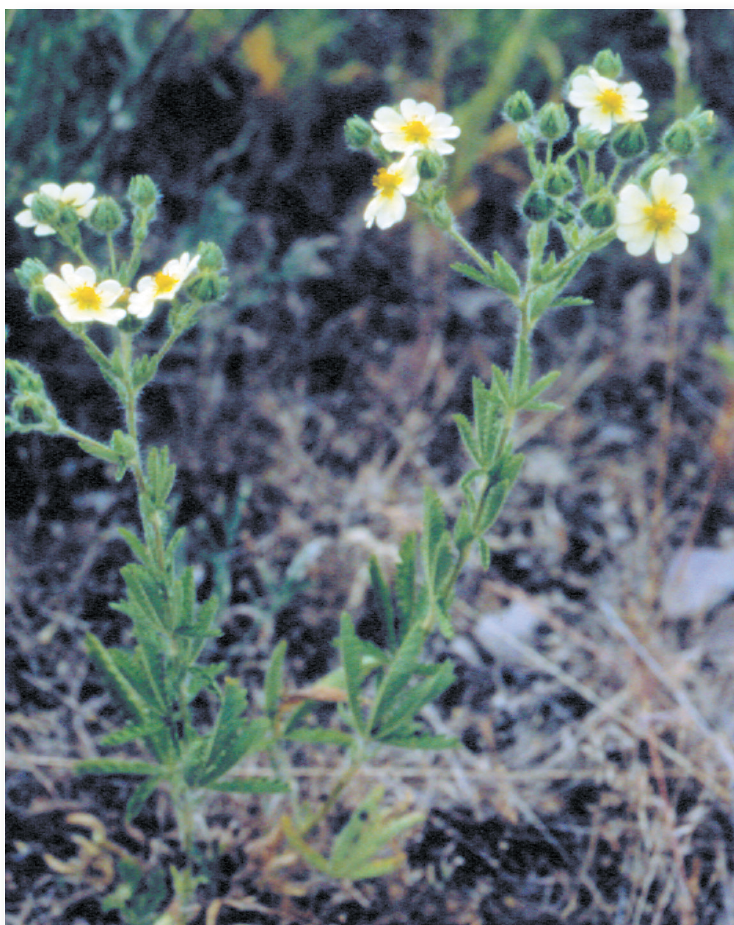
by

R.A. Frost, J.C. Mosley, and B.L. Roeder

Department of Animal and Range Sciences, Montana State University, Bozeman, MT

IMPACT STATEMENT

Sheep or goats that prescriptively graze sulfur cinquefoil infestations during flowering or later plant growth stages should remain in a corral for at least 3 days to allow any viable seeds to be excreted before moving livestock to a new area.



RECOVERY AND VIABILITY OF SULFUR CINQUEFOIL SEEDS FROM THE FECES OF SHEEP AND GOATS

by R.A. Frost, J.C. Mosley, and B.L. Roeder

SUMMARY

Targeted grazing by sheep or goats is a potentially useful tool for suppressing the noxious weed sulfur cinquefoil (Potentilla recta). However, possible transmission of weed seeds by grazing livestock is a serious concern that needs to be addressed in any targeted grazing prescription. We investigated the effect of sheep and goat digestion on the viability of sulfur cinquefoil seeds. Eight sheep and 8 goats were each orally gavaged with 5,000 sulfur cinquefoil seeds. Four animals of each species received immature seeds and 4 animals of each species received mature seeds. Total fecal collection began immediately after oral gavage and continued for 7 consecutive days. Once each day, all identifiable sulfur cinquefoil seeds were recovered and counted from fecal subsamples. Passage through the digestive tract of sheep or goats dramatically reduced the viability of both immature and mature sulfur cinquefoil seeds, but some viable seed was excreted. Almost all (98%) of the viable seeds recovered from sheep and goats were excreted during Day 1 and Day 2 after oral gavage. No viable seeds were recovered from either sheep or goats after Day 3. Grazing livestock that consume sulfur cinquefoil seeds should be kept in a corral for at least 3 days to prevent transferring viable seeds to uninfested areas.

INTRODUCTION

Sulfur cinquefoil (Potentilla recta) is a non-indigenous, perennial forb that can invade healthy, undisturbed rangeland and replace native species (Rice 1999). The plant reproduces only by seed, but each plant can produce thousands of seeds per year (Dwire et al. 2006; Frost and Mosley 2012), and individual plants can live as long as 20 years (Perkins et al. 2006). Once established, sulfur cinquefoil is very difficult to control. There are no approved biological control agents and herbicides have provided mixed results (Lesica and Martin 2003). Current recommendations suggest that sulfur cinquefoil management focus on suppressing seed production and preventing the introduction of seed into uninfested areas (Dwire et al. 2006; Perkins et al. 2006).

Our previous research has demonstrated that defoliation of sulfur cinquefoil at the flower stage or later can reduce viable seed production (Frost and Mosley 2012). Targeted livestock grazing is a potential way to defoliate sulfur cinquefoil on rangeland, however, grazing livestock that consume viable seeds may disseminate the seeds in other areas and contribute to weed expansion (Bartuszevige and Endress 2008, Hogan and Phillips 2011).

We have observed sheep and goats grazing both the foliage and the fruits of sulfur cinquefoil, but it is unknown if livestock consuming the seeds of sulfur cinquefoil can excrete viable seeds. Livestock and wildlife are capable of excreting viable seeds of other noxious weeds, including leafy spurge (Euphorbia esula; Lacey et al. 1992; Olson et al. 1997; Olson and Wallander 2002; Wald et al. 2005), spotted knapweed (Centaurea stoebe; Wallander et al. 1995), and others. To prevent the spread of noxious weeds, confining livestock in a corral is recommended as a best management practice before moving livestock to new areas (Kott et al. 2006). It is important to know the length of time animals should be corralled in order to minimize the amount of time, labor, and feedstuffs required before returning animals to rangeland grazing. Our objective was to determine the recovery and viability of sulfur cinquefoil seeds from the feces of sheep and goats following oral gavage.

PROCEDURES

Yearling wether crossbred goats (Spanish × Boer) and Targhee sheep (8 goats, 8 sheep) were used in this study. All treatments were approved by the Montana State University Animal Care and Use Protocol number AA-039. Animals were placed in individual metabolism stalls 7 days before the experiment began and fitted with fecal collection bags for 2 days before the study began to familiarize the animals with the research procedures. Once daily during the acclimation period and throughout the experiment, animals were fed ground grass hay in excess. Hay intake averaged 2.0% body weight/day.

Sulfur cinquefoil seeds were collected from infested foothill rangeland near Bozeman, MT. Seeds were collected at 2 developmental stages: immature seeds were collected in mid-July, and mature seeds were collected 2 weeks later in late July. In the laboratory, collected seeds were purified, counted, and stored in cool, dry conditions from July to October when they were administered to the animals.

Each animal was orally gavaged with 5,000 sulfur cinquefoil seeds suspended in water, with 4 goats and 4 sheep receiving immature seeds, and 4 goats and 4 sheep receiving mature seeds. Total fecal collection began immediately after oral gavage and continued for 7 consecutive days. Fecal collection bags were emptied once daily. After thoroughly mixing fecal material within each collection bag, a sample was collected from each bag and examined for sulfur cinquefoil seeds. All identifiable sulfur cinquefoil seeds were extracted, counted, and tested for viability.

RESULTS AND DISCUSSION

Recovery of viable sulfur cinquefoil seeds did not differ between sheep and goats. Most (91%) of the viable seeds that were recovered were mature seeds. Almost all (98%) of the viable seeds that were recovered from sheep and goats were excreted during Day 1 and Day 2 after oral gavage. No viable sulfur cinquefoil seeds were recovered from either sheep or goats after Day 3.

Sulfur cinquefoil seed viability before oral gavage averaged 36% for immature seeds and 76% for mature seeds, while viability of recovered seeds averaged 3% for immature seeds and 27% for mature seeds. Thus, passage through the digestive tract of sheep or goats dramatically reduced the viability of both immature and mature seeds. Therefore, even when sheep or goats excrete sulfur cinquefoil seeds on the landscape, the number of viable seeds added to the soil seedbank will be less when the area is grazed by sheep or goats than if the area had remained ungrazed. Finally, our estimates of sulfur cinquefoil seed excretion and viability in sheep and goat feces are likely inflated compared with targeted grazing animals because oral gavage with seeds bypassed mastication.

Our results indicate that targeted grazing by sheep or goats is a promising tool for reducing the number of viable sulfur cinquefoil seeds added to the soil seedbank. However, some viable seed is capable of surviving the digestive system of sheep and goats. Sulfur cinquefoil plants in the pre-flower growth stage have not yet produced seeds. Therefore, grazing livestock that consume sulfur cinquefoil during this stage do not need to be quarantined before moving to a new area. Sulfur cinquefoil plants in the early-flowering stage also have not yet produced viable seeds. However, sulfur cinquefoil infestations characterized to be in the flowering stage likely contain some sulfur cinquefoil plants that are more advanced into the seedset stage. Therefore, sheep or goats that have grazed within sulfur cinquefoil infestations during flowering or later plant growth stages should remain in a corral for at least 3 days afterwards to allow any viable seeds to be excreted before moving the livestock to a new area. Complete details about our study are published in Frost et al. (2013).

REFERENCES

Bartuszevige, A.M., and B.A. Endress. 2008. *Do ungulates facilitate native and exotic plant spread? Seed dispersal by cattle, elk and deer in northeastern Oregon*. J. Arid Environments 72:904–913.

Dwire, K.A., C.G. Parks, M.L. McInnis, and B.J. Naylor. 2006. *Seed production and dispersal of sulfur cinquefoil in northeast Oregon*. Rangeland Ecology and Management 59:63–72.

Frost, R.A., and J.C. Mosley. 2012. S*ulfur cinquefoil (Potentilla recta) response to defoliation on foothill rangeland.* Invasive Plant Science and Management 5:408– 416.

Frost, R.A., J.C. Mosley, and B.L. Roeder. 2013. *Recovery and viability of sulfur cinquefoil seeds from the feces of sheep and goats.* Rangeland Ecology and Management 66:51-55.

Hogan, J.P., and C.J.C. Phillips, 2011. *Transmission of weed seed by livestock: a review*. Animal Production Science 51:391–398.

Kott, R., T. Faller, J. Knight, D. Nudell, and B. Roeder. 2006. Animal husbandry of sheep and goats for vegetative management. In: K. Launchbaugh and J. Walker [EDS.]. T*argeted grazing: a natural approach to vegetation management and landscape enhancement.* Centennial, Colorado, USA: American Sheep Industry Association. p. 22–31.

Lacey, J.R., R. Wallander, and K. Olson-Rutz. 1992. *Recovery, germinability, and viability of leafy spurge (Euphorbia esula) seeds ingested by sheep and goats.* Weed Technology 6:599–602.

Lesica, P., and B. Martin. 2003. *Effects of prescribed fire and season of burn on recruitment of the invasive exotic plant, Potentilla recta, in a semiarid grassland*. Restoration Ecology 11:516–523.

Olson, B.E., and R.T. Wallander. 2002. *Does ruminal retention time affect leafy spurge seed of varying maturity?* Journal of Range Management 55:65–69.

Olson, B.E., R.T. Wallander, and R.W. Kott. 1997. *Recovery of leafy spurge seed from sheep.* J. Range Management 50:10–15.

Perkins, D.L., C.G. Parks, K.A. Dwire, B.A. Endress, and K.L. Johnson. 2006. *Age structure and age-related performance of sulfur cinquefoil (Potentilla recta)*. Weed Science 54:87–93.

Rice, P. 1999. Sulfur cinquefoil. In: R.L. Sheley and J.K. Petroff [EDS.]. *Biology and management of rangeland weeds.* Corvallis, OR, USA: Oregon State University Press. p. 382–388.

Wald, E.J., S.L. Kronberg, G.E. Larson, and W.C. Johnson. 2005. *Dispersal of leafy spurge (Euphorbia esula L.) seeds in the feces of wildlife.* American Midland Naturalist 154:342–357.

Wallander, R.T., B.E. Olson, and J.R. Lacey. 1995. *Spotted knapweed seed viability after passing through sheep and mule deer.* J. Range Management 48:145–149.

ACKNOWLEDGMENTS

Authors thank Nina and John Baucus and Sieben Ranch for use of their goats; Quincy Orhai for access to his land; John Terry and Lucy Cooke for assistance with seed viability testing; and Mo Harbac and John Paterson for assistance with metabolism stalls and fecal collection bags. Research was funded by Western SARE (Sustainable Agriculture Research and Education), the USDA Joe Skeen Institute for Rangeland Restoration, and the Montana Agricultural Experiment Station.

Influence of Long-Term Progesterone on Feed Efficiency and Body Composition in Mature Rambouillet Ewes

by

M. R. Herrygers, J. M. Thomson, K. Perz, K. B. Herrygers, K. Metcalf, M. Knerr, P. Merta, and J. G. Berardinelli

Department of Animal and Range Sciences, Montana State University, Bozeman, MT

IMPACT STATEMENT

Mimicking progesterone concentration for least 70 d of using a controlled internal drug-releasing device (CIDR) did not appear to alter feed efficiency or calculated body composition of mature Rambouillet ewes. However, pregnancy in the sheep lasts for almost 145 days, and perhaps exposing ewes to progesterone for a longer period of time may be necessary to observe the effect of progesterone on feed efficiency and body composition in ewes treated with long-tern progesterone.

INFLUENCE OF LONG-TERM PROGESTERONE ON FEED EFFICIENCY AND BODY COMPOSITION IN MATURE RAMBOUILLET EWES

by M. R. Herrygers, J. M. Thomson, K. Perz, K. B. Herrygers, K. Metcalf, M. Knerr, P. Merta, and J. G. Berardinelli

SUMMARY

The objectives of this study were to evaluate the effects of long-term progesterone (P4) treatment on changes in feed efficiency, BW, and body composition in mature Rambouillet ewes. Thirty, multiparous, 5- and 6-year-old Rambouillet ewes were stratified by age and metabolic BW and assigned randomly to receive long-term P4 administration using controlled intravaginal releasing devices (CIDR) or no P4 (CIDRX; CIDR backbone only). Initially, ewes were synchronized for estrus using a 7 d CIDR and PGF_{2a} protocol. All ewes exhibited estrus within 72 h after PGF_{2a}. Twelve d after estrus (d = 0), each ewe received either a CIDR (n = 15) or a CIDRX (n = 15). Every 2 weeks thereafter, the CIDR or CIDRX was removed from each ewe and replaced with a new CIDR or CIDRX for 126 d. Individual feed intake was recorded using the GrowSafe units beginning at d 0 following a 3 week adaptation period. Ewes were fed a mixed grass hay diet ad libitum that met the nutrient requirements for maintenance. BW for each ewe was collected every 2 weeks when CIDR or CIDRX were replaced. Back fat (BF) and rib-eye area (REA) were measured for each ewe every 28 d using ultrasonography. Data reported herein represent the first 70 d of the experiment. BW, RFI, BF, and REA did not differ (P > 0.10) between CIDR- and CIDRX-treated ewes. Calculated estimates of muscle mass (kg), intra-muscular fat (kg), empty body weight (kg), empty body weight dry matter (%), empty body weight fat (%), empty body weight protein (%), carcass weight (kg), carcass weight dry matter (%), carcass weight fat (%), and carcass weight protein (%) did not differ (P > 0.10) between CIDR- and CIDRX-treated ewes.

INTRODUCTION

Recently, Swartz et al. (2014) showed that P4 concentrations were greater in Rambouillet ewes selected for high reproductive rates (HL) than in ewes selected for low reproductive rate (LL) during pregnancy. In their study, nutrient intake and TDN did not differ between lines of ewes. However, the total kg of TDN consumed per ewe per kg of lamb born was 24% greater in LL line ewes than in HL ewes. The physiological mechanism appeared to be related to greater concentrations of progesterone (P4) between d 60 and d 120 of gestation in HL ewes than in LL ewes.

We hypothesized that long-term, systemic P4 concentrations may be related to increase in feed efficiency and changes in partitioning of nutrients. The objectives of the study were to evaluate the effects of long-term P4 treatment, independent of the influence of the placenta and fetus, on changes in feed efficiency, BW, and body composition in mature Rambouillet ewes.

PROCEDURES

Thirty, multiparous, 5- and 6-year-old commercial Rambouillet ewes from the Montana State University Red Bluff Research Ranch flock in Norris, Montana were used for this study. Ewes were adapted to the GrowSafe system for 3 weeks. Treatments were: 1) long-term P4 maintenance using CIDR (CIDR; n = 15) or 2) no long-term P4 maintenance using a CIDR backbone (CIDRX; n = 15). Ewes were synchronized for estrus using the 7 d CIDR and PGF_{2a} Twelve d (d = 0). After estrus each CIDR-treated and CIDRX-treated ewe received a CIDR or CIDRX, respectively. This event was the beginning of the feeding trial and d 0 of the experiment. P4 concentrations in each ewe were maintained by replacing a CIDR every 14 d with a new CIDR.

Body weights of each ewe were recorded every 14 d and estimates of BF and REA were obtained by ultrasonography every 28 d beginning at d 0.

Feed intake data reported herein represent the first 70 d of the experiment. Ewes were given ad libitum access to mixed grass hay, water, and mineralized salt blocks. The chemical composition is given in Table 1. The chemical composition of the mixed grass hay on an as fed basis met the NRC (NRC, 2006) nutrient requirements for maintenance of a 132-pound adult ewe.

Daily intakes were computed for each of the ewes from the feed intakes derived from the GrowSafe Data software. Residual feed intake (RFI) was calculated for each ewe using

TABLE 1. Chemical composition of mixed grass hay diet[1]

Item	Mixed Grass Hay diet
Nutrient analyses, %	
DM	86.2
CP[2]	7.5
TDN[2]	60.2

[1] Ewes had free access to the mixed grass hay diet.
[2] CP and TDN are based on a percentage DM basis.

standard calculations for RFI (Redden et al., 2013).

Estimates of body composition muscle mass (lb) and intra-muscular fat (lb) were calculated from BF, REA and BW based on regression equations reported by Silva et al. (2006) for mature ewes.

Data for BW, RFI, BF, and REA at 70 d were analyzed by ANOVA for completely randomized design using PROC ANOVA of SAS.

RESULTS AND DISCUSSION

Body weight, RFI, BF and REA did not differ between CIDR- and CIDRX-treated ewes by 70 d of the experiment (Table 2). Likewise, calculated estimates of body composition did not differ between CIDR- and CIDRX-treated ewes by 70 d of the experiment.

The objectives of this study were to evaluate the effects of long-term P4 treatment on changes in feed efficiency, BW, and body composition in mature Rambouillet ewes, independent of placental and fetal functions. We found that maintaining P4 concentrations in ewes using P4-containing CIDR did not influence feed efficiency, BW, and body composition relative to ewes whose P4 concentrations were not constantly maintained during the first 70 d of this experiment. Furthermore, maintaining P4 concentrations did not alter calculated estimates of muscle mass, intra-muscular fat, empty body weight, carcass weight; percentages of empty body weight as dry matter, fat, and protein; and, percentages of carcass weight as dry matter, fat, and protein compared to ewes in which P4 concentrations were not constantly maintained.

Our hypothesis that long-term maintenance of P4 concentrations would alter feed efficiency by altering metabolic processes of ewes, was developed from the work of Swartz et al. (2014). They reported that nutrient intake and TDN did not differ during gestation in ewes from lines selected for high (HL) and low (LL) reproductive rates. However, the total pounds of TDN consumed per ewe per pounds of lamb born was 24% greater in LL line ewes than in HL ewes. The only endocrinological difference between ewes of these lines was that systemic concentrations of P4 were greater in HL ewes than in LL ewes between 60 and 120 d of gestation. Essentially one could interpret this to mean that the increase in efficiency of nutrient utilization in HL ewes during gestation was the result of increased concentrations of P4 between d 60 and d 120 of gestation.

The results reported in the present study include only 70 d of maintenance of P4 concentrations. The lack of differences in feed efficiency, BW, and body composition could be related to the duration of maintenance of P4 concentrations. In this regard, one has to take into account that CIDRX ewes were exhibiting regular estrous cycles accompanied by natural increases in P4 from the start of the experiment through the end of the breeding season (approximately the end of January). In the study by Sarda et al. (1973), P4 concentrations in pregnant ewes did not markedly increase until after d 80 to 90 of gestation. Furthermore, Swartz et al. (2014) reported that P4 concentrations did not differ between HL and LL ewes on d 30 and 60; a time frame that corresponds to this study for CIDR- and CIDRX- treated ewes. This may indicate that P4 concentrations must be maintained for longer than 60 to 70 d in order to cause a change in metabolism in sheep. In fact, feeding melengesterol acetate (MGA), a synthetic progestin, to beef heifers required at least 57 d to affect an increase in ADG, marbling score, and tenderness relative to these characteristics in heifers not fed MGA (Busby et al., 2002).

To our knowledge this is the first study that evaluated the effects of long-term P4 treatment on feed efficiency and body composition in ewes. In conclusion, it appears that maintaining P4 concentrations for 70 d does not affect feed efficiency and body composition in ewes. Furthermore, it remains to be determined as to whether maintaining P4 concentrations for greater than 70 d up to 126 d will alter feed efficiency and body composition in ewes.

TABLE 2. Body weight (BW), residual feed intake (RFI), back fat depth (BF), and rib-eye area (REA) in Rambouillet ewes that received a P4-containing controlled intravaginal releasing device (CIDR) or a CIDR backbone (no P4; CIDRX) for 70 d

Item	Treatment		SEM	*P*-value
	CIDR	CIDRX		
n	15	15		
BW, lb	130	129	17	0.87
RFI, lb/d	0.06	-0.17	0.51	0.23
BF, in	0.07	0.08	0.004	0.56
REA, in^2	0.04	0.04	0.001	0.78

REFERENCES

Busby, D., D. Loy, and G. Rouse. 2002. *Effect of MGA on performance, sexual behavior, carcass quality and tenderness in mixed-sex pens of cattle.* Beef Research Report. http://lib.dr.ia.state.edu/beefreports_2001/9 (Accessed 11 March 2015).

NRC. 2007. *Nutrient requirements of small ruminants*. Natl. Acad. Press. Washington D.C. p. 246.

Redden, RR., L.M.M. Surber, A.V. Grove, and R. W. Kott. 2013. *Growth efficiency of ewe lambs classified into residual intake feed intake groups and pen fed a restricted amount of feed.* Small Rumin. Res. 114: 214-219

Sarda, I. R., H. A. Robertson, and T. C. Smeaton. 1973. *Sequential changes in plasma progesterone levels in the ewe during the estrous cycle, and during pregnancy in intact and ovariectomized sheep*. Can. J. Anim. Sci. 53: 25-34.

Swartz, J.D., J.G. Berardinelli, J.M. Thomson, M. Lachman, K. Westveer, M.R. Herrygers, R.W. Kott, P.G. Hatfield, and C.J. Yeoman. 2014. *Temporal patterns of intake, energy-related metabolites, metabolic hormones, progesterone concentrations, and lambing rates in Rambouillet ewes selected for high and low reproductive rate*. Proc. West. Sect. Amer. Soc. Anim. Sci. 65: 98-101.

ACKNOWLEDGEMENTS

Appreciation is expressed to Andrew Williams, Arianne Perlinski, and Dr. Lisa Surber for their excellent technical assistance. This study was supported by the Montana Agricultural Experiment Station, and is a contributing project to the Multistate Research Project, W2112, Reproductive Performance in Domestic Ruminants.

Preliminary Study of the Influence of 2,4-D on the Digestibility of Ensiled Lawn Clippings and the Level of Acceptance by Lambs

by

A. R. Hicks-Lynch, S. J. Meyer, D. L. Ragen, P. G. Hatfield, and E. C. Glunk

Department of Animal and Range Sciences, Montana State University, Bozeman, MT

IMPACT STATEMENT

Grass lawn clippings were able to be successfully ensiled and were an acceptable form of forage for sheep. The addition of 2,4-D herbicide did not have a significant effect on digestibility, however some of the 2,4-D did pass through the digestive tract of the lambs and ended up in the fecal matter. Lawn clipping silage may be a promising forage feed source for the livestock industry.

PRELIMINARY STUDY OF THE INFLUENCE OF 2,4-D ON THE DIGESTIBILITY OF ENSILED LAWN CLIPPINGS AND THE LEVEL OF ACCEPTANCE BY LAMBS

by A. R. Hicks-Lynch, S. J. Meyer, D. L. Ragen, P. G. Hatfield, and E. C. Glunk

SUMMARY

Approximately 20% of all waste placed in landfills in the United States consists of grass clippings. While the acres in lawn production have been increasing, with an estimated 120,000 km2 of lawns in 1987 and 163,801 km2 in 2005, the number of landfills in the United States has been decreasing, from 7,683 in 1986 to 1,908 in 2009. The purpose of this study was to evaluate whether lawn clippings could be successfully used as livestock feed in order to redirect and productively utilize this large waste stream. Lawn clippings from a local golf course were evenly divided into a control and a treatment pile. Both piles were treated with 3 parts water and 1 part 99% acetic acid, with the treatment pile also being treated with 2,4-D and ensiled for five weeks. Eight Rambouillet lambs were fed the ensiled lawn clippings for 9 days, with 3 days of acclimation prior to sampling. Four lambs were fed the control silage and four lambs were fed the treated silage. Results from the study showed the lawn clippings could be successfully ensiled. The lambs readily accepted the lawn clipping silage as a feed, with only one lamb refusing to eat the silage for 24 hours at the start of the feeding trial and no silage refusal the remainder of the feeding period. There was no significant difference between digestible ADF, digestible NDF, digestible CP, and DM digestibility between the control and treated silage. The results demonstrate the silage is an acceptable feed source and the 2,4-D did not have an effect on silage digestibility.

INTRODUCTION

The rapidly declining agricultural land base and a continuously increasing world population have many experts searching for more efficient ways to produce enough food. As income increases, the demand for quality meat increases as well (Gerbens-Leenes, et al., 2010). The need to produce more meat is preceded by the need to have more land on which to grow the additional animal protein, or farmland to produce grain crops to feed animals in feedlot systems. In the United States alone, land in agriculture production has decreased by 73 million square miles from 1990 to 2012 (EPA, 2013). The estimated per capita poultry and red meat consumption within the United States as of 2015 is 208.5 pounds, up from 199 pounds in 1990 (USDA, 2015a,b). With the increase in population from 1990 to 2013 of 66.3 million, this is an increase of 4 billion pounds of total meat consumed since 1990 (USDA, 2015b).

In addition to the continual increase of meat consumption within the United States, the United States Department of Agriculture: Economic Research Service projects that developing countries around the world will constitute 81% of the global increase in meat consumption within the next eight years (Trostle and Seeley, 2013). It is unlikely there will be an increase in the amount of land available for agricultural production in the near future, making more efficient methods of producing food, especially meat, of great importance. In the pursuit of decreasing food waste and waste streams associated with the food system, waste streams that can be used in the production of food need to be identified.

Residential lawn production is estimated to cover about 20 million square miles in the United States, compared to the estimated 56 million square miles in hay production, and 80 million square miles in corn production (EPA, 2013; USDA, 2014). Lawns, residential and recreational, are a relatively large sector of grass production in this country, accounting for 40.5 million square miles of land (Milesi et al., 2005). According to Wilson and Koski (2014) from Colorado State University, grass clippings make up 20% of the material sent into landfills each year within the United States. While the current amount of land already used to produce livestock feed is extensive, production on farmland is nearing the yield ceiling (de Bossoreille de Ribou et al., 2013). Additionally, the number of landfills countrywide is decreasing. In 1986 there were 7,683 landfills in the U.S., and by 2009 that number had fallen to just 1,908 landfills (Palmer, 2011; EPA, 2010). If lawn clippings can be used as a livestock feed, a portion of the waste stream yard debris creates could be redirected from going into landfills.

TABLE 1. Nutrient content of the ensiled grass clippings

	DM (%)	CP (%)	NDF (%)	ADF (%)	TDN (%)	NEl (Mcal/lbs)	NEm (Mcal/lbs)	NEg (Mcal/lbs)	RFV (%)
Control silage	33.64	18.7	60.4	40.9	55.9	0.57	0.54	0.31	88
Treated silage	31.28	18.3	61.9	40.6	56.2	0.57	0.55	0.32	86

PROCEDURES

Two students from Montana State University recently conducted a preliminary study to determine whether the idea of using lawn debris as a livestock feed is feasible or not. For the study, the students collected grass clippings from Black Bull Golf Course in Bozeman, MT. The students split the grass clippings from the golf course into two piles, a control and a treatment pile. Both piles contained 232.75 pounds of grass clippings each and were treated with one liter of acetic acid and three gallons of water. The acetic acid was sprayed on the grass clippings to aid in the ensiling process and the water was added to bring the moisture content of clippings up to the desired amount of 66.5%. The treatment pile was also sprayed with 4 ounces of Spectracide Weed Stop. The active herbicides in Spectracide Weed Stop are 2,4-D, Mecoprop, and Dicamba, at concentrations of 7.59%, 3.66%, and 0.84% respectively. The 2,4-D was added to the treatment pile in order to determine whether feeding lawn clippings from lawns that have been treated with an herbicide would have an ill effect on the feed value of the silage and on the animals consuming the feed. Once both the control and the treatment piles were processed, the clippings were packed into individual 55-gallon steel barrels that were then sealed with airtight lids. The grass clippings were then left to ensile for five weeks.

After the grass clippings were ensiled, the silage was fed to eight lambs for nine days. Four of the lambs were fed the control silage, while the other four were fed the treated silage. The lambs were fed at 2% of individual body weight each day (NRC, 2007). The average weight of the lambs was 81 lbs. ± 6.2. The lambs fed the control silage received an average of 6.2 pounds (± 4.4) of silage per day and the lambs fed the treated silage received an average of 6.6 pounds (± 2.2) of silage per day. The lambs were fed half of their daily ration in the morning and the other half in the evening. During the study each lamb was kept in an individual crate and had ad libitum access to water at all times.

RESULTS AND DISCUSSION

The results from this study show that lawn clippings can be successfully ensiled, the resulting silage is readily accepted by lambs, the feed value of the silage is comparable to commonly fed livestock feeds, and the herbicide content in the feces was less than the herbicide content in the silage.

The ensiling process was successful as determined by the final pH and DM content of the silage (BonSilage, Grass Silage Handbook).The DM, NDF, and pH were within the ideal ranges for DM, pH, and NDF of 28-35%, 4.0-4.8, and 42-48, respectively. The final pH of the silage was 4.6 (± 0.17) and the final DM content of the silage was 40%. The DM content was slightly high for ideal grass silage but the pH level of the silage was within the desired range (BonSilage; Harrison et al., 1994).

Throughout the entirety of the feeding period, only one lamb refused to eat the silage, and that was only during the first 24-hours of the feeding trial. No silage refusal was collected the remainder of the sampling period.

The NDF content was higher than desired, with 60.4% and 61.9% for the control and treated silage, respectively (BonSilage). The CP levels were high in both silage groups, 18.7% and 18.3% CP for the control and treated, respectively. These CP levels are comparable to the CP levels in dairy quality alfalfa hay (Balliette and Torell, 2007). The overall digestibility of the silage was low with dNDF at 30.5% (± 4.9) and 27.6% (± 4.9), dADF at 16.5% (± 4.2) and 13.7% (± 3.4), and DMD at 41.6% (± 3.7) and 40.3% (± 3.7) for control and treatment silage, respectively. The NDF levels were thought to be high and the digestibility was thought to be low due to the maturity of the grass used for the study. It was found that the 2,4-D did not affect the digestibility, with no significant differences between the control and treated silage. In addition, numerical data showed less 2,4-D in the feces than in the silage, with 82mg/kg of 2,4-D in the treated grass (before ensiling), 110mg/kg in the treated silage, and 6.8 mg/kg in the combined fecal matter from the lambs fed the treated silage. To better understand where the herbicide residue ends up further studies will need to be conducted.

This preliminary study illustrates that lawn clippings may be a source of livestock feed. In future studies it will be necessary to feed the silage ad libitum and to offer the silage with another available feed source. However, based on a previous study by Przemyslaw S. et al. (2015), we expect the grass silage would still be readily desired. Additionally, the metabolic path of 2,4-D will need to be examined further by collecting urine, muscle, and adipose tissue samples in addition to fecal samples and analyzing the 2,4-D content of each.

Overall this study shows there is the possibility of redirecting the large waste stream lawn clippings to be a valuable source for livestock feed.

REFERENCES

Balliette, J., and Torell, R., 2007. *Alfalfa for beef cows.* Fact sheet. University of Nevada Cooperative Extension. http://www.unce.unr.edu/publications/files/ag/other/fs9323.pdf#search="alfalfa%20for%20beef%20cows". Accessed: March 19, 2015.

BonSilage. *Grass silage handbook: guide to successful grass ensiling.* Schaumann. http://www.bonsilage.de/_pdf/FIBEL_BONSILAGE_grass_en.pdf. Feuchtwangen, Germany. Accessed: March 19, 2015.

Bormann, F. H., Balmori, D., and Geballe, G. T. 1993. U.S. lawn care facts as annual totals and percentages. Redesigning the American lawn. http://www.epa.gov/greenacres/wildones/handbk/wo8.html. Accessed: November 4, 2014.

de Bossoreille de Ribou, S., Douam, F., Hamant, O., Frohlich, M. W., and Negrutiu, I.. 2013. *Plant science and agricultural productivity: Why are we hitting the yield ceiling?* J. Plant Sci. 210: 159-176.

EPA. 2010. Municipal solid waste in the United States, 2009 facts and figures. http://www.epa.gov/waste/nonhaz/municipal/pubs/msw2009rpt.pdf. Accessed: March 3, 2015.

EPA. 2013. Land use overview. http://www.epa.gov/agriculture/ag101/landuse.html. Accessed: December 8, 2014.

Garabrant, D. D., and Philbert, M. A. 2002. Review of 2,4-dichlorophenoxyacetic acid (2,4-D) epidemiology and toxicology. Critical review in toxicology. 32(4):233-257. http://eds.a.ebscohost.com/ehost/pdfviewer/pdfviewer?sid=3893d359-c2d0-4dc5-a95c-a15779ebb81c%40sessionmgr4004&vid=2&hid=4202. Accessed: February 26, 2015

Gerbens-Leenes, P. W., S. Nonhebel, and M. S. Krol. 2010. *Food consumption patterns and economic growth. Increasing affluence and the use of natural resources.* Appetite. 55:3:597-608.

Harrison, J. H., Blauwiekel, R., and Stokets, M. R. 1994. Fermentation and utilization of grass silage. J. Dairy Sci. 77(10):3209-3235. http://www.journalofdairyscience.org/article/S0022-0302(94)77264-7/pdf. Accessed: March 19, 2015.

Milesi, C., Running, S. W., Elvidge, C. D., Dietz, J. B., Tuttle, B. T., and Nemani, R. R. 2005. Mapping and modeling the biogeochemical cycling of turf grasses in the United States. http://link.springer.com/article/10.1007/s00267-004-0316-2. Accessed: March 4, 2015.

NRC. 2007. *Nutrient Requirements of Small Ruminants.* Animal Nutrition Series. The National Academies Press. Washington DC.

USDA. 2013. USDA and EPA launch U.S. food waste challenge: calls on both public sector and private industry to reduce food waste. http://www.usda.gov/wps/portal/usda/

Forage Quality, Intake, and Wastage by Ewes in Swath Grazing and Bale Feeding Systems

by

E.E. Nix[1], D.L. Ragen[1], J. Bowman[1], R.W. Kott[1], M.K. Petersen[2], A.W. Lenssen[2], and P.G. Hatfield[1]

[1]Department of Animal and Range Sciences, Montana State University, Bozeman, MT; †USDA-ARS Fort Keogh Livestock and Range Research Laboratory, Miles City, MT; and [2]Department of Agronomy, Iowa State University, Ames, Iowa

IMPACT STATEMENT

Harvested feed costs, particularly throughout the winter, are traditionally the highest input associated with maintaining a ruminant livestock operation. Swath grazing reduces labor, time, and costs associated with feeding baled forages because the burden of harvest is transferred to the livestock. Our research expands on previous research for cattle and suggests that swath grazing forage may have utility in sheep production. Although our results show that nutrient composition tended to be lower in the swathed forage, wastage and animal performance were similar between swathed and grazed treatments, and suggests that a swathed feeding system could function as a viable alternative to a traditional baled feeding system in arid climates. Our study furthers our understanding of alternative feeding systems for sheep, and provides a biological foundation for a future economic evaluation of a swath verses bale feeding system in commercial sheep operations.

FORAGE QUALITY, INTAKE, AND WASTAGE BY EWES IN SWATH GRAZING AND BALE FEEDING SYSTEMS

by E.E. Nix, D.L. Ragen, J. Bowman, R.W. Kott, M.K. Petersen, A.W. Lenssen, and P.G. Hatfield

SUMMARY

Sixty mature, white-faced ewes were used in a completely randomized design repeated for 2 years to evaluate whether a feeding method (swath grazed or fed as hay in confinement) of intercropped field pea (Pisum sativum L.) and spring barley (Hordeum vulgare L.) forage affected forage DMI, wastage, or nutrient composition. Each year, 30 ewes were allocated to 3 confinement pens (10 ewes/pen) and 30 ewes were allocated to 3 grazing plots (10 ewes/plot). In 2010, DMI was lower for swathed versus baled forage, but DMI did not differ between treatments in 2011. Forage wastage was similar between treatments for both years. Wastage and animal performance were similar between the two treatments despite lower nutrient values in swathed forage, suggesting that a swathed feeding system can function as a viable alternative to a traditional baled feeding system in commercial sheep operations.

INTRODUCTION

Swath grazing, practiced for over 100 years, is the process of cutting hay at peak nutritional value and leaving it in windrows or raking it into swaths for livestock to graze at a later date. As the burden of harvest is transferred to livestock, swath grazing reduces labor, time, and costs associated with baled forages. The quality of forage tends to be lower in swaths compared to bales because exposure to precipitation and other environmental conditions degrade its nutritive value (Nayigihugu et al. 2007). However, swathed forage may still be a viable feeding alternative for livestock operations if lower feed costs offset nutritive limitations (Karn et al., 2005).

PROCEDURES

Research was conducted at the Fort Ellis Experiment Station of Montana State University. The study used 12 distinct forage plots (intercropped field pea and spring barley forage) with each plot measuring 15.2 m × 91.4 m.

Activities involving live animals were approved by the Agricultural Animal Care and Use Committee at Montana State University (2009-AA04). This study used 120 non-pregnant, non-lactating, mature western white-faced ewes over a two year period. Ewes were randomly assigned to either a swath grazing treatment (GRAZE, n=30), or a bale-fed treatment (BALE, n=30). For the GRAZE treatment, forage was defined as 1) the swath and 2) standing forage including post-harvest stubble and regrowth. For the BALE treatment, forage was defined as baled forage fed in an outdoor drylot enclosure. Ten ewes were assigned to each plot based on NRC (2007) projected DMI levels for mature non-lactating ewes (75.0 – 81.5 kg), adjusted for ad libitum access to forage which allowed for 3 replications for GRAZE treatment and 3 replications for BALE treatment. Our stocking protocol assumed 75-80% consumption of initial available forage over the span of 7 d (with no less than 15-20% forage refusal) for GRAZE treatments. Ewes in BALE treatments were fed an amount of hay sufficient to ensure no less than 10% forage refusal.

TABLE 1. Dry matter intake, initial BW, BW change, initial forage availability, and forage wastage for ewes in swath grazing and confinement feeding systems for two years

Year	Parameter	Feeding system		SEM[3]	*P*-value
		GRAZE[1]	BALE[2]		
2010	DMI, kg ewe^{-1} d^{-1}	1.68	2.38	0.22	0.06
	DMI, % BW	2.45	3.54	0.36	0.07
	BW change, kg	5.58	6.57	0.59	0.27
	Wastage, kg[4]	121.64	52.50	17.41	0.02
	Wastage, %[5]	31.96	19.71	7.51	0.28
2011	DMI, kg ewe^{-1} d^{-1}	1.93	1.54	0.22	0.25
	DMI, % BW	3.05	2.52	0.36	0.33
	BW change, kg	1.47	1.73	0.59	0.77
	Wastage, kg[4]	35.91	12.43	17.41	0.37
	Wastage, %[5]	17.44	10.22	7.51	0.52

1. Ewes grazed pea-barley swaths and standing forage;
2. Ewes fed pea-barley hay in confinement;
3. Standard error of means;
4. Wastage = initial forage availability – ending forage availability – total DMI;
5. Percent wastage = (wastage / beginning forage availability) * 100.

All ewes were permitted ad libitum access to water as well as salt mixed with Sheep Range Mineral (CHS, Inc., Sioux Falls, SD) for all classes of sheep. We measured DMI via daily Cr2O3 dosing and fecal grab sampling and wastage during October 9 -15, 2010 and September 13¬-19, 2011.

In both GRAZE and BALE treatments, initial and final forage availability was determined to calculate DM wastage as W = Fi – Ff – I, where W is wastage, Fi is initial available forage, Ff is final available forage, and I represents intake over the 7-d collection period. Final edible forage available for BALE and GRAZE treatments was estimated by weighing refused forage (unsoiled and untrampled in GRAZE and remaining in the feeder in BALE) at the end of the 7-d data collection period.

This study was a completely randomized design with each GRAZE or BALE enclosure as the experimental unit. PROC GLM of SAS (SAS Institutional Inc. Cary, NC) was used to evaluate within-year treatment differences in DMI, BW, wastage, and nutrient composition. Means were separated using the LSD procedure when a significant F value was found ($P \leq 0.10$).

RESULTS AND DISCUSSION

Ewe Performance. Proper nutrients and intake are critical in winter feeding systems for animal performance. DMI, measured as kilograms per ewe per day, and percentage of BW, differed between feeding treatments ($P \leq 0.08$) in 2010 (Table 1). In 2010, both measures of DMI were lower ($P < 0.08$) for GRAZE ewes compared with BALE ewes. Substantial regrowth was available to GRAZE ewes in 2010 but not in 2011 due to application of glyphosate in 2011 to prepare the area for future research. In 2011, DMI did not differ ($P > 0.24$) between GRAZE and BALE treatments (Table 1). Despite GRAZE ewes demonstrating decreased intake in 2010, their BW did not differ ($P > 0.26$) between GRAZE and BALE treatments for either 2010 or 2011 (Table 1). Nevertheless, our finding of no change in BW over such a short period may not be indicative of results on a long term application.

Forage Wastage. Wastage can represent a costly aspect of feeding systems in both expense of feed lost as well as labor for removal of soiled feed (Karn et al., 2005). In 2010, a difference ($P = 0.02$) was observed between feeding treatments for wastage expressed in kilograms; GRAZE wastage (121.6 kg) exceeded BALE wastage (52.5 kg; Table 1). However, there was no difference found for wastage expressed as a percent of initial available forage in 2010 ($P=0.28$). Similarly, wastage did not differ between feeding treatments in 2011 ($P > 0.36$; Table 1).

Forage Quality. Our results for initial CP were inconsistent between years of the study. In 2010, changes in CP during the feeding trial differed between the treatments ($P < 0.01$) despite no difference ($P = 0.24$) in initial CP among the swathed, standing forage in GRAZE, and BALE forages (Table 2). In GRAZE, the CP in the swathed forage increased but decreased in the standing forage. Crude protein remained relatively constant in BALE forage. In 2011, a difference ($P = 0.07$) was found for initial CP with BALE forage being greater than the swathed forage in the GRAZE plots in 2011. However, change in CP between swathed and baled forages did not differ ($P = 0.52$) in 2011.

TABLE 2. Forage quality over time[1] with CP, ISDMD[2], NDF, and ADF of standing and swathed forage, or baled pea-barley forage feeding systems

Year	Parameter	Forage Type			SEM[4]	P-value
		Swath	Standing[3]	Baled		
2010	Initial CP, %	10.80	10.00	11.83	0.68	0.24
	CP change, %	1.65[c]	-1.71[a]	-0.15[b]	0.28	< 0.01
	Initial ISDMD, %	72.70	62.97	62.00	5.15	0.33
	ISDMD change, %	-3.70	2.17	5.40	5.24	0.50
	Initial ADF, %	26.53[a]	34.33[b]	25.20[a]	0.77	< 0.01
	ADF change, %	5.47[c]	-6.57[a]	-1.97[b]	1.14	< 0.01
2011	Initial CP, %	5.30	—	6.93	0.47	0.07
	CP change, %	0.01	—	-0.35	0.36	0.52
	Initial ISDMD, %	36.80	—	40.10	1.85	0.28
	ISDMD change, %	-7.03	—	3.63	2.48	0.04
	Initial ADF, %	34.47	—	26.53	1.48	0.02
	ADF change, %	4.83	—	3.00	1.97	0.55

1. Forage types were sampled on Aug. 11 and Oct. 7 in 2010 and on Aug. 22 and Oct. 27 in 2011;
2. In situ dry matter disappearance;
3. Regrowth with post-harvest stubble not present in 2011;
4. Standard error of means;
a-c. Within 2010, means without a common superscript differ ($P < 0.10$).

Initial and change in ISDMD did not differ between feeding treatments in 2010 (P > 0.32; Table 2). Similarly, initial ISDMD did not differ between the swathed forage in GRAZE and BALE forage (P = 0.28). However, change in ISDMD differed between treatments in (P = 0.04) ISDMD decreased in the swathed forage and increased in the BALE forage.

In 2010, we observed differences (P < 0.01) in initial ADF and change in ADF over time among swath and standing forage in the GRAZE, and baled forage in BALE feeding systems (Table 2). Initial ADF of standing forage was greater compared to both swathed and baled forages. The ADF content increased in the swathed forage, decreased the greatest amount in standing forage, and decreased slightly in the baled forage. In 2011, we observed a difference (P = 0.02) in initial ADF between the swathed and baled forage, and no difference in changes in ADF (P = 0.55) was found between the forage treatments. Swathed forage had greater initial ADF content than baled forage, but the ADF content increased in both forages overtime.

REFERENCES

Karn, J. F., D. L. Tanaka, M. A. Liebig, R. E. Ries, S. L. Kronberg, and J. D. Hanson. 2005. *An integrated approach to crop/livestock systems: Wintering beef cows on swathed crops.* Renew Agric. Food Syst. 20:232-242.

Nayigihugu, V., A. D. Schleicher, L. J. Koch, J. W. Flake, and B. W. Hess. 2007. *Beef cattle production, nutritional quality, and economics of windrowed forage vs. baled hay during winter.* Agron. J. 99:944-951.

NRC. 2007. *Nutrient requirements of Small Ruminants.* Natl. Acad. Press, Washington, DC.

ACKNOWLEDGEMENTS:

The authors acknowledge financial support from the Bair Ranch Foundation, USDA 5 State Ruminant Consortium, USDA-CAR, USDA CSREES ICGP-002154, and the Montana Agricultural Experiment Station.

Carcass Characteristics and Body Composition of Lambs Selected for Divergent Residual Feed Intake

by

K.A. Perz, M.R. Whitmore, A.F. Williams, A.R. Hicks-Lynch, M. R. Herrygers, J.A. Boles, J.G. Berardinelli, and J.M. Thomson

Department of Animal and Range Sciences, Montana State University, Bozeman MT

IMPACT STATEMENT

This research is aimed at improving the existing knowledge of the physiological basis of variation in residual feed intake (RFI). A better understanding of the cause of RFI variation will assist producers in making informed selection decisions when breeding for improved efficiency.

CARCASS CHARACTERISTICS AND BODY COMPOSITION OF LAMBS SELECTED FOR DIVERGENT RESIDUAL FEED INTAKE

by K.A. Perz, M.R. Whitmore, A.F. Williams, A.R. Hicks-Lynch, M. R. Herrygers, J.A. Boles, J.G. Berardinelli, and J.M. Thomson

SUMMARY

The objective of this study was to evaluate differences in growth performance measures, carcass characteristics and quality, and body composition in lambs selected for high and low residual feed intake (RFI). Mixed-breed wether lambs (n = 65), approximately 4-months-old, were placed on a 47 d feeding trial, which was conducted to get an estimate of individual lamb intake. Residual feed intake, an efficiency measurement based upon the difference in actual feed intake and expected feed intake, was calculated for each lamb. Wethers with an RFI of one standard deviation greater (HIGH; less efficient; n = 6) or lower (LOW; more efficient; n = 6) than the mean RFI of the 65 wethers were used in the present study. Upon completion of the feeding trial, lambs were harvested and organ weights were collected immediately after slaughter. Carcass data was collected 24 hours after slaughter. Initial and final liveweights, as well as average daily gain (ADG) were not affected ($P > 0.05$) by RFI class. Back fat thickness (BF) and yield grade (YG) were greater ($P < 0.03$) in HIGH carcasses than in LOW lamb carcasses. No other carcass traits differed between RFI classes. Lung and trachea weights were heavier ($P < 0.03$) in LOW lamb carcasses than in HIGH lamb carcasses. Rumen weight was greater ($P < 0.005$) for LOW lambs than for HIGH lambs. Total GIT and total organ weights were greater ($P < 0.03$) for LOW lambs than in HIGH lambs. In growing lambs, selection for RFI seems to affect fat deposition and organ weights, although more research is necessary to understand the relationship between lung weight, RFI, and HCW.

INTRODUCTION

The most costly resource in any livestock production system is the cost of feed (Moore et al., 2009). As feed prices continue to rise, selection for efficient animals that can gain more on less feed will become more economically important. Residual feed intake (RFI) has been suggested as the optimal selection trait for enhancing efficiency of production in beef cattle, since it has been reported to not be affected by growth or maturity of animals and instead reflects physiological differences between individual animals (Carstens and Kerley, 2009).

The physical causes of variation in RFI are not clear or completely understood. Richardson and Herd (2004) estimated that the cause of 27% of the variation in RFI cannot be explained. This can be problematic when using RFI as a selection tool, as our lack of understanding of what causes variation in RFI might lead to accidental selection of undesirable traits.

The objective of this study was to investigate patterns of variation in RFI and to determine if young wethers selected for extreme high or low RFI differed in performance traits and produced carcasses with different carcass characteristics and organ weights. Our hypothesis was that this selection process would not influence performance traits such as ADG, but would lead to carcasses with different carcass characteristics and organ weights.

PROCEDURES

Crossbred wethers (n = 65), approximately 4 monthd of age, from the Montana State University flock were transported to the Fort Ellis Research Farm in Bozeman, MT. Following vaccination for enterotoxaemia and a 2 week acclimation period, a 47 d RFI feeding trial was conducted. Due to space constraints, lambs were separated into two groups; group 1 (n = 45) and group 2 (n = 25). Lambs were brought into a barn twice daily, 12 h apart, and individually penned to allow unlimited access to an 80:20% alfalfa:barley pelleted diet for 2 to 3 h. Feed was weighed prior to and after each feeding for calculating individual lamb intake. Lambs were penned in a drylot with unlimited access to water, but no access to forage. Wethers were weighed on two consecutive days to get an average weight at week 1, 3, 4, and 6 after the adaptation period.

Daily intakes for each wether were used to calculate ADG. Statistical regression methods were used to calculate the initial and final BW, mid-test metabolic BW (MBW), and expected feed intake (EFI), and then to calculate RFI as actual dry matter intake (DMI) – EFI (Koch et al., 1963). Wethers with an RFI greater than (HIGH; less efficient; n = 6) and less than (LOW; more efficient; n = 6) one standard deviation of the mean of the 65 wethers were retained and moved to the Bozeman Agricultural Research and Teaching Farm (BARTF).

Wethers were transported to Big Timber, MT, and processed following standard industry procedures. Organ weights were taken immediately after slaughter. Gastrointestinal tracts (GIT) of each wether were emptied, transported back to Montana State University, and weighed 24 to 48 h later.

Following a 24 h chill, carcasses were transported back to the Meat Laboratory at Montana State University, where carcass data (back fat thickness, rib-eye area, maturity, leg score, conformation, flank streaking, and quality grade) was collected by a trained meat evaluator. Yield grade (YG) was calculated with the following equation: YG= [10*back fat thickness (in)] + 0.4.

RESULTS AND DISCUSSION

Initial live weight, final live weight, and ADG did not differ (P > 0.05) between HIGH and LOW RFI lambs. HIGH wethers were 64 pounds at the start of the study and 99 pounds at the end; LOW wethers were 68 pounds at the start and 101 pounds at the end. Both groups gained 0.6 pounds/day. Carcass characteristics other than BF and YG were not affected (P < 0.03) by RFI class (Table 1). HIGH wethers produced carcasses with more BF and higher YG. As YG is calculated based upon BF, it was not surprising that both of these values were significant. It is important to note that these lambs were on feed for a fixed period and were not "finished" prior to processing. This resulted in carcasses that were smaller than industry average, and it is possible that if these wethers had been fed longer, the results might have been different

Prior research has also reported that inefficient sheep (Redden et al., 2013; Perry et al, 1997) and cattle (Perry et al., 1997) deposit more BF. This was expected to also be true for our study; however, it is interesting that this excess fat was already deposited at a young age, in sheep that would not have been finished enough for slaughter in a commercial setting. This may indicate that whatever is causing inefficiency begins to have physical effects at a young age, and might be something that has been accidentally selected for when selecting for efficient animals.

HIGH and LOW wethers had different total organ and total GIT weights (P < 0.03; Table 2). LOW RFI wethers had heavier (P < 0.03) lungs and heavier (P < 0.005) rumens than HIGH RFI wethers. It was expected that rumen weights in efficient sheep would be lighter, not heavier. It is possible that heavier rumen weight in efficient wethers is related to a greater surface area of the rumen, which would allow for increased nutrient absorption, but more investigation is required to determine this. More research is necessary on the relationship between lung weight and RFI class, as this is another scenario where selection for efficient animals might be changing more physical characteristics than expected.

This research suggests that we still do not fully understand the effect of RFI on carcass composition and quality, and that more research is necessary. It is important to fully understand what is physically changing in animals with different RFI classifications in order to help producers select for efficient animals that will help save money on feed, without negatively impacting physical and production characteristics.

TABLE 1. Carcass characteristics and quality of wethers from divergent RFI classes

	RFI Classification		
Item	HIGH	LOW	*P*-value
Hot carcass wt, lb	46.2	45.8	0.90
Backfat thickness, in	0.23[a]	0.13[b]	0.03
Ribeye area, in^2	2.3	2.2	0.87
Leg Score[1]	9.3	9.3	1.00
Maturity[2]	1.67	1.8	0.55
Conformation[1]	9.3	9.3	1.00
Flank Streaking[3]	225	245	0.75
Quality Grade[1]	9.3	9.2	0.88
Yield Grade[4]	2.65[a]	1.73[b]	0.03

1. Utility = 7, High Good = 9, Low Choice = 10, Average Choice = 11, High Choice = 12;
2. A00 to A33 = 1, A34 to A67 = 2.
3. Practically devoid = 100-199, Traces = 200-299, slight = 300-399, small = 400-499;
4. YG= [10*back fat thickness (in)] + 0.4;
a,b. Means within a row with different superscripts differ (P ≤ 0.05).

TABLE 2. Viscera weights (lb) from carcasses from HIGH and LOW RFI wethers

	RFI Classification		
Weight, lb	HIGH	LOW	*P*-value
Heart	0.77	0.82	0.67
Intestine	3.76	4.19	0.13
Kidney	0.40	0.35	0.33
Liver	1.97	2.03	0.71
Lungs and trachea	1.27[a]	1.44[b]	0.03
Rumen	3.12[a]	3.67[b]	0.005
Spleen	0.15	0.16	0.75
Total GI Tract [1]	6.89[a]	7.86[b]	0.03
Total Viscera [2]	11.46[a]	12.67[b]	0.03

1. Rumen weight + intestine weight;
2. Heart weight + kidney weight + liver weight + spleen weight + total GI tract weight.
a,b. Means within a row with different superscripts differ (P ≤ 0.05).

REFERENCES

Carstens, G.E. and M.S. Kerley. 2009. *Biological basis for variation in energetic efficiency in beef cattle.* In: Proc. Beef Improve. Fed. 41st Annual Research Symposium, Sacramento, CA. p. 124–131.

Koch, R.M., L.A. Swiger, D. Chambers, and K.E. Gregory. 1963. *Efficiency of feed use in beef cattle*. J. Anim. Sci. 22:486-494. doi:10.2134/jas1963.222486x

Moore, S.S., F.D. Mujibi, and E.L. Sherman. 2009. *Molecular basis for residual feed intake in beef cattle.* J. Anim. Sci. 87 (Suppl. 14):E41-47. doi: 10.2527/jas.2008-1418.

Perry, D., A.J. Ball, J.M. Thompson, and V.H. Oddy. 1997. *The relationship between residual feed intake and body components in animals selected for divergent growth rate.* Proc. Assoc. Advmt. Anim. Breed. Genet. 12:238-241.

Redden, R.R., L.M.M. Surber, A,V. Grove, and R.W. Kott. 2013. *Growth efficiency of ewe lambs classified into residual feed intake groups and pen fed a restricted amount of feed.* Sm. Rum. Res. 114:214-219. doi:10.1016/j.smallrumres.2013.07.002

Richardson, E.C. and R.M. Herd. 2004. *Biological basis for variation in residual feed intake in beef cattle.* 2. Synthesis of results following divergent selection. Anim. Prod. Sci. 44:431-440. doi:10.1071/EA02221.

ACKNOWLEDGEMENTS:

The authors thank Philip Merta for his excellent technical assistance during the course of this study. This study was supported by the Montana Agricultural Experiment Station, and is a contributing project to Multistate Research Project, W2010, Integrated Approach to Enhance Efficiency of Feed Utilization in Beef Production Systems.

Effects of Pasture vs. Drylot Flushing on Ewe Body Weight Change and Number of Lambs Born

by

D.L. Ragen, E.E. Nix, L.B. McNew, W.A. Whitehurst, T.M. Liles, R.B. Sager, E.S. Read, B.S. Hauptman, C.G. Hooley, and P.G. Hatfield

Department of Animal and Range Sciences, Montana State University, Bozeman, MT

IMPACT STATEMENT

In the current study, flushing environment did not have an impact on number of lambs born (NLB). Average daily gain and final body weight also did not impact NLB. In non-extreme weather conditions, it may be more economical for livestock producers to flush ewes on pasture alone, or on a poor quality pasture with supplementation vs. confining ewes and providing full feed. As an alternative to flushing ewes immediately prior to breeding, it may be possible for producers to flush ewes on pasture earlier in the season, when forage nutrient quality is higher, and still experience a flushing effect. However, long-term studies are needed to assess the relationship between flushing and the length of time between nutritional influence, breeding, and number of lambs born.

EFFECTS OF PASTURE VS. DRYLOT FLUSHING ON EWE BODY WEIGHT CHANGE AND NUMBER OF LAMBS BORN

by D.L. Ragen, E.E. Nix, L.B. McNew, W.A. Whitehurst, T.M. Liles, R.B. Sager, E.S. Read, B.S. Hauptman, C.G. Hooley, and P.G. Hatfield

SUMMARY

Flushing is the practice of increasing nutrient intake before and during breeding in order to increase ovulation and ultimately the number of lambs born (NLB). Two flushing trials were conducted to evaluate NLB per ewe, and BW gain of ewes receiving 1 of 3 treatments: 1) ad libitum access to pea-barley hay in drylot (DRY), 2) ad libitum access to swathed pea-barley forage in paddocks (PAD), and 3) ad libitum access to swathed spring wheat straw in paddocks with 0.45 kg of supplement·ewe-1·d-1 (WHT). Feeding treatments did not influence ADG, final BW, lambing date, or NLB in our study, suggesting cost-saving benefits for sheep producers using swath grazing flushing practices. Similar responses by ewes to feeding treatments suggest swath grazing as a viable flushing strategy to reduce inputs while maintaining high productivity.

INTRODUCTION

Flushing, the practice of increasing nutrient intake before and during breeding to increase ovulation and the number of lambs born, is commonly used to increase reproductive performance of ewes (NRC, 2007).

Despite reported benefits of flushing on ewe productivity, little information exists on how feeding conditions and environment influence its efficacy. Flushing ewes with forage in a confinement system is time and labor intensive, requiring the baling and hauling of hay. An alternative approach that may reduce feeding costs is flushing ewes on cut forage left in swaths in the field. Nevertheless, reproductive benefits accrued from flushing may be reduced if swath-grazing results in reduced gains in body weight and lower fecundity compared to confinement flushing.

PROCEDURES

All animal procedures were approved by the Montana State University Agricultural Animal Care and Use Committee (Protocol #2009-AA04).

This study was conducted at Montana State University's Fort Ellis Experiment Station near Bozeman, MT.

Sheep Selection and Management. In 2010 (Trial 1), 90 yearling Targhee ewes (average BW = 65.4 ± 5.8 kg, non-pregnant, non-lactating, 18 mo of age) were transported from the Bair Ranch in Martinsdale, MT, on September 25 (d 0) to Montana State University's Fort Ellis Experiment Station near Bozeman, MT. In 2011 (Trial 2), 60 mature Rambouillet ewes (BW = 61.9 ± 6.3 kg BW, non-pregnant, non-lactating, 3.3 + 0.48 yr of age) from the Red Bluff Research Ranch near Norris, MT, were transported on September 6, 2011 (d 0) to the Fort Ellis Experiment Station. Ewes in both trials were fasted for 24 to 48 h before arrival to reduce effects of gut fill on initial body weight. Ewes were paint-branded or ear-tagged for identification purposes and fasted weights were recorded. Ewes had ad libitum access to treatment forage, water, and a salt and mineral supplement. All treatments were formulated to be isonitrogenous and isocaloric, meeting or exceeding NRC (2007) recommendations for ewes at flushing and gaining 0.10 kg/d.

Trial 1. Upon arrival at Fort Ellis on d 0, groups of 10 yearling ewes were randomly allocated to 1 of 3 treatments: 1) ad libitum access to pea-barley hay in drylot (DRY), 2) ad libitum access to swathed and standing pea-barley forage in paddocks (PAD), and 3) ad libitum access to swathed and standing spring wheat straw stubble in paddocks plus 0.45 kg of an 18.9% CP supplement·ewe-1·d-1 (WHT). Drylot pens measured 40 m × 12 m and swath grazing paddocks measured 91 m × 15 m for PAD and 91 m × 50 m for WHT. Intense grazing of spring wheat stubble by ewes caused forage to become scarce. Therefore ewes were supplemented with additional wheat straw in the WHT treatment on d 21 through 27. In an effort to match diet quality, supplemental alfalfa hay was added to both DRY and PAD treatments on d 21 through 27 of the trial. Ewes in the WHT treatment received their daily ration of supplement in feed buckets. The trial ended on October 22, 2010 (d 27). Body weights were recorded after a 16 h fast on d 28 and ewes were returned to the Bair Ranch and were placed on alfalfa stubble until breeding (November 1, 2010). Lambing began April 2, 2011 and the number of lambs born (NLB) for each ewe was recorded at parturition.

Trial 2. On September 6, 2011 (d 0), 60 mature ewes were randomly assigned to either DRY or PAD. The trial ended on September 19, 2011 (d 13) and ewes were weighed on d 14 after 24 h of fasting. Ewes were returned to the Red Bluff Research Ranch and placed on alfalfa stubble until breeding (November 10, 2011). Lambing began April 13, 2012 and the NLB for each ewe was recorded at parturition.

Statistical Analysis. Average daily gain and final BW were analyzed with normal linear mixed effects models, whereas NLB was sampled from a non-normal distribution (i.e., discrete count data) and thus analyzed with a Poisson mixed effects model (McCullagh and Nelder, 1989), where pen was treated as a random effect. All statistical analyses were performed in R statistical software (ver. 2.4; R Development Core Team 2011, Vienna, Austria), where GLMM models were fit with the lme4 packages (Bates et al., 2012).

RESULTS AND DISCUSSION

ADG. Overall, ADG did not differ between DRY, WHT and PAD treatments regardless of trial (P > 0.10; Table 1), suggesting similar net nutritional benefits between swathed and bale-fed pea-barley hay treatments and wheat stubble with supplementation treatments.

Final BW. Final BW among treatments did not differ (P > 0.10; Table 1). Our results are consistent with Dahmen et al. (1976) who reported that BW among four groups of mature ewes (flushed in drylot or pasture) was similar. In our study, final BW was driven by initial BW, not by feeding treatments, and as a result, final BW did not differ among treatments.

NLB. Effects of feeding treatment on NLB were not supported for either trial (Table 1). In contrast to our results, Dahmen et al. (1976) reported that NLB per ewe bred under pasture management exceeded the drylot managed ewes and was related to increased ovulation rate. Although Trials 1 and 2 differed in duration, NLB was similar for all treatments. Flushing a few weeks immediately prior to breeding is an accepted practice among producers. However, Hulet et al. (1962) reported that termination of flushing treatment 13 to 18 d prior to mating did not lower the ovulation and/or embryo survival rates relative to the controls as measured by NLB. While Hulet et al. (1962) did not increase the gap between flushing and mating beyond 18 d, they did report a greater flushing effect with increased time from 6 to 18 d between flushing and mating.

In our study, ewes were mated approximately 8 d after flushing commenced in Trial 1 and 52 d after flushing commenced in Trial 2. Irrespective of the length of time between flushing and breeding, NLB was similar for all treatments.

CONCLUSION

Feeding treatments did not influence ADG, final BW, lambing date, or NLB in our study, suggesting cost-saving benefits for sheep producers using swath grazing flushing practices. In non-extreme weather conditions, it may be more economical for livestock producers to flush ewes on pasture alone, or on a poor quality pasture with supplementation vs. confining ewes and providing full feed. As an alternative to flushing ewes immediately prior to breeding, it may be possible for producers to flush ewes on pasture earlier in the season, when forage nutrient quality is higher, and still experience a flushing effect. However, long-term studies are needed to assess the relationship between flushing and the length of time between nutritional influence and breeding.

REFERENCES

Bates, D., M. Maechler, and B. Bolker. 2012. lme4: linear mixed-effects models using S4 classes. R package version 0.999999-0. Available from package=lme4 (accessed February 2015).

Dahmen, J. J., C. V. Hulet, D. A. Price, and D. O. Everson. 1976. *Effects of drylot and pasture management on ovulation rate and lamb production in Panama ewes.* J. Anim. Sci. 42:427–433.

TABLE 1. Average initial and final BW, ADG, number of lambs born (NLB) and Julian lambing date to yearling ewes (Trial

Item	Treatment[a]			*P*-value[b]
	DRY	PAD	WHT	
Trial 1				
Initial BW, kg	65.0 (1.1)	66.3 (1.6)	65.4 (1.6)	0.73
Final BW, kg	71.8 (1.1)	71.6 (1.6)	70.1 (1.6)	0.21
ADG, kg	0.25 (0.03)	0.22 (0.04)	0.17 (0.04)	0.14
NLB•ewe	1.45 (0.15)	1.53 (0.21)	1.64 (0.21)	0.35
Lambing date	101 (1.4)	103 (2.0)	104 (2.0)	0.16
Trial 2				
Initial BW, kg	60.8 (1.2)	63.2 (1.6)	–	0.21
Final BW, kg	62.5 (1.1)	64.7 (1.6)	–	0.95
ADG, kg	0.12 (0.03)	0.11 (0.04)	–	0.74
NLB•ewe	1.42 (0.16)	1.58 (0.23)	–	0.65
Lambing date	112 (1.2)	114 (1.6)	–	0.26

a. DRY = ad libitum access to pea-barley hay in drylot; PAD = ad libitum access to swathed and standing pea-barley forage in paddocks; WHT = ad libitum access to swathed and standing spring wheat straw stubble with 0.45 kg of an 18.9% CP supplement·ewe-1·d-1.
b. *P*-values for treatment effects evaluated from linear mixed effects models where Pen was included as random effect.

Hulet, C. V., R. L. Blackwell, S. K. Ercanbrack, D. A. Price, and R. D. Humphrey. 1962. *Effects of feed and length of flushing period on lamb production in range ewes.* J. Anim. Sci. 21:505–510.

McCullagh, P., and J. A. Nelder. 1989. *Generalized linear models, 2nd Edition*. Chapman and Hall, London, UK.

NRC. 2007. *Nutrient Requirements of Small Ruminants.* Natl. Acad. Press, Washington, D. C.

ACKNOWLEDGEMENTS:

The authors acknowledge support from the Montana Agricultural Experiment Station and the Bair Ranch Foundation in Martinsdale, MT.

Individual Mineral Supplement Intake by Ewes Swath Grazing or Confinement Fed Pea-Barley Forage

by

D.L. Ragen[1], E.E. Nix[1], R.L. Endecott[1], P.G. Hatfield[1], M.K. Petersen[2], and J.G.P. Bowman[1]

[1]Department of Animal and Range Sciences, Montana State University, Bozeman, MT, and [2]USDA-ARS Fort Keogh Livestock and Range Research Laboratory, Miles City, MT

IMPACT STATEMENT

Mineral intake was highest by grazing ewes in 2011 and 2010, intermediate by ewes in confinement in 2010 and lowest by ewes in confinement in 2011. This study found a large variation in mineral supplement intake by individual ewes (CV of 34–67%), and indicated there may be up to 0.10 of ewes in a flock which consume only trace amounts. A better understanding of the factors that regulate mineral supplement intake could possibly improve the effectiveness of mineral supplement programs.

INDIVIDUAL MINERAL SUPPLEMENT INTAKE BY EWES SWATH GRAZING OR CONFINEMENT FED PEA-BARLEY FORAGE

by D.L. Ragen, E.E. Nix, R.L. Endecott, P.G. Hatfield, M.K. Petersen, and J.G.P. Bowman

SUMMARY

Previous research has reported high variation in intake of self-fed protein and/or energy supplements by individual animals, however little is known about variation in consumption of mineral supplements. Sixty mature range ewes (non-pregnant, non-lactating) were used in a completely randomized design repeated for 2 years to determine if feeding method of intercropped field pea and spring barley forage (swath grazed or fed as hay in confinement) affected individual ewe mineral consumption. Ewes in confinement consumed more forage DM than grazing ewes in 2010, but less than grazing ewes in 2011. Mean mineral intake was highest by grazing ewes in 2011 and 2010 (average 2.4 oz/d), intermediate by confinement ewes in 2010 (2.0 oz/d), and lowest by confinement ewes in 2011 (1.1 oz/d). A year×treatment interaction existed for mineral intake CV, which was higher for confinement ewes in 2011 (67 vs. 34%), but was not different between treatments in 2010. In this study, variation in individual ewe intake of mineral supplement was large in both grazing ewes and ewes fed hay in confinement.

INTRODUCTION

A major limitation to providing appropriate mineral nutrients to sheep is a lack of understanding factors affecting individual animal supplement consumption. Bowman and Sowell (1997) reported that some cows refuse protein and energy supplements altogether, while others consume excessive amounts. Deviation from the targeted supplement intake can negatively impact animal production. Interpretation of data from grazing trials with supplementary feeding is difficult due to the lack of information concerning the quantity of supplement consumed by each animal in a group-feeding situation (Nolan et al., 1975). Researchers have looked at individual intake of protein and energy supplements (Curtis et al., 1994), but few studies have evaluated variation in individual consumption of mineral. The objective of this study was to determine if the feeding method of pea–barley forage (swath grazing or hay fed in confinement) affected individual ewe mineral consumption.

PROCEDURES

All animal procedures were approved by the Montana State University Agricultural Animal Care and Use Committee (Protocol #2009-AA04). The study was conducted at the Montana State University's Fort Ellis Research Station in Bozeman, MT, during fall 2010 and fall 2011.

Sixty mature western whiteface range ewes were selected from the Bair Ranch in Martinsdale, MT, to be used in 2010. The ewes (144 ± 13 lb body weight; BW) were non-pregnant, and non-lactating. For the second year, 60 mature western whiteface range ewes (136 ± 14 lb BW, non-pregnant, non-lactating) were selected from the Red Bluff Research Ranch near Norris, MT.

The swath grazing treatment consisted of 3 pastures (10 ewes/pasture) where pea-barley forage had been mechanically swathed and left in the field. The confinement feeding treatment consisted of 3 pens (10 ewes/pen) where pea-barley hay (harvested from the same field where the swath grazing pastures were located) was fed. The experiment consisted of 7 days for diet adaptation, followed by 7 days of data collection.

Throughout the experiment, ewes had ad libitum access to forage, water, and a commercial mineral supplement (Payback – Sheep Range Mineral 16-8, Cenex Harvest States, Inc., Great Falls, MT).

One mineral feeder was placed in each confinement pen and grazing pasture. Mineral feeders were checked daily and kept full of mineral. Throughout the entire experiment, ewes on both treatments were moved into handling facilities daily and dosed with gelatin capsules filled with 2 g Cr2O3 as an external marker to estimate fecal output (FO). During the data collection, all ewes were gathered daily, and fecal grab samples were collected via rectum.

Distribution of supplement intake was evaluated by grouping ewes into four mineral supplement intake categories; none (≤0.35 oz/d), low (0.4–1.0 oz/d), average (1.0–3.0 oz/d) and high consumers (≥3.0 oz/d).

Data were analyzed using the GLM procedure of SAS (9.1 version, 2003) for a completely randomized design. Ewe was the experimental unit for mineral supplement, and forage intake. Pasture or pen (a group of 10 ewes) within year was the experimental unit for the coefficient of variation (CV) of supplement intake, and supplement intake distribution. Means were separated using the LSD procedure when a significant F value was found ($P \leq 0.05$).

RESULTS AND DISCUSSION

Year by treatment interactions were seen for forage DMI ($P < 0.01$), expressed both as lb/d and as lb/100 lb BW (Table 1). Ewes in confinement in 2011 consumed the least amount of mineral supplement. Ewes grazing in 2010 consumed a similar and intermediate amount of supplement to those in confinement in 2010, and to those grazing in 2011.

Ewes in confinement had a lower ($P = 0.05$) minimum supplement intake (average 0.35 oz/d) compared with ewes grazing (average 1.2 oz/d). Mineral supplement intake CV demonstrated a year by treatment interaction (P = 0.05). In 2010, ewes in confinement and grazing had similar supplement intake CV (55.4 vs. 46.5%, respectively). In 2011, ewes in confinement had a greater supplement intake CV compared with ewes grazing (67.2 vs. 33.7%, respectively).

The proportion of ewes consuming ≤0.35 oz/d of mineral was not affected by year, treatment, or the interaction (P ≥ 0.08; Table 1), and averaged 0.03. The proportion of ewes consuming an average amount of supplement was greater (P = 0.04) for grazing ewes compared with ewes in confinement (0.71 vs. 0.50, respectively). In addition, the proportion of ewes consuming a high level of supplement was greater (P = 0.04) for ewes swath grazing than for those in confinement (0.26 vs. 0.12, respectively).

Intake of mineral supplement was similar for grazing and confinement-fed ewes during the first year, but higher for grazing ewes the second year (Table 1).

Doreau et al. (2004) suggested that salt block intake was higher when cows were fed at low intake, probably due to boredom. However, in our study, ewes had ad libitum access to forage, and a greater proportion of grazing ewes consumed an average and a high level of supplement compared to ewes in confinement. Ducker et al. (1981) found that as the grazing area per ewe increased so did the proportion of ewes not consuming feed-block. Therefore, increased consumption of mineral by grazing ewes could be due to the small area of the grazing plots. Confinement pens measured 0.12 acres, but hay was fed in the same designated areas every day, reducing the amount of travel past mineral feeders by ewes.

The previous experience with supplements, social interactions, and forage quality and availability has been shown to influence the amount of supplement consumed by individual animals (Bowman and Sowell, 1997) and may have affected the distribution of mineral supplement intake in our study. The variation in mineral supplement intake seen in this study was similar to the variation in individual animal intake of protein and energy supplements reported by Bowman and Sowell (1997).

TABLE 1. Individual performance, forage DMI, mineral supplement DMI, and mineral supplement DMI distribution by ewes consuming pea-barley forage in confinement or swath grazing.

Item	Treatment				P value[2]			
	2010		2011					
	Conf.	Grazing	Conf.	Grazing	SEM	Year	Trt	Year×Trt
Initial weight, lb[1]	142.3	145.6	133.8	139.0	1.09	0.02	0.07	0.66
ADG, lb/d[1]	0.53	0.46	0.26	0.24	0.023	<0.01	0.26	0.70
Forage DMI, lb[1]	5.7[b]	4.2[a]	4.4[a]	5.5[b]	0.14	0.96	0.40	<0.01
Forage DMI, lb/100 lb BW[1]	8.6[b]	5.9[a]	7.3[a]	8.6[b]	0.23	0.21	0.30	<0.01
Mineral supplement DMI, oz/d[1]	2.0[b]	2.2[b,c]	1.1[a]	2.6[c]	5.2	0.10	<0.01	<0.01
Supplement DMI, oz3								
Minimum[3]	0.35	0.88	0.35	1.44	4.0	0.08	0.05	0.07
Maximum[3]	4.13	4.13	2.91	4.27	14.4	0.31	0.21	0.22
Supplement DMI CV, %3	55.4[b,c]	46.5[a,b]	67.2[c]	33.7[a]	5.33	0.92	0.04	0.05
Supplement DMI, proportion of ewes3								
None, ≤0.35 oz[3]	0.03	0	0.10	0	0.019	0.35	0.08	0.34
Low, 0.4 – 1.0 oz[3]	0.14[a]	0.07[a]	0.50[b]	0[a]	0.065	0.07	<0.01	0.01
Average, 1.0 – 3.0 oz[3]	0.66	0.69	0.33	0.72	0.059	0.14	0.04	0.07
High, ≥3.0 oz[3]	0.17	0.24	0.06	0.28	0.035	0.59	0.04	0.27

1. Experimental unit was individual ewe; number of ewes per treatment was 28 in 2010; in 2011 it was 29 in confinement (Conf.), and 28 in grazing;
2. P value for the ANOVA *F* test of year, treatment, and the interaction;
3. Experimental unit was confinement pen or grazing pasture; n = 3 per treatment per year.
a-c. Means within a row with different superscripts differ (P<0.05).

REFERENCES

Bowman, J.G.P., and B. F. Sowell. 1997. *Delivery method and supplement consumption by grazing ruminants: A review.* J. Anim. Sci. 75:543-550.

Curtis, K.M.S., P. J. Holst, and P. J. Murray. 1994. *Measuring supplement intake in the field using Ytterbium.* Aust. J. Exp. Agric. 34:339-343.

Doreau, M., B. Michalet-Doreau, and G. Bechet. 2004. *Effect of underfeeding on digestion in cows. Interaction with rumen degradable N supply.* Livest. Prod. Sci. 88:33–41.

Ducker, M. J., P. T. Kendall, R. G. Hemingway, and T. H. McClelland. 1981. *An evaluation of feedblocks as a means of providing supplementary nutrients to ewes grazing upland/hill pastures.* Anim. Prod. 33:51-57.

Nolan, J. V., B.W. Norton, R. M. Murray, F. M. Ball, F. B. Roseby, W. Rohan-Jones, M. K. Hill, and R. A. Leng. 1975. *Body weight and wool production in grazing sheep given access to a supplement of urea and molasses: intake of supplement/response relationships.* J. Agric. Sci. 84: 39–48.

ACKNOWLEDGEMENTS:

This work was supported in part by the Bair Ranch Foundation, Billings, MT, and the Montana Agricultural Experiment Station.

Effects of Supplementation of Expired Human Foodstuffs on Intake and Digestion by Wethers Fed a Base Diet of Grass Hay and Alfalfa/Barley Pellets

by

D.L. Ragen[1], R.R. Redden[2], A.N. Hafla[3], B.M. Nichols[1], J.L. Nichols[1], J.I. Keithly[1], T.J. McDonald[1], J. Uhrig[1], L.A. Cook[1], A.L. Kellom[1], and P.G. Hatfield[1]

[1]Department of Animal and Range Sciences, Montana State University, Bozeman, MT; [2]Department of Animal Sciences, North Dakota State University, Fargo ND; [3]USDA-ARS, Pasture Systems & Watershed Management Research Unit, University Park, PA

IMPACT STATEMENT

There is potential for expired human foodstuffs to be used as an energy supplement for livestock. In our study, no particular treatment stood out as superior or inferior in digestibility or DMI compared to the whole barley diet. Expired human food products (macaroni, potato chips, and donuts) did not impact intake of low-quality forage or measures of digestibility. Using expired human foodstuffs as an energy supplement for livestock may be an expense-saving opportunity for producers, as well as a favorable disposal option for otherwise wasted products. Increasing production costs challenge livestock producers to investigate novel sources of feed. Expired human foodstuffs could provide an economical alternative to traditional energy supplements, without substantial negative impacts on intake or digestibility. Further studies on production parameters such as BW gain and feed efficiency in larger numbers of animals in different stages of production are warranted.

EFFECTS OF SUPPLEMENTATION OF EXPIRED HUMAN FOODSTUFFS ON INTAKE AND DIGESTION BY WETHERS FED A BASE DIET OF GRASS HAY AND ALFALFA/BARLEY PELLETS

by D.L. Ragen, R.R. Redden, A.N. Hafla, B.M. Nichols, J.L. Nichols, J.I. Keithly, T.J. McDonald, J. Uhrig, L.A. Cook, A.L. Kellom, and P.G. Hatfield

SUMMARY

There is potential for expired human foodstuffs to be used as an energy supplement for livestock. Sixteen crossbred wether lambs were used in a completely randomized design to investigate the effects of feeding supplemental expired human foodstuffs on DM, OM, ADF and NDF digestibility, and intake. Wethers were fed (DM basis) isocaloric amounts of the following treatments: whole barley served as the control (BAR: 0.44 lb·wether-1·d-1), potato chips (PC: 0.33 lb·wether-1·d-1), macaroni (MAC: 0.46 lb·wether-1·d-1), and donuts (DON: 0.33 lb·wether-1·d-1). Wethers were fed 1.32 lb·wether-1·d-1 alfalfa/barley pellets and allowed ad libitum access to chopped hay. Wethers were placed in confinement crates for a 7 d acclimation period, fitted with fecal bags on d 0 and fed twice daily. Following acclimation, daily intakes, refusals, and fecal outputs were used to determine DM, OM, fiber digestibility and intake. Measures of intake and digestibility did not differ ($P > 0.23$) among treatments. It is concluded that these expired human foodstuffs have the potential to be used in ruminant diets as an alternative to traditional feedstuffs.

INTRODUCTION

Every year, large quantities of retail food products are removed from the supply chain because they have expired. In 2001, more than $900 million of expired food was wasted (GMA, 2002). Forty percent of food in the United States goes uneaten, which is the equivalent of throwing $165 billion dollars into landfills (NRDC, 2012). In the last 10 years, barley, a common traditional energy supplement for livestock, has increased in price by 124% (NASS, 2012). As an alternative to expensive energy supplements, expired human foodstuffs may have the potential to be part of a ration for livestock, as well as provide an environmentally friendly method of disposal.

Sources of supplemental energy traditionally have included grains, readily digestible-fiber sources, and high-quality forages. The objective of this study was to compare daily intakes and digestibility of DM, OM, ADF, and NDF of sheep fed chopped hay and alfalfa/barley pellets and supplemented with expired human foodstuffs (macaroni, potato chips, and donuts).

PROCEDURES

All animal use procedures were approved by the Montana State University Animal Care and Use Committee (Protocol #1144). Sixteen crossbred wether lambs (Suffolk/Hampshire x Western white face; 6-mo-old; BW = 83.6 ± 4.4 lb) were used in a completely randomized design to investigate the effects of feeding supplemental expired human food on the intake and digestibility of treatment diets.

Treatments were: barley fed at 0.44 lb·wether-1·d-1 (BAR), potato chips fed at 0.33 lb·wether-1·d-1 (PC), macaroni fed at 0.46 lb·wether-1·d-1 (MAC), and donuts fed at 0.33 lb·wether-1·d-1 (DON), all on a DM basis. Treatments were formulated to be isocaloric based on NRC (1985) estimated TDN values for barley, brome grass hay, and alfalfa, and calculated TDN values of macaroni, donuts, and potato chips based on estimated nutrient content (USDA, 1999) (Tables 1 and 2). Wethers were allowed ad libitum access to chopped-grass hay and fed 1.32 lb·wether-1·d-1 of an 80% alfalfa, 20% barley pellet (DM basis) to insure adequate CP intake.

TABLE 1. Analysis of dietary components[1]

Item	Chopped hay	Alfalfa/barley pellets	Barley	Donuts	Macaroni	Potato Chips
DM, %	92.1	96.2	91.7	83.8	92.7	97.9
OM, %	91.2	89.5	98.6	98.1	99.1	94.9
NDF, %	58.8	48.2	20.3	5.4	8.4	3.8
ADF, %	40.5	37.6	16.9	4.7	7.6	3.0
CP, %	9.0	16.8	10.6	5.2	13.0	7.9
EE[2,3], %	1.0	1.3	1.8	28.5	1.7	33.0
TDN[2,4], %	58.1	68.3	88.0	118.7	85.4	119.4

1. All values presented on DM basis. Dietary composition was determined by analyzing subsamples collected and composited throughout the trial. Accuracy was ensured by adequate replication with acceptance of mean values that were within 5% of each other.
2. Values for Donut, Macaroni, and Potato Chips calculated based on energy values from National Nutrient Database for Standard Reference (USDA, 1999). Values for Chopped hay and Alfalfa/barley pellets taken from NRC (1985).
3. EE = ether extract.
4. TDN, %= (0.5 x %Crude Fiber) + (0.90 x %Nitrogen-Free Extract) + (0.75 x %Crude Protein) + (2.25 x 0.90 x %Ether Extract)

Wethers were housed in metabolism crates (30 in x 50 in), fitted with fecal bags at the beginning of the acclimation period, and allowed a 7 d period to acclimate to diets and environment. The study took place under 24 h light. Wethers were offered total respective treatments and a half ration of chopped hay (60% of previous day's intake) and 0.66 lb·wether-1·d-1 of alfalfa/barley pellets at 0600 h. The remaining chopped hay (60% of previous day's intake) and 0.66 lb·wether-1·d-1 of alfalfa/barley pellets were fed at 1600 h. Feed samples were taken daily, and each feedstuff was compiled over the 7 d period for later analysis. At the end of the 7 d trial, total fecal weights for each lamb were recorded, and a subsample of feces was gathered and composited by animal for determination of nutrient component analyses, DMI, OM intake, DM digestibility, NDF digestibility, and OM digestibility in vivo.

Daily intakes and digestibility of DM, OM, ADF, and NDF were calculated. Data were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, N.C.), with expired feedstuff as the fixed effect. Animal was considered the experimental unit. Differences among treatments were considered significant at $P < 0.10$.

RESULTS AND DISCUSSION

Three wethers were removed from the trial during the adaptation period, two from the MAC treatment and one from the PC treatment, due to inability to adjust to the research environment. Daily intakes of each treatment ingredient, alfalfa/barley pellets, and chopped hay are presented in Table 2. Wethers consumed all of the alfalfa/ barley pellets and treatment ingredients provided.

Total diet digestibility of DM, OM, NDF, and ADF is presented in Table 3. Measures of intake and digestibility did not differ ($P > 0.23$) among treatments. Compared to the BAR control treatment in our study, none of the expired foods impacted either measures of intake or digestibility when fed at an equivalent of 20% barley in the diet or the barley equivalent of 0.50% of BW.

The PC supplement contained the most fat (Table 1) of all the treatments, but did not negatively impact digestibility. Nutrient variation for by-product feeds, such as those examined in this study, can be considerable depending on factors, such as source, basal ingredients, and manufacturing processes.

TABLE 2. Actual amounts of feed ingredients consumed by wethers with ad libitum access to chopped hay and supplemented with isocaloric treatments and alfalfa/barley pellets (0.60 kg·wether1·d1)[1]

Item	BAR[2]	DON[3]	MAC[4]	PC[5]	SE
No. of wethers	4	4	2	3	—
Treatment DMI, lb[6]	0.44	0.33	0.46	0.31	—
Alfalfa/barley pellet DMI, lb[6]	1.32	1.32	1.32	1.32	0.000
Chopped hay DMI, lb[6]	0.75	0.95	1.10	0.90	0.056

1. All values presented on DM basis. Dietary composition was determined by analyzing subsamples collected and composited throughout the trial. Accuracy was ensured by adequate replication with acceptance of mean values that were within 5% of each other.
2. Fed barley at 0.44 lb·wether-1·d-1, alfalfa/barley pellets at 1.32 lb·wether-1·d-1, and ad libitum access to chopped hay.
3. Fed donuts at 0.33 lb·wether-1·d-1, alfalfa/barley pellets at 1.32 lb·wether-1·d-1, and ad libitum access to chopped hay.
4. Fed macaroni at 0.46 lb·wether-1·d-1, alfalfa/barley pellets at 1.32 lb·wether-1·d-1, and ad libitum access to chopped hay.
5. Fed potato chips at 0.33 lb·wether-1·d-1, alfalfa/barley pellets at 1.32 lb·wether-1·d-1, and ad libitum access to chopped hay.
6. Mean daily DMI over 1 wk trial.

TABLE 3. Diet digestibility of wethers fed alfalfa/barley pellets (0.66 kg·wether1·d1), expired human foodstuffs, and chopped hay (ad libitum access)

Item	BAR[1]	DON[2]	MAC[3]	PC[4]	SE
No. of wethers	4	4	2	3	—
Digestibility (%)					
DM	74.7	69.8	67.3	71.4	2.40
OM	76.1	71.1	69.0	72.6	2.32
NDF	62.9	58.1	59.3	63.8	4.02
ADF	62.4	55.0	52.7	59.1	4.24

1. Fed barley at 0.44 lb·wether-1·d-1, alfalfa/barley pellets at 1.32 lb·wether-1·d-1, and ad libitum access to chopped hay.
2. Fed donuts at 0.15 lb·wether-1·d-1, alfalfa/barley pellets at 1.32 lb·wether-1·d-1, and ad libitum access to chopped hay.
3. Fed macaroni at 0.21 lb·wether-1·d-1, alfalfa/barley pellets at 1.32 lb·wether-1·d-1, and ad libitum access to chopped hay.
4. Fed potato chips at 0.15 lb·wether-1·d-1, alfalfa/barley pellets at 1.32 lb·wether-1·d-1, and ad libitum access to chopped hay.

REFERENCES

GMA. 2002. Unsaleables Benchmark Report. Food Marketing Institute and Food Distributors International. http://www.gmaonline.org/downloads/research-and-reports/expiredproducts.pdf (Accessed October 26, 2012).

NASS. 2012. Field Crops: Barley, national statistics, price per unit. http://www.nass.usda.gov/QuickStats/index2.jsp (Accessed October 25, 2012).

NRC. 1985. *Nutrient Requirements of Sheep 6th ed*. The National Academies Press. Washington DC.

NRDC. 2012. Wasted: How America is losing up to 40% of its food from farm to fork to landfill. http://www.nrdc.org/food/files/wasted-food-IP.pdf (Accessed March 25, 2013).

USDA. 1999. Database for Standard Reference. United States Department of Agriculture, Agricultural Research Service. USDA Nutrient, Release 13. Nutrient Data Laboratory. http://www.ars.usda.gov/main/site_main.htm?modecode=12-35-45-00 (Accessed March 26, 2013)

AKNOWLEGMENTS

Project was funded by the Montana Agricultural Experiment Station.

The Impact of Supplemental Salt Form, Diet, and Feeding Location on Salt Intake in Weaned Lambs

by

D.L. Ragen[1], M.R. Butler[1], J.L. Weeding[2], and P.G. Hatfield[1]

[1]Department of Animal and Range Sciences, Montana State University, Bozeman, MT, and [2]Department of Mathematical Sciences, Montana State University, Bozeman, MT

IMPACT STATEMENT

Previous research has reported high variation in intake of self-fed protein and/or energy supplements by livestock, however little is known about variation in consumption of salt. Sheep that are salt deprived will consume less feed and water. However, the overconsumption of salt by sheep can have detrimental effects including reduced feed intake and a decline in body weight. This project investigates the impact of form of salt, location of feeding, and type of feed on salt intake in weaned lambs. The results of this study will aid feed companies in formulating salt, mineral, and feed rations that help meet sheep nutritional requirements.

THE IMPACT OF SUPPLEMENTAL SALT FORM, DIET, AND FEEDING LOCATION ON SALT INTAKE IN WEANED LAMBS

by D.L. Ragen, M.R. Butler, J.L. Weeding, and P.G. Hatfield

SUMMARY

The objective of this study was to determine the effect of finishing diet (alfalfa based vs. barley based), feeding location (sheltered confinement vs. open stubble ground) and salt form (loose vs. block) on salt intake in weaned lambs. No two- or three-way interactions were detected ($P > 0.05$). Therefore results are presented as the main effects of feeding location, diet, and salt form over the two-year study period. Sheep housed in pens consumed 0.007 oz•lamb-1•d-1 more ($P < 0.01$) salt than sheep fed on wheat stubble fields. In addition, sheep feed loose salt consumed, 0.006 oz•lamb-1•d-1 more ($P < 0.01$) salt than sheep offered block salt. The type of diet did not impact ($P = 0.91$) salt consumption.

INTRODUCTION

Previous research has reported high variation in intake of self-fed mineral supplements by sheep (Ragen et al. 2014). However little is known about the differences in the intake of plain salt by sheep. All livestock have an innate attraction to salt and this behavior is used to supplement animals with trace minerals (Burghardi, 1982). Sheep that are salt deprived will consume less feed and water. However, the overconsumption of salt by sheep can result in reduced feed intake and a decline in body weight (Peirce, 1957).

In a review of salt appetite, Denton (1967) noted that all mammals have the ability to taste salt, and there is a universal liking for it. Burghardi et al. (1982) concluded that the palatability of minerals and the hardness of supplement blocks were among the main factors accounting for differences in the amount consumed by lambs.

Rocks et al. (1982) found that the intake of granulated salt by individual grazing sheep was consistently greater, and appeared more uniform, than the intake of the same material compressed into blocks. The use of loose instead of compressed salt has a substantial advantage in cost per unit. Providing a supplement in block form has the advantages of convenience, much greater resistance to rain and dew, and assured uniformity of any additives in the salt mixture. The control of excessive intakes by the use of blocks may be a significant advantage (Rocks et al., 1982). Hagsten et al. (1975) reported the optimal dietary feeding level of salt for growing lambs to be 0.39% of the ration. However, no research has addressed intake of salt and as impacted by the interaction of form of salt, type of diet, and location of feeding.

PROCEDURES

Sheep Selection and Management. All animal procedures were approved by the Montana State University Agricultural Animal Care and Use Committee (Protocol #2013-AA04). Ninety crossbred lambs (ewes and wethers; Blackface x Western whiteface; 6-mo-old; BW = 76.8 ± 12.7 lb) and 18 Targhee lambs (ewes; 6-mo-old; BW = 85.4 ± 6.9 lb) were used in year 1 (September 25 to November 25, 2013) of the study. Targhee ewe lambs were used because of insufficient number of crossbred lambs in year 1. One hundred and eight crossbred lambs (ewes and wethers; Blackface x Western whiteface; 5-mo-old; BW = 70.0 ± 10.3 lb) were used in year 2 (September 3 to November 3, 2014) of the study. On d 0 all lambs were placed in a dry lot pen and held off of feed and water overnight. On d 1 lambs were weighed, and paint-branded for identification purposes. Lambs were then stratified by BW and allocated to treatments. Treatments were 1) feed location (confinement pens vs. wheat stubble fields) 2) Finishing diet (alfalfa based pelleted diet vs. a barley based pelleted diet) and 3) form of salt (loose vs. block) (Table 1). Electronic ID tags (Allflex USA, Inc., Dallas-Ft. Worth, TX) were attached to the exterior of the left ear on lambs allocated to confinement pens for the measurement of individual feed and salt intake with the GrowSafe feed intake system (GrowSafe Systems Ltd., Airdrie, AB, Canada). Weaned lambs fed the barley-based pelleted diet were stepped up to the high grain ration over a period of 20 days. For lambs fed the finishing diets on wheat stubble fields, diet and salt consumption was measured by the amount offered of each minus amount refused at the end of the study period.

All lambs had ad libitum access to their finishing diet (alfalfa or barley pellets), salt supplement (block or loose), and water. The GrowSafe feed intake system was used in the confinement pens (23 ft × 37 ft). Elevated platforms and false bottoms were constructed to modify GrowSafe beef cattle stanchions and feed bunks (2.6 ft × 3.3 ft), respectively, for sheep. Finishing rations and salt were offered

TABLE 1. Treatment

Location	Feed	Salt Form
Pen	Barley	Loose
Pen	Barley	Block
Pen	Alfalfa	Loose
Pen	Alfalfa	Block
Field	Barley	Loose
Field	Barley	Block
Field	Alfalfa	Loose
Field	Alfalfa	Block

in separate GrowSafe bunks in each confinement pen so that individual feed and salt intake could be recorded for each lamb. Feed allowances were checked and more feed offered daily at 0800 and 1700 h. Daily feed and salt intake was computed using the Process Intakes and Export Behavior Data routine of the GrowSafe Data Acquisition software.

In the wheat stubble fields (50 ft × 145 ft), pellet feeders, salt feeders and water troughs were placed in the fields and moved twice during the study to allow for more even manure distribution addressed in a companion study. There was one pellet feeder and salt feeder per six lambs. The salt feeders were raised off the ground and protected from rain and wind so the salt was not lost or wasted. The pellet feeders were also raised off the ground and mostly protected from rain and wind; however, in inclement weather some of the pellets in the bunk became wet but were still consumed by the lambs.

Salt. The salt offered in this study was American Stockman brand with a guaranteed analysis of 98.0% to 99.9% Sodium Chloride. For year 1, salt was weighed on d 0, 19, 33, 46 and 53. For year 2, salt was weighed on d 0, 31, 45, and 60. All lambs had access to a salt/mineral mixture prior to the study. At the end of the study, the remaining salt was removed from the feeders, weighed, and salt disappearance was recorded.

Statistical Analyses. All statistical analyses were performed in R statistical software (ver. 2.4; R Development Core Team 2011, Vienna, Austria). All lambs on a particular treatment were housed in one pen but were stratified by BW and randomly assigned to one of the experimental units within the pen. The model included the effect of treatment. The response variable was salt intake. A two-way ANOVA model was originally fit, including a three-way interaction for the location the sheep were housed (pen or field), the form the salt was provided (loose or block), and the type of feed (alfalfa or barley) the sheep were consuming. Also included were all two-way interactions for average feed intake (feed intake by location, feed intake by salt form, and feed intake by type of feed). The full model was reduced sequentially, where the term with the largest P-value ($P > 0.05$) was removed at each step. This process was continued until all terms had $P < 0.05$. The final model was a two-way additive ANOVA model containing effects for the location the sheep were housed and for the form the salt was offered.

RESULTS AND DISCUSSION

Salt Intake. There were no two- or three-way interactions detected; therefore main effects are presented in Table 2. Sheep housed in pens consumed 88% more ($P < 0.01$) salt on a daily basis than sheep located on fields. In addition, sheep fed loose salt consumed 76% more ($P < 0.01$) salt per day than sheep offered block salt. The type of finishing diet had no impact on salt intake. Salt intake by lambs in our study ranged from 0.006 to 0.016% of the diet and therefore lambs did not consume recommended levels of salt (Hagsten et al., 1975).

Feed companies may use these results in formulating salt, mineral, and feed rations that help meet nutritional requirements for sheep based on producers' specific enterprises.

REFERENCES

Burghardi, S. R., R. D. Goodrich, J. C. Meiske, M. L. Thonney, D. H. Theuninck, T. S. Kahlon, D. E. Pamp, and K. Kraiem. 1982. *Free choice consumption of minerals by lambs fed calcium-adequate or calcium-deficient diets.* J. Anim. Sci. 54: 410-418.

Denton, D. A. 1967. *Salt appetite.* Handbook of Physiology I. Am. Physiological Society, Washington, DC.

Hagsten, I., T. W. Perry, and J. B. Outhouse. 1975. *Salt requirements of lambs.* J. Anim. Sci. 42: 1187-1190.

Peirce, A. W. 1957. *Studies on salt tolerance of sheep. I. The tolerance of sheep for sodium chloride in the drinking water.* Aust. J. of Agric. Res. 8(6):711-722.

TABLE 2. Salt intake by weaned lambs[1]

Item	Treatment						SE	*P*-value		
	Location		Feed		Salt Form					
	Pen[2]	Field[3]	ALF[4]	BAR[5]	Loose[6]	Block[7]		Pen vs. Field	ALF vs. BAR	Loose vs. Block
Average Salt Intake, oz•lamb[1]•d[1]	0.011	0.004	0.007	0.008	0.010	0.005	0.04	< 0.01	0.91	< 0.01

1. No two- or three-way interactions were detected for location, feed or salt form.
2. Pen = Sheltered confinement.
3. Field = Wheat stubble field.
4. ALF = pellet containing 71% alfalfa, 18% barley, 5% molasses, 0.013% Bovatec, and 6.1% vitamin/mineral package (no salt).
5. BAR = pellet containing 60% barley, 26% alfalfa, 4% molasses, 4% bentonite, 2.5% soybean-hi pro, 0.016% Bovatec, and 7.4% vitamin/mineral package (no salt).
6. Loose = Plain white granulated salt. American Stockman brand with a guaranteed analysis of 98.0% to 99.9% Sodium Chloride.
7. Block = Plain white 22.7-kg block salt. American Stockman brand with a guaranteed analysis of 98.0% to 99.9% Sodium Chloride.

Peirce, A. W. 1957. *Studies on salt tolerance of sheep. I. The tolerance of sheep for sodium chloride in the drinking water*. Aust. J. of Agric. Res. 8(6):711-722.

Ragen, D. L., E. E. Nix, R. L. Endecott, P. G. Hatfield, M. K. Petersen, and J.G.P. Bowman. 2014. *Individual mineral supplement intake by ewes swath grazing or confinement fed pea-barley forage.* Anim. Feed Sci. Technol. 200:107-111.

Rocks, R. L., J. L. Wheeler, and D. A. Hedges. 1982. *Labelled waters of crystallization in gypsum to measure the intake by sheep of loose and compressed mineral supplements.* Aust. J. Exp. Agric. Anim. Husb. 22:35-42.

ACKNOWLEDGEMENTS:

The authors acknowledge financial support from the Montana Agricultural Experiment Station.

Emergence and Growth of Tall Buttercup *(Ranunculus Acris L.)* Seedlings Along a Soil Moisture Gradient

by

H. Strevey and J. Mangold

Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT

IMPACT STATEMENT

Moisture appears to play a large role in tall buttercup recruitment and growth. Because soil moisture availability can be manipulated through irrigation practices, hay producers may have a non-chemical option for reducing current and future infestations of this invasive, toxic forb.

EMERGENCE AND GROWTH OF TALL BUTTERCUP *(RANUNCULUS ACRIS L.)* SEEDLINGS ALONG A SOIL MOISTURE GRADIENT

by H. Strevey and J. Mangold

SUMMARY

We conducted a greenhouse study to investigate the influence of soil moisture on emergence and growth of tall buttercup (Ranuculus acris, L.), a non-native invasive perennial forb that invades moist pastures, grasslands, and irrigated meadows. Tall buttercup seeds were planted into pots where soil moisture was maintained at 25%, 50% or 100% field capacity and allowed to grow for about two months. At the end of two months, tall buttercup seedling emergence, height, number of leaves, and biomass were measured. Tall buttercup emergence and growth was optimal in field capacities of 50% to 100%. Results suggest altering irrigation amount or timing should be considered as a management tool to reduce or eliminate tall buttercup infestations.

INTRODUCTION

Tall buttercup *(Ranunculus acris L.)* is a perennial, invasive forb that occurs in moist habitats including pastures, grasslands, and flood or sub-irrigated meadows (Lamoureaux and Bourdôt 2007). It is native to central and northern Europe (Coles 1971) and has spread to parts of northern North America (Bourdôt et al. 2013). Tall buttercup can displace pasture grasses and clovers (Conner 1977) and is cause for concern due to its toxicity to livestock, especially cattle. In Montana it has invaded over 8300 hectares and was listed as a priority 2A noxious weed in 2003 (Montana Noxious Weed Summit Advisory Council 2008).

Tall buttercup has been predominantly troublesome in western Montana in flood and sub-irrigated hayfield meadows. Irrigation may create conditions conducive to tall buttercup growth and survival (Bourdôt et al. 2013), but the amount of moisture required for optimal seedling emergence and growth has not been explored. Understanding the importance of soil moisture on seedling recruitment will aid in the development of effective management strategies.

PROCEDURES

We conducted a greenhouse study to assess seedling emergence and growth along a gradient of soil moisture. We collected seed from tall buttercup growing in flood and sub-irrigated hayfields near Twin Bridges, MT, planted them in soil in 2 liter pots, and subjected them to three soil moisture treatments including 25, 50, and 100 percent field capacity. Each soil moisture treatment was replicated 12 times, and soil moisture treatments were maintained throughout the study. After 65 days, tall buttercup seedlings in each pot were counted and measured (height, number of leaves, biomass).

RESULTS AND DISCUSSION

Tall buttercup seedling emergence, height, number of leaves, and biomass were all affected by soil moisture (Table 1). Seedling emergence was lowest in the 25% field capacity treatment where 18% of the seeds emerged. The 50% and 100% field capacity treatments resulted in similar seedling density with 40% and 36% of the seeds emerging as seedlings. All three soil moisture treatments resulted in different seedling heights. The 50% field capacity treatment had the tallest seedlings followed by the 100% field capacity treatment and 25% field capacity treatment. Treatments also affected the number of leaves on tall buttercup seedlings. The lowest number of seedling leaves was from the 25% field capacity; the 50% and 100% field capacity treatments resulted in similar tall buttercup seedling leaf numbers. Finally, biomass was affected by soil moisture treatments. The 50% field capacity treatment had the highest seedling biomass followed by the 100% field capacity treatment followed by the 25% field capacity treatment.

Seedling emergence and growth are critical stages of plant development that result in recruitment of new individuals in plant communities (Fay and Schultz 2009). Both are sensitive to environmental variability and require certain soil moisture conditions (Fay and Schultz 2009). While it has been observed that suitable habitat for tall buttercup encompasses areas of high soil moisture content (Lamoureaux and Bourdôt 2007), prior to this study there was no data on the influence of soil moisture on tall buttercup seedling recruitment. In our study, soil moisture

TABLE 1. Tall buttercup average emergence and seedling height, number of leaves, and biomass as affected by soil moisture treatments

Soil Moisture Treatment	Emergence (%)	Height (cm)	Number of Leaves	Biomass (g)
25% field capacity	18[a]	0.8 ± 0.2[a]	1.2 ± 0.3[a]	0.009 ± 0.001[a]
50% field capacity	40[b]	6 ± 0.3[c]	5.7 ± 0.4[b]	0.2 ± 0.03[c]
100% field capacity	36[b]	4 ± 0.5[b]	4.0 ± 0.6[b]	0.1 ± 0.02[b]

a-c. Means with similar letters within a measured parameter (i.e. emergence, height, number of leaves, biomass) are statistically similar to each other ($\alpha = 0.05$).

affected all tall buttercup seedling response variables including seedling emergence, height, leaf number and biomass. Our results indicate that tall buttercup emergence and growth was optimal in field capacities of 50% to 100%, and minimal in drier conditions. Bourdôt et al. (2013) reported that without irrigation, habitat for the species declines in areas that do not receive sufficient rainfall. Flood and sub-irrigation management practices in western Montana with problematic tall buttercup infestations could be playing a role in the species' ability to persist.

Tall buttercup seedling emergence was generally low. Even with soil moisture at 50 and 100% field capacity, emergence was 40% and 36%, respectively. It is possible that the viability of seeds used in this study was relatively low. Thompson and Grime (1983) stated that tall buttercup seeds need exposure to warm, moist conditions in order to germinate. In the same study they found that a similar species, Ranunculus repens, requires fluctuating temperatures for optimal germination in the light. For this study, seeds were collected in late July and were stored at room temperature (23.5 degrees C) until planted in October. Seed storage and greenhouse conditions throughout the study may not have been optimal to achieve a higher seedling density than what was observed. However, because all seeds were stored in similar conditions, any reduction in seedling emergence due to seed viability was equal across treatments.

He and others (1999) found that in river floodplains tall buttercup thrives in the zone with approximately 30 days of flooding per year. Further, they observed that it is more resistant to flooding than other Ranunculus species. However, while tall buttercup is tolerant of flooding, perhaps mature tall buttercup plants can withstand long periods of flooding more so than seedlings. While seedling emergence from the 100% field capacity treatment was similar to the 50% field capacity treatment, seedling height and biomass were lower. Seedlings from the 100% field capacity treatment also showed signs of stress from overwatering including chlorosis. In comparison, seedlings from the 50% field capacity treatment had leaves that were a dark green color and were overall visibly healthier. Lower seedling biomass in the 100% field capacity treatment compared to the 50% field capacity treatment is indicative of plants having different requirements for emergence compared to growth following emergence (Lloret et al. 2004). It was not surprising that seedling biomass was lowest at 25% field capacity as previous research has shown tall buttercup to be poorly tolerant of drought (Sarukhan 1974).

Understanding how both tall buttercup seedling emergence and established seedlings respond to varying soil moisture conditions helps to understand how soil moisture may affect recruitment into a plant communities by this species (Fay and Schultz 2009). Further research could test tall buttercup seedling emergence and establishment at varying moisture conditions ranging from 30% and 100% field capacity both in the field and under controlled conditions in the greenhouse. Moisture conditions could be altered after the seedlings are established to understand how tall buttercup seedling growth may be positively or negatively influenced by the amount of moisture in the soil. Studies could also explore the differences in tall buttercup emergence and growth in simulated flood or sub-irrigation conditions versus overhead irrigation.

Integrated management with herbicides and other tools like mowing and fertilizer have resulted in site-specific outcomes (Strevey 2014). These results suggest altering irrigation amount or timing should be considered as a management tool to reduce or eliminate tall buttercup infestations. Removing flood or sub-irrigation practices for one to two years may be enough to eliminate tall buttercup infestations since studies have shown that tall buttercup does not typically accumulate a long-lasting seed bank (Champness and Morris 1948, Harper 1957, Sarukhan 1974). If altering irrigation practices eliminates current infestations of tall buttercup, it is possible that after a few years the tall buttercup seed bank would be depleted and irrigation practices could be reinstated with minimal growth of remaining viable seeds in the seedbank.

REFERENCES

Bourdôt, G. W., S. L Lamoureaux, M. S. Watt, and D. J. Kriticos. 2013. *The potential global distribution of tall buttercup (Ranunculus acris ssp. Acris): Opposing effects of irrigation and climate change.* Weed Sci. 61: 230-238.

Champness, S. S. and K. Morris. 1948. *The population of buried viable seeds in relation to contrasting pasture and soil types.* J. Ecol. 36: 149-173.

Coles, S. M. 1971.*The Ranunculus acris L. complex in Europe.* Watsonia 8: 237-261.

Conner, H. E. 1977. *The Poisonous Plants in New Zealand.* NZ DSIR, E.C. Keating Government Printer, Wellington.

Fay, P. and M. Schultz. 2009. *Germination, survival, and growth of grass and forb seedlings: Effects of soil moisture variability.* Acta Oecologica 35: 679-684.

Harper, J. L. 1957. *Biological flora of the British Isles: Ranunculus acris L., R. repens L., R. bulbosus L.* J. Ecol. 45: 289-342.

He, J. B., G. M. Bogemann, H. M. van de Steeg, J. G. H. M., Rijnders, L. A. Voesenec, and C. W. Blom. 1999. *Survival tactics of Ranunculus species in river floodplains.* Oecologia 118: 1-8.

Lamoureaux, S. and G. W. Bourdôt. 2007. *A review of the ecology and management of Ranunculus acris L. in pasture.* Weed Res. 47: 461-471.

Lloret, F., J. Penuelas, and M. Estiarte. 2004. *Experimental evidence of reduced diversity of seedlings due to climate modification in a Mediterranean-type community.* Glob. Change Biol. 10: 248-258.

Montana Noxious Weed Summit Advisory Council. 2008. Montana Weed Management Plan. Montana Department of Transportation, Helena.

Sarukhan, J. 1974. *Studies on plant demography: Ranunculus repens L., R.bulbosus L. and R. acris L. II. Reproductive strategies and seed population dynamics.* J. Ecol. 62: 151-177.

Strevey, H. K. 2014. The ecology and integrated management of tall buttercup (Ranunculus acris L.). MS thesis. Montana State Univ., Bozeman.

Thompson, K. and J. P. Grime. 1983. *A comparative study of germination responses to diurnally-fluctuating temperatures.* J. Appl. Ecol. 20: 141-156.

Impacts from Winter-Early Spring Elk Grazing in Foothills Rough Fescue Grassland

by

T.M. Thrift[1], T.K. Mosley[2], and J.C. Mosley[3]

[1]Bureau of Land Management, Bruneau Field Office, Boise, ID; [2]Park County Extension, Montana State University Extension, Livingston, MT; and [3]Department of Animal and Range Sciences, Montana State University, Bozeman, MT

IMPACT STATEMENT

Periodic rest from wildlife or livestock grazing during winter-early spring (mid-November through April) is necessary to sustain native perennial bunchgrasses in foothills rough fescue grasslands. The frequency of rest needed is unknown but is no more often than once every 4 years.

IMPACTS FROM WINTER-EARLY SPRING ELK GRAZING IN FOOTHILLS ROUGH FESCUE GRASSLAND

by T.M. Thrift, T.K. Mosley, and J.C. Mosley

SUMMARY

Foothills rough fescue *(Festuca campestris)* grasslands provide important foraging habitat for wildlife and livestock in the northwestern United States and southwestern Canada. Foothills rough fescue is a perennial bunchgrass that is sensitive to grazing during late spring-early summer but is believed to be more tolerant of grazing during winter-early spring. We evaluated vegetation and soil impacts from long-term winter-early spring grazing at 2 intensities (HG = heavy grazing, LG = light grazing). We studied a foothills rough fescue grassland in west central Montana that had been grazed almost exclusively by Rocky Mountain elk during winter-early spring for 58 years. Foothills rough fescue tolerated LG but not HG, whereas bluebunch wheatgrass (Pseudoroegneria spicata) and Idaho fescue (Festuca idahoensis) did not tolerate either LG or HG. Decreased productivity of foothills rough fescue in HG was accompanied by decreased herbaceous ground cover and increased abundance of the invasive dense clubmoss (Selaginella densa). Soil bulk density was 18% greater in HG vs. LG, and the topsoil was 20% thinner in HG. Overall, our results indicated that long-term elk grazing during winter-early spring degraded this grassland, and we concluded that periodic rest from wildlife or livestock grazing during winter-early spring is necessary to sustain foothills rough fescue grasslands.

INTRODUCTION

Foothills rough fescue *(Festuca campestris)* grasslands provide important wildlife and livestock foraging habitat in foothills and mountains of the northwestern U.S. and southwestern Canada. In Montana, potential natural plant communities of these grasslands are dominated by foothills rough fescue, a native, perennial bunchgrass. Bluebunch wheatgrass (Pseudoroegneria spicata) and Idaho fescue (Festuca idahoensis) are native, perennial bunchgrasses that often co-occur with foothills rough fescue.

The common name for foothills rough fescue was previously "buffalo bunchgrass" because it was the primary winter forage for bison on foothill grasslands in the Northern Rocky Mountains (Fryxell 1928; USDA-Forest Service 1937; Johnston and MacDonald 1967; Dormaar and Willms 1990). Foothills rough fescue is believed to have evolved with heavy grazing by bison during winter, which belief fostered misconceptions that foothills rough fescue was tolerant of heavy grazing during other seasons (Johnston and MacDonald 1967). Several studies have documented that foothills rough fescue does not tolerate heavy grazing during late spring or early summer (Johnston et al. 1971; McLean and Wikeem 1985b; Willms et al. 1985, 1988). Co-occurring bluebunch wheatgrass and Idaho fescue also do not tolerate heavy grazing during late spring or early summer (McLean and Wikeem 1985a; Willms et al. 1988; Brewer et al. 2007).

In contrast, light or moderate grazing intensities in late spring or early summer are sustainable for foothills rough fescue and co-occurring bluebunch wheatgrass and Idaho fescue, provided that defoliation does not occur more frequently than 2 successive years (McLean and Wikeem 1985a, 1985b; Willms et al. 1985, 1988; Brewer et al. 2007)

Grazing by wildlife or livestock during winter plant dormancy or early spring is generally believed to impact foothills rough fescue grasslands much less than grazing later in the growing season (McLean and Tisdale 1972; Brewer et al. 2007). However, sustainable thresholds of winter-early spring grazing intensity and frequency have not been established for foothills rough fescue grasslands.

PROCEDURES

We evaluated vegetation, ground cover, and soil effects of long-term winter-early spring grazing at two intensities (HG = heavy grazing, LG = light grazing). Our study area was a foothills rough fescue grassland near Augusta, Montana, that had been grazed almost exclusively by Rocky Mountain elk during winter-early spring for 58 years. Four LG study sites and 4 HG study sites were randomly selected using GIS. Long-term data records documented that elk grazing use of foothills rough fescue averaged 30% in LG sites and 68% in HG sites. Our 8 study sites had the same slope, aspect, elevation, soils, and potential natural plant community. The 8 sites differed only in their long-term elk grazing intensity during winter-early spring (LG vs. HG).

Study sites were sampled for 2 consecutive years during July. We measured plant vigor of foothills rough fescue, Idaho fescue, and bluebunch wheatgrass; plant canopy cover; herbaceous plant yield; ground cover; soil bulk density; and the thickness of the topsoil (i.e., Ah soil horizon).

RESULTS AND DISCUSSION

Grazing responses of the dominant perennial grasses in this foothills rough fescue grassland varied among species. Every measure of foothills rough fescue plant vigor and productivity was lower in HG than in LG. Also, the relative amount of foothills rough fescue in the plant community was less in HG than in LG (3% in HG vs. 38% in LG), and the relative amount in LG compared favorably with relict sites (38% in LG vs. 38% in relict sites; Mueggler and Stewart 1980). Bluebunch wheatgrass and Idaho fescue were slightly less productive in HG than in LG, but the amounts present in our study sites were much lower than in relict sites. Bluebunch wheatgrass comprised 13% of LG and HG plant communities compared with 26% in relict sites (Mueggler and Stewart 1980), whereas Idaho fescue comprised 7% in LG and HG sites compared with 15% in relict sites (Mueggler and Stewart 1980). Overall, foothills rough fescue tolerated long-term LG during winter-early spring but not HG, while bluebunch wheatgrass and Idaho fescue did not tolerate either long-term LG or HG during winter-early spring.

Herbaceous plant ground cover was much less in HG than in LG (30% vs. 51%, respectively), and clubmoss ground cover was dramatically greater in HG than in LG (31% vs. < 1%, respectively). Relative abundance of clubmoss generally increases on Montana rangeland when grazing pressure is excessive (Dolan and Taylor 1972). Herbaceous plant ground cover lost under HG during winter-early spring was apparently replaced largely by clubmoss. Soil bulk density was 18% greater in HG than in LG, and the topsoil was 20% thinner in HG than in LG.

Our results indicate that long-term elk grazing during winter-early spring degraded the vegetation, ground cover, and soils of this foothills rough fescue grassland. Our results add to the small but growing body of literature that documents wild ungulate overgrazing effects on soils and herbaceous vegetation in western North America (Zeigenfuss et al. 2002; Best and Bork 2003; Binkley et al. 2003; Rexroad et al. 2007; Gass and Binkley 2011). Our results also indicate that periodic rest from HG during winter-early spring is necessary to sustain foothills rough fescue, and periodic rest from either LG or HG during winter-early spring is necessary to sustain bluebunch wheatgrass and Idaho fescue. The frequency of rest is unknown but is no more often than once every 4 years for bluebunch wheatgrass (Brewer et al. 2007). Complete details about our study are published in Thrift et al. (2013).

REFERENCES

Best, J.N., and E.W. Bork. 2003. *Using transplanted plains rough fescue (Festuca halli [Vasey] Piper) as an indicator of grazing in Elk Island national Park, Canada.* Natural Areas Journal 23:202-209.

Binkley, D., F. Singer, M. Kaye, and R. Rochelle. 2003. *Influence of elk grazing on soil properties in Rocky Mountain National Park*. Forest Ecology and Management 185:239-247.

Brewer, T.K., J.C. Mosley, D.L. Lucas, and L.R. Schmidt. 2007. *Bluebunch wheatgrass response to spring defoliation on foothill rangeland.* Rangeland Ecology and Management 60:498-507.

Dolan, J.J., and J.E. Taylor. 1972. *Residual effects of range renovation on dense clubmoss and associated vegetation.* J. Range Management 25:32-37.

Dormaar, J.F., and W.D. Willms. 1990. *Sustainable production from the rough fescue prairie.* J. Soil and Water Conservation 45:137-140.

Fryxell, F.M. 1928. *The former range of the bison in the Rocky Mountains.* J. Mammalogy 9:129-139.

Gass, T.M., and D. Binkley. 2011. *Soil nutrient losses in an altered ecosystem are associated with native ungulate grazing.* J. Applied Ecology 48:952-960.

Johnston, A., J.F. Dormaar, and S. Smoliak. 1971. *Long-term grazing effects on fescue grassland soils.* J. Range Management 24:185-188.

Johnston, A., and M.D. MacDonald. 1967. *Floral initiation and seed production in Festuca scabrella Torr.* Can. J. of Plant Science 47:577-583.

McLean, A., and E.W. Tisdale. 1972. *Recovery rate of depleted range sites under protection from grazing.* J. Range Management 25:178-184.

McLean, A., and S. Wikeem. 1985a. *Influence of season and intensity of defoliation on bluebunch wheatgrass survival and vigor in British Columbia.* J. Range Management 38:21-26.

McLean, A., and S. Wikeem. 1985b. *Rough fescue response to season and intensity of defoliation.* J. Range management 38:100-103.

Mueggler, W.F., and W.L. Stewart. 1980. *Grassland and shrubland habitat types of western Montana.* USDA Forest Service General Technical Report INT-66.

Rexroad, E.A., K.H. Beard, and A. Kulmatiski. 2007. *Vegetation responses to 35 and 55 years of native ungulate grazing in shrubsteppe*. Western North American Naturalist 67:16-25.

Thrift, T.M., T.K. Mosley, and J.C. Mosley. 2013. *Impacts from winter-early spring elk grazing in foothills rough fescue grassland.* Western North American Naturalist 73:497-504.

USDA-Forest Service. 1937. Range plant handbook. US Government Printing Office, Washington, DC.

Willms, W.D., J.F. Dormaar, and G.B. Schaalje. 1988. *Stability of grazed patches on rough fescue grasslands.* J. Range Management 41:503-508.

Willms, W.D., S. Smoliak, and J.F. Dormaar. 1985. *Effects of stocking rate on rough fescue grassland vegetation.* J. Range Management 38:220-225.

Zeigenfuss, L.C., F.J. Singer, S.A. Williams, and T.L. Johnson. 2002. *Influences of herbivory and water on willow in elk winter range*. J. Wildlife Management 66:788-795.

ACKNOWLEDGMENTS:

Authors gratefully acknowledge Josh Bilbao, Stephanie Keep, Merrita Fraker-Marble, Heidi Crum, Brent Roeder, Jamie Saxton, Stephanie Sever, and Brian Thrift for assistance with field sampling; Jon Siddoway for assistance with ecological site descriptions; and Rachel Frost for assistance with statistical analyses. Research was funded by the USDA Joe Skeen Institute for Rangeland Restoration and the Montana Agricultural Experiment Station.

Impacts of Feeding Rumensin® to Growing Bull Calves

by

M.L. Van Emon[1], B. Shipp[2], and A. Roberts[2]

[1]Department of Animal and Range Sciences, Montana State University, Bozeman, MT, and [2]USDA-ARS Fort Keogh Livestock and Range Research Laboratory, Miles City, MT

IMPACT STATEMENT

Rumensin is primarily fed to feedlot cattle to improve feed efficiency. However, little information is available on feeding rumensin to growing bull calves when developed in the feedlot. This research has the potential to have a large impact on producers developing bulls in the feedlot by improving growth and feed efficiency. Therefore, this research may lead to improvements in bull development and reduce the time needed for development.

IMPACTS OF FEEDING RUMENSIN® TO GROWING BULL CALVES

by M.L. Van Emon, B. Shipp, and A. Roberts

SUMMARY

The objective of the trial was to determine the impacts of feeding rumensin to bull calves on postweaning development and carcass measurements. Bull calves were stratified by BW into one of two treatments: control, no rumensin (CON, n = 3) or rumensin, which fed 0.2 lb/hd/d (RUM, n = 3). There was no difference (P ≥ 0.17) in DMI or IMF due to dietary treatment. Bull calves fed RUM had greater (P ≤ 0.006) off test BW, ADG, REA, and backfat compared with bull calves fed CON. Bull calves fed RUM required less (P = 0.003) pounds of feed per pound of gain than CON bull calves. In conclusion, feeding rumensin to bull calves improves weight gain and feed efficiency, which could reduce the time and feed needed for bull development.

INTRODUCTION

Feed is the number one cost for livestock producers. More efficient cattle in converting feed to pounds of gain will reduce feed costs. Rumensin® (Elanco Animal Health, Greenfield, IN) is primarily fed to feedlot cattle to improved feed efficiency and growth and as a preventative and control of coccidiosis. Data summarized by Goodrich et al. (1984) determined that cattle fed monensin gained 1.6% faster and consumed 6.4% less feed compared with cattle not fed monensin. However, minimal research has been conducted on the impacts of feeding rumensin to growing bulls. Boucqué et al. (1982) did not observe any differences in live weight gain, final BW, or carcass measurements in mature Belgian white-blue bulls fed a diet with or without monensin-sodium. Therefore, the objective of this research is to determine if the impacts of feeding rumensin to bull calves during development will alter feedlot performance and carcass parameters.

PROCEDURES

All animal procedures were approved by the USDA-ARS Fort Keogh institutional animal care and use committee.

Animals and Experimental Design. One hundred and sixty-seven and 185 Red Angus crossbred bull calves in years 1 and 2, respectively, were used to determine the impacts of feeding rumensin to bull calves on postweaning development and ultrasound carcass characteristics. Bulls were stratified by BW into one of two treatments: control, no rumensin (CON, n = 3) or rumensin, which fed 0.2 lb/hd/d (RUM, n = 3). The trial lasted 167 days in both years, with rumensin being fed during the entire trial period to bulls fed RUM. Body weights (BW) and hip heights were collected on consecutive days at the beginning and end of the trial with weights collected every 28 days on the interim. Carcass ultrasound measurements were collected for ribeye area (REA), backfat, and intramuscular fat (IMF) at the conclusion of the trial.

Statistical Analysis. Data were analyzed using the MIXED procedure of SAS. The model included the fixed effects of postweaning treatment (control vs. rumensin), year, and the interaction. On and off test body weights were analyzed with the weaning weight covariate. Off test height was analyzed with the on test height covariate. Treatment*year interaction was initially included in the model, but was not significant (P ≥ 0.09). Statistical differences were determined at P ≤ 0.05 and tendencies at P ≤ 0.10.

RESULTS AND DISCUSSION

There were no differences (P ≥ 0.16; Table 2) in on test BW, DMI, on test height, off test height, or IMF due to dietary treatment. Bull calves fed RUM had greater (P ≤ 0.006) off test BW, ADG, REA, and backfat compared with bull calves fed CON. Bull calves fed CON required greater (P = 0.003) pounds of feed per pound of gain, which equates to being less efficient. There were no differences (P ≥ 0.46) in ADG, on test height, or backfat due to year (Table 3). In year 1, bull calves had greater (P ≤ 0.003) on and off test BW and DMI than in year 2. Off test height, REA, and IMF were greater (P ≤ 0.009) in year 2 compared with year 1. Bulls calves fed CON tended (P = 0.09) to have greater pounds of feed per pound of gain in year 1 than in year 2.

Although DMI was not altered in the current studies, gain was improved, which ultimately improved the feed efficiency in the RUM bull calves. Contrary to the current results, Benchaar et al. (2006) observed a reduction in DMI of monensin fed beef steers compared with control steers, without altering gain and feed efficiency. Similarly, Goodrich et al. (1984) also observed a reduction in feed consumption and more rapid weight gain in steers fed

TABLE 1. Dietary ingredients and composition of bull calf postweaning diets[1] in years 1 and 2.

	Year 1		Year 2	
Item, % of DM	CON	RUM	CON	RUM
Corn silage	65	65	65	65
Ground hay	10	10	10	10
Ground corn	10	10	20	20
Barley	10	10	—	—
Supplement	5	4.3	5	4.3
Rumensin	—	0.7	—	0.7

1. CON: no rumensin, RUM: rumensin fed at 0.2 lb/hd/d.

monensin. However, Boucqué et al. (1982) did not observe any differences in performance, feed intake, or carcass measurements in Belgian white-blue bulls fed with our without monensin-sodium.

Average daily gain was slightly greater in the previous studies compared with the current study, while DMI was similar between the current and previous studies. Feed efficiency of beef steers was not impacted by monensin intake according to Benchaar et al. (2006). However, in 228 trials, Goodrich et al. (1984) calculated that cattle fed monensin required 7.5% less feed per 200 pounds of gain compared with control cattle. In the current study, RUM bull calves only required 153 days to reach the same off test BW as the CON bull calves. This potential reduction in the number of days required to reach similar off test BW reduces the amount of feed needed and resulted in approximately 255 pounds (7.11%) less feed per RUM bull calf needed to reach the off test BW of a CON bull calf.

In conclusion, bull calves fed rumensin were more feed efficient than control calves. The increased growth of the bull calves fed rumensin may reduce the amount of time needed for bull development, which may result in a reduction in feed costs.

TABLE 2. Impacts of bull treatment[1] across both years on postweaning performance and carcass ultrasound measurements.

Item	CON	RUM	SEM	*P* - value
On test BW, lbs	530.7	531.4	2.23	0.84
Off test BW, lbs	886.6[b]	924.7[a]	4.43	<0.001
ADG, lb/d	2.15[b]	2.32[a]	0.039	0.006
DMI, lb/hd/d	17.94	18.19	0.117	0.17
Feed effiency[2]	18.8[a]	17.4[b]	0.258	0.003
On test height, in	42.7	42.8	0.12	0.57
Off test height, in	47.9	47.9	0.12	0.68
REA, in^2	10.63[b]	11.16[a]	0.077	<0.001
Backfat, in	0.15[b]	0.16[a]	0.003	<0.001
IMF, %	3.06	3.13	0.036	0.16

1. Bull treatments include: CON: no addition of rumensin or RUM: inclusion of 0.2 lb/hd/d rumensin.
2. Pounds of feed per pound of gain.
a,b. Means in a row without common superscripts differ (P ≤ 0.05).

TABLE 3. Impacts of year on postweaning performance and carcass ultrasound measurements.

Item	Year 1	Year 2	SEM	P - value
On test BW, lbs	542.4[a]	519.7[b]	2.28	<0.001
Off test BW, lbs	916.4[a]	895.0[b]	4.55	<0.001
ADG, lb/d	2.24	2.23	0.039	0.72
DMI, lb/hd/d	18.39[a]	17.74[b]	0.117	0.003
Feed efficiency[1]	18.4	17.8	0.26	0.09
On test height, in	42.8	42.7	0.13	0.46
Off test height, in	47.6[b]	48.1a	0.12	0.009
REA, in^2	10.10[b]	11.68[a]	0.079	<0.001
Backfat, in	0.16	0.15	0.003	0.49
IMF, %	2.90[b]	3.29[a]	0.037	<0.001

1. Pounds of feed per pound of gain.
a,b. Means in a row without common superscripts differ (P ≤ 0.05).

REFERENCES

Benchaar, C., J.L. Duynisveld, and E. Charmley. 2006. *Effects of monensin and increasing dose levels of a mixture of essential oil compounds on intake, digestion and growth performance of beef cattle.* Can. J. Anim. Sci. 86:91-96.

Boucqué, C.V., L.O. Fiems, B.G. Cottyn, M. Casteels, and F.X. Buysse. 1982. *Monensin-sodium as a performance-promoting additive for fattening bulls and its impact on carcass and meat quality characteristics.* Anim. Feed Sci. Tech. 7:401-410.

Goodrich, R.D., J.E. Garrett, D.R. Gast, M.A. Kirick, D.A. Larson, and J.C. Meiske. 1984. *Influence of monensin on the performance of cattle.* J. Anim. Sci. 58:1484-1498.

Sheep Grazing for Field Pea Cover Crop Termination in a Winter Wheat Production System

by

J. Westbrook[1], C. Carr[1], P. Hatfield[1], P. Miller[2], F. Menalled[2]

[1]Department of Animal and Range Sciences, Montana State University, Bozeman, MT, and [2]Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT,

IMPACT STATEMENT

Sheep (Ovis aries) gained weight while effectively terminating a field pea (Pisum sativum) cover crop using either continuous, low stocking density or rotational, high stocking density grazing systems. In a one-year trial, winter wheat yields in plots where cover crops were previously terminated through grazing were equal to those where herbicide or tilled termination approaches were implemented.

SHEEP GRAZING FOR FIELD PEA COVER CROP TERMINATION IN A WINTER WHEAT PRODUCTION SYSTEM

by J. Westbrook, C. Carr, P. Hatfield, P. Miller, F. Menalled

SUMMARY

Targeted sheep grazing represents an alternative to conventional cover crop termination. This study assessed the use of targeted sheep grazing to terminate a field pea cover crop in sequence with winter wheat. These data represent the cropping sequence effect of winter pea on winter wheat in a one-year trial. Our objectives were: 1) to compare the effects of low and high stocking density sheep grazing on efficacy of cover crop termination, sheep live weight gains, and subsequent winter wheat yield, and 2) to compare the efficacy of tillage, herbicide, and grazing methods on cover crop termination and subsequent winter wheat yield.

Rambouillet yearling wethers grazed the cover crop for 32 days (June 16-July 18, 2013) either in rotational (93 sheep acre-1) or continuous (23 sheep acre-1) grazing systems. Both grazing treatments were equally effective for cover crop termination. Sheep grazing was an effective termination method, based on plant cover measured after termination (averaging 77% dead pea, 1% live pea, 22% bare ground across the two treatments).

Grazing system had no impact on sheep weight gains and sheep from both systems gained an average of 0.37 lbs day-1. There was no difference in subsequent wheat yield (yield evaluated at 12% moisture) between grazing treatments or between cover crop termination methods (grazing, tillage, and herbicide). These results indicated that sheep grazing was effective at terminating a field pea cover crop regardless of the grazing system and that grazing did not impact subsequent wheat yield when compared with mechanical or chemical termination approaches. However, these results represent a 2-year crop sequence, so results may change with time as the crop rotation matures or with a different legume cover crop.

INTRODUCTION

Cover crops provide valuable services to the agricultural ecosystem including competing with weed species and improving soil properties such as erosion resistance, soil organic matter, and nutrient status, (Mulholland et al., 1976; Azooz, and A' Arshad, 1996; Miller, 2005; Clark, 2007; Kolb et al., 2010; Moore et al., 2010). Cover crops are usually terminated, or killed, using herbicides or tillage prior to sowing the subsequent crop.

Sheep grazing has been proposed as an alternative method for cover crop termination (Hepworth, 1998). Legumes, which are a favored cover crop because of their biological nitrogen fixation, have the potential to provide quality forage for sheep. For example, field peas contain between 16 and 18% crude protein (Allden and Geytenbeek, 1980; Tan et al. 2013). Integrating sheep into cropping systems that incorporate cover crops may provide a source of high quality forage for sheep production while potentially reducing the need for herbicide application or tillage.

The sustainable integration of sheep and crop production must benefit both producers and the environment, thus a large MSU research effort evaluating the environmental and economic effects of this integration is ongoing. This paper presents results from one phase of the larger study, focusing on the effects of grazing treatment on sheep production, cover crop termination, and wheat yield.

PROCEDURES

We tested the efficacy of grazing for cover crop termination at the Fort Ellis Research Farm, 6 miles east of Bozeman, MT. The cover crop was field pea, a winter pea that was planted September 2012. Two sheep grazing treatments were used. The first treatment was a continuous grazing system with a stocking density of 23 sheep acre-1. The second treatment had a stocking density of 93 sheep acre-1, and the sheep were rotated through strip pastures every four days followed by a 12-day rest period. Sheep grazed from June 16-July 18, 2013 in both systems. Continuous grazing is a commonly used grazing system that minimizes labor and animal handling stress (Launchbaugh et al. 1978; Owensby 1991; Glindemann et al., 2009). Rotational grazing requires increased handling and labor but may improve animal distribution and increases the uniformity of utilization (Owensby 1991; Launchbaugh and Howery. 2005), which could be desirable in a cropping system setting.

Conventional herbicide terminated plots, tillage terminated plots, and sheep grazed plots were compared for termination (cover) and wheat yield. Tillage and chemical termination took place on June 18, 2013. Chemical termination used a mixture of glyphosate (24 oz acre-1) and dicamba (4 oz acre-1) with a 0.5% by volume HellFire adjuvant. We set a goal for termination as having at least 80% dead pea, 0% live pea, and 20% or less bare ground cover. These termination goals were set to maintain sufficient vegetation cover to protect the soil from erosion. Termination was measured on July 19, 2013. Winter wheat was planted in September 2013, following cover crop termination, and harvested in August 2014.

RESULTS AND DISCUSSION

Both grazing treatments were equally effective at terminating the cover crop (Figure 1). Continuously grazed plots had 77% (SD = 4%) dead pea cover, 2% (SD = 3%) live pea cover, and 22% (SD = 2%) bare ground cover. Rotational Grazing had 77% (SD = 5%) dead pea cover, 1% (SD = 1%) live pea cover, and 22% (SD = 6%) bare ground cover. In fact, sheep grazing was closest to the target termination (Figure 2). Tillage was successful at terminating the pea, but it left more bare ground than the goal, putting the tilled plots at increased erosion risk (Figure 2). Although the herbicide treatment retained excellent soil cover, at the time of sampling for termination, the herbicide mixture did not appear very effective on the pea, leaving 73% (SD = 8%) live pea cover (Figure 2).

There was no difference in subsequent wheat yield between grazing treatments (P = 0.91) nor were there any differences in wheat yield among any of the termination methods (P > 0.13) (Figure 3).

Continuously grazed sheep had mean average daily gains of 0.34 (SD = 0.037) lbs day-1, while rotational sheep gained 0.40 (SD = 0.013) lbs day-1 (Figure 4), with no differences between treatments (p = 0.12).

These results are promising, as we were able to successfully utilize the cover crop as a forage resource while terminating it without the use of tillage or herbicides. The experiment also demonstrated potential economic benefits for sheep producers, as we observed valuable sheep weight gains.

Further research is necessary, as results may vary with different cover crops or from changing the timing, intensity, or duration of grazing. This is a subset of a longer-term study which incorporates sheep grazing into a wheat, lentil, and safflower production system, the results of which will further explain the effects of grazing on cropping systems.

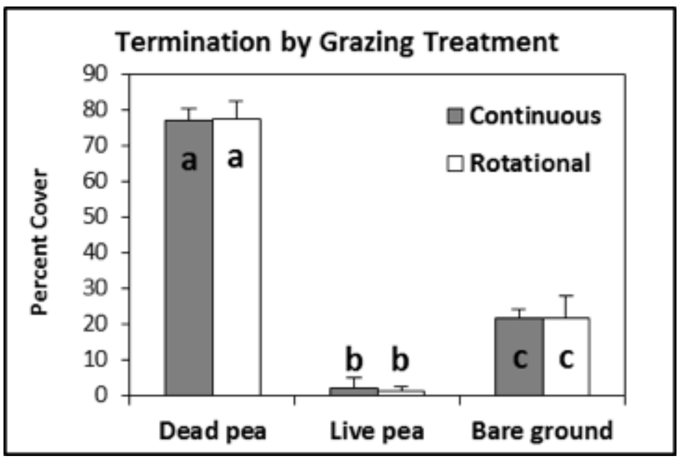


FIGURE 1. Mean Percent cover by grazing treatment and cover type (error bars = SD, letter codes represent statistical differences (α = 0.05) within cover types).

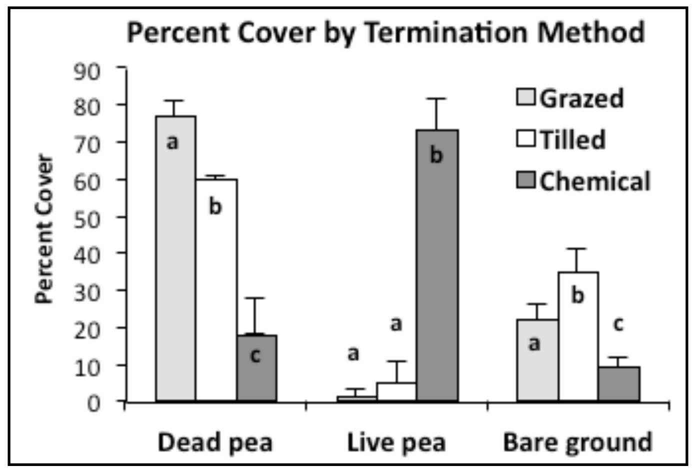


FIGURE 2. Mean percent cover by termination treatment and cover type (error bars = SD, letter codes represent statistical differences (α = 0.05) within cover types).

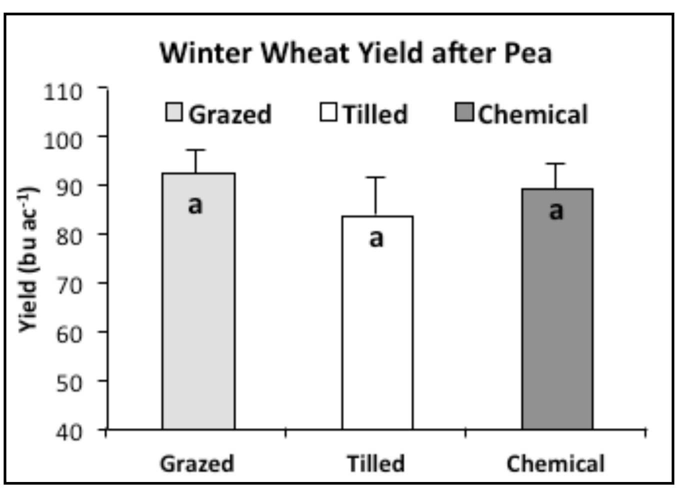


FIGURE 3. Winter wheat yield after pea cover crop by termination method (error bars = SD, letter codes represent statistical differences (α = 0.05)). Wheat yield evaluated at 12% moisture.

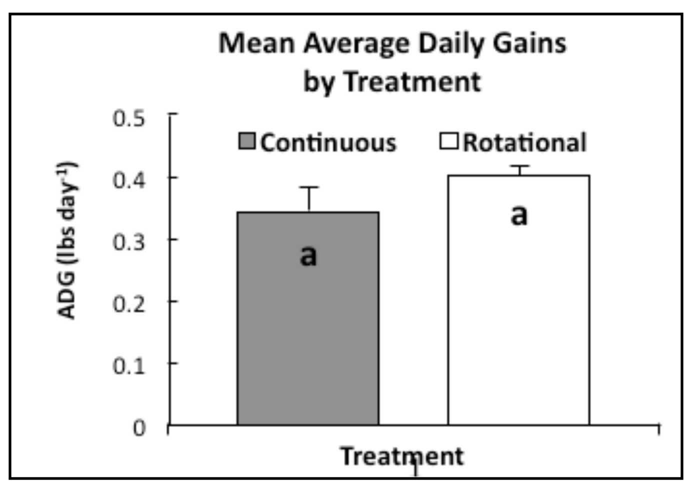


FIGURE 4. Mean average daily gains in sheep grazing field pea cover crop (error bars = SD, letter codes represent statistical differences (α = 0.05)).

REFERENCES

Allden, W.G. and P.E. Geytenbeek. 1980. *Evaluation of nine species of grain legumes for grazing sheep.* Animal Production in Australia.

Azooz, R. H. and M. A' Arshad. 1996. *Soil infiltration and hydraulic conductivity under long-term no-tillage and conventional tillage systems.* Northern Agriculture Research Centre, Alberta, Canada.

Clark, A. 2007. Field Peas. *Managing cover crops profitably, 3rd Ed.* SARE. United Book Press, Inc., College Park, MD.

Glindemann, T., C. Wang, B. M. Tas, A. Schiborra, M. Gierus, F. Taube, and A. Susenbeth. 2009. *Impact of Grazing Intensity on Herbage Intake, Composition, and Digestibillity and on Live Weight Gain of Sheep on the Inner Mongolian Steppe.* Livestock Science, Vol. 124: 142-147.

Hepworth, G. 1998. *Mature Crops Help Produce Out of Season Lambs.* Farming Ahead, Vol. 81

Kolb, L. N., E. R. Gallandt, T. Molloy. 2010. *Improving Weed Management in Organic Spring Barley: Physical Weed Control vs. Interspecific Competition.* Weed Research, Vol. 50: 597-605.

Launchbaugh, J. L., C. E. Owensby, F. L. Schwartz, and L. R. Corah. 1978. *Grazing Management to Meet Nutritional and Functional Needs of Livestock.* Proceedings of the First International Rangeland Congress, Denver, CO. pg 541-546.

Launchbaugh, K. L. and L. D. Howery. 2005. *Understanding Landscape Use Patterns of Livestock as a Consequence of Foraging Behavior.* Rangeland Ecology and Management, Vol. 58: 99-108.

Miller, P., K. McKay, C. Jones, S. Bludgett, F. Menalled, J. Riesselman, C. Chen, and D. Wichman. 2005. *Growing Dry Pea in Montana.* Montguide.

Moore, S., G. Cumming, L. Jenkins, and J. Gentry. 2010. *Northern Region Field Pea Management Guide.* Pulse Australia.

Mulholland, J. G., J. B. Coombe, P.R. Dann. 1976. *Use of Oat, Lupin, and Field Pea Stubbles by Grazing Sheep.* Australian Journal of Experimental Agriculture and Animal Husbandry, Vol. 16

Owensby, C. E. 1991. *Introduction to Range Management.* Kansas State University. pg VII 141-150, IX 153-175.

Tan, M., A. Koc, Z. Dumlu Gül, E. Elkoca, and I. Gül. 2013. *Determination of dry matter yield and yield components of local forage pea (Pisum sativum spp. arvense L.) ecotypes.* Journal of Agricultural Sciences, Vol. 29: 289-296