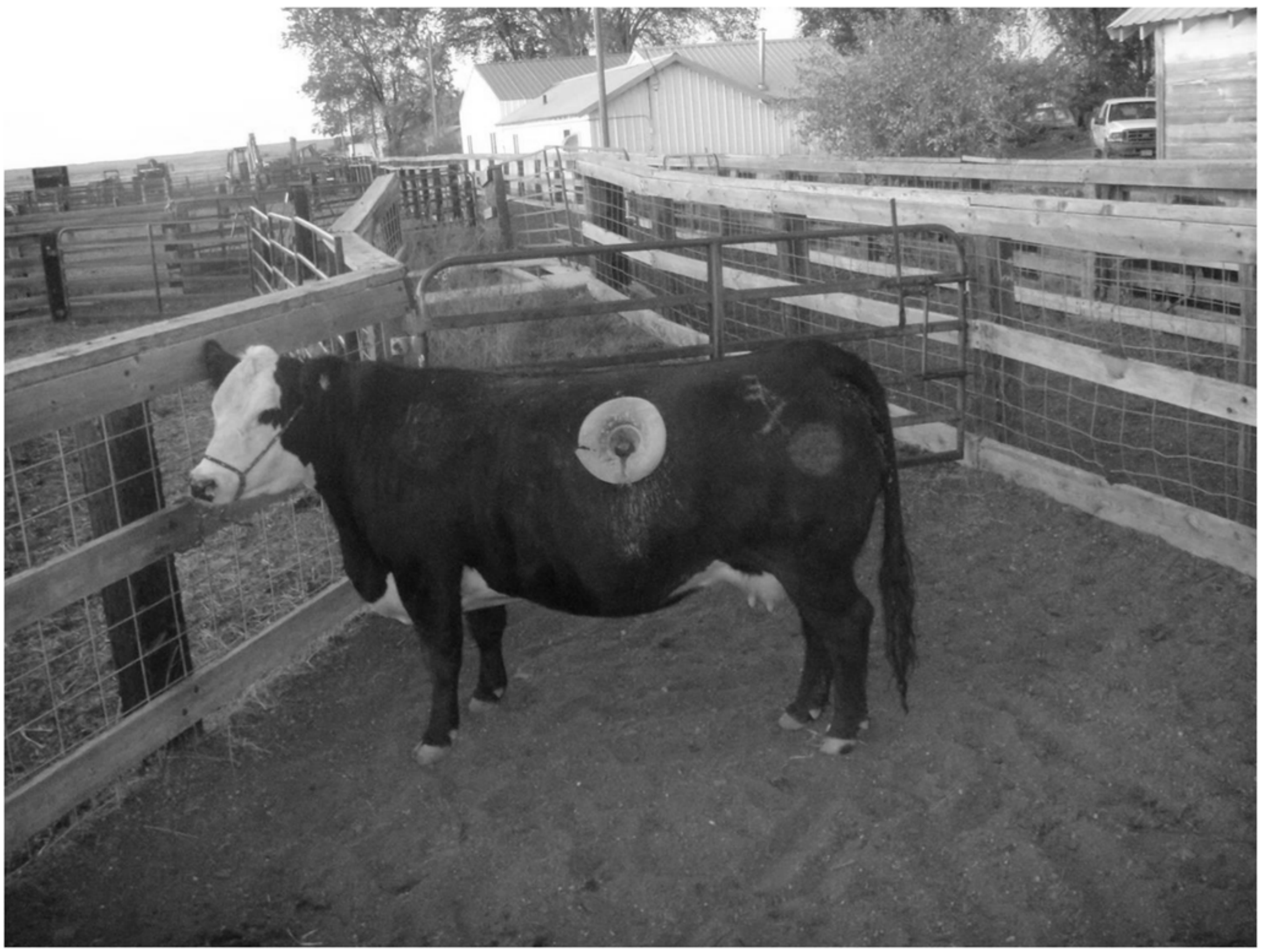
Oregon State University

Beef Cattle Sciences

Oregon Beef Council Report

2010 Edition



Oregon State University | Extension Service

REPORT STATUS OF STUDIES FUNDED BY THE OREGON BEEF COUNCIL

Progress report not required for studies funded prior to 2009-2010 FY and with a full report submitted.

Projects funded in 2007 – 2008 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Report Status Full
Rangeland Ecology and Management			
Wolf impact on cattle productivity and behavior	D.E. Johnson		X
Development of digital charting system for range health	D.E. Johnson		X
Livestock, plant community, and sage-grouse food sources	J. Miller		X
Animal Sciences			
Digestibility of cool-season in dairy farms	T. Downing		X
Female hormones and immune cells in cattle	M. Cannon		
Diagnostic test for pregnancy detection in cattle	F. Menino		
Assay to assess bovine embryo viability during transfer	F. Menino		
Farm-based livestock manure/biogas production	M. Gamroth		X
Glycerol supplementation to cattle	C. Mueller	X	
Copper and Zinc in dairy forage systems	T. Downing		X

Projects funded in 2008 – 2009 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Report Status Full
Rangeland Ecology and Management			
Wolf impact on cattle productivity and behavior (cont.)	D.E. Johnson		X
Rangeland vegetation and sediment monitoring	L. Larson	X	
Animal Sciences			
Late gestation protein supplementation of beef cows	D. Bohnert		X
Grazing options with *Brassicas* and Fodder Radishes	C. Engel		X
Maternal marbling potential and ultrasound technology	C. Mueller		X
Replacement heifers sired by high or low-marbling bulls	C. Mueller	X	
BVDV and BVDV PI screening to initiate BVDB control	B. Riggs		X
Selenium supplementation and retention in beef cattle	G. Pirelli	X	
Farm-based livestock manure/biogas production (cont.)	M. Gamroth		X

Projects funded in 2009 – 2010 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Report Status Full
Rangeland Ecology and Management			
Wolf impact on cattle productivity and behavior (cont.)	D.E. Johnson		X
DNA analysis for cattle diet in sagebrush rangelands	R. Mata-Gonzales	X	X
Behavior and distribution of cattle grazing riparian zones	D.E. Johnson		X
Animal Sciences			
PFG2α to improve uterine health and reproductive efficiency	M. Cannon		
Disposition and reproductive performance of brood cows	R. Cooke	X	X
Acclimation to handling and heifer development	R. Cooke	X	X
Farm-based livestock manure/biogas production (cont.)	M. Gamroth		X

Projects funded in 2010 – 2011 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Report Status Full
Rangeland Ecology and Management			
Conflict stressors, spatial behavior and grazing budgets of cattle	D.E. Johnson	**X**	
Behavior and distribution of cattle grazing riparian zones **(cont.)**	D.E. Johnson		**X**
Grazing and medusahead invasion in sagebrush steppe	D. Johnson	**X**	
Weeds to suppress cheatgrass and medusahead	P. Dysart	**X**	
Effects of wolves on cattle production systems **(cont.)**	D.E. Johnson		**X**
Quantities diet analysis in cattle using fecal DNA	R. Mata-Gonzales	**X**	
Animal Sciences			
Protein Supplementation to Low-Quality Forage	D. Bohnert	**X**	
Disposition, acclimation, and steer feedlot performance	R. Cooke	**X**	
Nutrition during bull development on calf performance	C. Mueller	**X**	
Changes in milk parameters in dairy cows with metabolic disorders	A. Villarroel	**X**	
Extending grazing season with warm season and Brassica forages	S. Filley	**X**	
Oral Selenium drench at birth to calves	J. Hall		

Oregon State University

BEEF049

Beef Cattle Sciences

Oregon Beef Council Report

Adaptation of *Brassica* spp. and fodder radishes as late season forages in the high desert region of Oregon [1]

C.L. Engel [2], B.A. Charlton [3], R.J. Roseberg [4], R.A. Bentley [5], and D.A. Culp [5]

Synopsis

Across all three planting dates both *Brassica* spp. and fodder radish varieties produced acceptable late season yields, and seem well-suited to extend the grazing season.

Summary

The objective of this study was to evaluate the yield potential and viability of winter triticale (TRT; n=1), Brassica spp. (BRS; n=6), and radish (RAD; n=3) varieties, as late season forages. The first year of this study was initiated in 2009. Three planting dates (PD1, 2 & 3; July 30, Aug.14, & Aug. 28, respectively) were analyzed with 2 harvest dates (HD; approximately 60 and 90 d after planting) per PD (4 replications per variety). Plots were arranged in a randomized complete block design with a split plot. Varieties included: Winter Triticale (TRT; trical102); Dwarf Siberian Kale, Winfred (WIN, hybrid); Purple Top White Globe Turnip; Hunter (hybrid); New York Turnip; Pulsar Rape (PR); Graza Radish; Colonel Radish (CR); and Terranova Radish. Plots were seeded with a modified Great Plains drill at 7, 9, and 100 lb pure live seed/acre (for BRS, RAD, and TRT; respectively) into glyphosate treated small grain stubble. Plots were fertigated with 67.3 lb nitrogen and 22.4 lb sulfur/acre and were irrigated through Oct.15. Across all three PD, TRT was the lowest yielding variety (1.65 ± 0.25, 1.12 ± 0.13, and 0.64 ± 0.22 tons dry matter (DM)/acre; PD1, 2, and 3, respectively). The variety with the greatest yield differed by PD (WIN, 3.34 ± 0.21; PR, 2.37 ± 0.19; WIN, 2.00 ± 0.19 tons DM / acre; for PD 1, 2, and 3, respectively). For both PD 1 and 2, CR, BRS hybrids and PR yielded more than turnip and other RAD varieties ($P \leq 0.05$). At PD 3 all BRS varieties yielded more than RAD varieties ($P \leq 0.05$). The 60 d HD yielded less ($P<0.01$) than the 90 d HD for PD 1 and 3, only (2.37 vs. 2.81 ± 0.09 and 1.18 vs. 1.80 ± 0.08 tons DM/ acre; for 60 vs.90 d HD, PD 1 and 3; respectively). No PD X HD interactions occurred ($P \geq 0.16$). Both BRS and RAD produced good late season yields, and seem well-suited to extend the grazing season.

Introduction

Forage brassicas (BRS; *Brassica)* spp. and fodder radish (RAD; *Raphanus sativus*) are cold-tolerant, fast- growing crops that have been used extensively as a forage resource for grazing livestock in Europe, Great Britain, New Zealand and locations in the United States. Interest in brassicas have increased in recent years as a forage resource with potential to extend fall grazing for 2-3 months in the United States. Since 2003 the price of hay in Oregon has increased from $88/ton to $153/ton (NASS;

1. This document is part of the Oregon State University – 2010 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://beefcattle.ans.oregonstate.edu.
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2007). The significant increases in hay prices have increased maintenance dietary costs from \$1.32/head/day to \$2.30/head/day. Extending the fall grazing season would reduce the months harvested forages are required and could reduce annual feed costs for cow-calf producers in the state and in other similar regions. Measured yields of BRS and RAD have ranged between 2.5-8.0 tons DM/acre (Piggot et. al, 1980; Bartholomew and Underwood, 1992; Reid et. al, 1994). *Brassica* spp. and RAD have been successfully planted following harvest of summer annual crops in other regions of the U.S. with longer growing seasons. However, research investigating planting dates and cropping systems that successfully integrate forage brassicas for extending fall grazing in short-season production locations is limited. The high desert region of Oregon produces small grains on several thousand acres of irrigated farmland. However, grain harvest is typically much later in the high desert region of Oregon (late August to early September) compared with other production areas in the United States (July and early August). Brassicas and RAD are cold tolerant and can withstand temperatures as low as 20° F making them an ideal choice for short-season production areas experiencing multiple early fall frosts, such as the high desert region of Oregon. Investigating varieties of BRS and RAD crops that can be planted late in the season following small grain harvest and still reach economic yields to allow for grazing is needed. In addition, significant acreage of small grain is planted in the high desert region of Oregon and harvested for hay in late June to early July. Investigating BRS and RAD varieties that provide the greatest yield potential, following cereal hay harvest, is also needed.

The objective of this study was to evaluate the yield potential and viability of winter triticale (TRT; n=1), *Brassica* spp. (BRS; n=6), and radish (RAD; n=3) varieties, as late season forages following a small grain harvest for hay or for grain.

Materials and Methods

In 2009 nine different *Brassica* spp. (BRS) and fodder radish (RAD; *Raphanus sativus*) varieties along with winter triticale (TRT; *X Triticosecale rimpaui* Wittm.) were tested at three planting dates (PD1, 2 & 3; July 30, August14, and August 28, respectively), with two harvest dates (HD; approximately 60 and 90 d after planting) per PD. There were four replications per variety. The PD were selected to best match timing options producers would typically have following either small grain harvested for hay or grain in the high desert region of Oregon. Treatment plots were assigned in a randomized complete block design, arranged as a split plot, at the Klamath Basin Research and Extension Center, Klamath Falls, OR. Varieties tested were: *Brassica napus L.* var. Pulsar rape (PR), *Brassica napus* var. Dwarf Siberian Kale (DSK), *Brassica napus* var. Winfed (WIN; turnip x kale hybrid), *Brassica rapa* var. Purple Top White Globe turnip (PT), *Raphanus sativus var.* Graza radish (GR), ; *Brassica campestris spp. rapa* var. Hunter (HUN; turnip x rape hybrid), *Brassica rapa* var. New York turnip (NYT), *Raphanus sativus* var. Colonel radish (CR), *Raphanus sativus* var. Terranova radish (TR), *X Triticosecale rimpaui* Wittm. Var. Trical 102 winter triticale (TRT). Plots were seeded into glyphosate-treated small grain stubble that had been previously harvested for hay, using a modified Great Plains© drill. Each seeded plot measured 5.63 ft by 20.00 ft. Seeding rates were 4, 7, and 100 lb/acre, pure live seed, for BRS, RAD, and TRT varieties, respectively. Given the small seed size for most of the varieties and the small plot area, a similar weight of cracked corn was used as a carrier to ensure more uniform plot seeding. Plots were irrigated at planting through October 15, when irrigation water was terminated for the season. Plots were fertilized through the irrigation system (fertigated) with 67.3 lb nitrogen and 22.4 lb sulfur/acre, using a solution consisting of 67.8% Solution 32 and 32.2 % Thiosul, after plants reached the true two-leaf stage for all PD (12, 20 and 17 d after planting for PD1, 2, and 3; respectively). The first HD for each PD were harvested by hand from a 5.2 ft^2 area of each plot on October 7 (69 d from PD 1), October 22 (69 d from PD 2), and October 27 (60 d from PD 3). All harvested wet plant material was placed in a paper bag weighed, dried in a forced air oven at 140 º F and weighed back to determine DM production per acre. From the same plots, a separate area (36.8 ft^2) was mechanically harvested for the second HD on October 28 (90d after planting for PD 1), November 12 (90d after planting for PD 2), and November 30 (94 d after planting for PD 3). The total plot wet weight was measured and recorded. Additionally a wet sub-sample was collected, placed in a paper bag and weighed, dried at 140 º F, and weighed back to determine DM production per acre. Statistical analysis was performed on the data for each PD using the PROC MIXED procedures in SAS for a randomized complete block with split plot.

Results

Planting Date 1

For PD 1, there were significant ($P < 0.001$) differences between varieties in DM yeild (Table 1). The WIN, CR, and PR varieties had the greatest DM Yields, exceeding 3.0 ± 0.21 tons/acre. The remaining varieties, with the exception of TRT, were similar ($P > 0.05$) with an average yield of 2.4 ± 0.22 tons/acre. TRT was the lowest yielding variety at 1.65 ± 0.25 tons/acre. There was also a significant effect of harvest timing, 69 d vs. 90d ($P < 0.001$). Harvesting at 69 d following planting netted a lower DM yield (2.4 ± 0.09 tons/acre) compared to harvesting at 90 d (2.8 ± 0.09 tons/acre) following planting. There was no variety by HD interaction ($P = 0.26$; Figure 1).

Table 1. 2009 Dry Matter Yields of BRAS, RAD, and TRT Varieties for the First Planting Date.[1]

Variety[2]	Dry Matter Yield	Standard Error
	Ton/acre	
WIN	3.34 [a]	0.21
CR	3.25 [a]	0.21
PR	3.18 [a,b]	0.21
HUN	2.56 [b,c]	0.21
TR	2.50 [c]	0.23
PT	2.47 [c]	0.21
GR	2.45 [c]	0.21
DSK	2.35 [c]	0.23
NYT	2.17 [c,d]	0.21
TRT	1.65 [d]	0.25

[1] Means with differing superscripts are different ($P < 0.05$).
[2]Pulsar rape (PR), Dwarf Siberian Kale (DSK), Winfed (WIN; turnip x kale hybrid), Purple Top White Globe turnip (PT), Graza radish (GR), Hunter (HUN; turnip x rape hybrid), New York turnip (NYT), Colonel radish (CR), Terranova radish (TR), Trical 102 winter triticale (TRT).

Planting Date 2

There was a significant ($P < 0.001$) variety effect for PD 2 (table 2). Five varieties (PR, DSK, CR, HUN, and WIN) had similar ($P > 0.05$) DM yields with an average yield of 2.3 ± 0.13 tons/acre. The remaining varieties (NYT, PT, TR, and GR), with the exception of TRT, were similar ($P > 0.05$) with an average DM yield of 1.7 ± 0.13 lbs/acre. For this PD, time of harvest (69 vs. 90 d) did not have a significant effect on DM yield ($P = 0.62$; 1.9 ± 0.06 lb/acre). Additionally, there was no variety by HD interaction ($P = 0.16$; Figure 2).

Table 2. 2009 Dry Matter Yields of BRAS, RAD, and TRT Varieties for the Second Planting Date.[1]

Variety	Dry Matter Yield	Standard Error
	Ton/acre	
PR	2.37 [a]	0.13
DSK	2.33 [a]	0.14
CR	2.26 [a]	0.13
HUN	2.23 [a]	0.13
WIN	2.21 [a]	0.13
NYT	1.83 [b]	0.13
PT	1.82 [b]	0.13
TR	1.64 [b]	0.14
GR	1.63 [b]	0.13
TRT	1.12 [c]	0.13

[1] Means with differing superscripts are different ($P < 0.05$).
[2]Pulsar rape (PR), Dwarf Siberian Kale (DSK), Winfed (WIN; turnip x kale hybrid), Purple Top White Globe turnip (PT), Graza radish (GR), Hunter (HUN; turnip x rape hybrid), New York turnip (NYT), Colonel radish (CR), Terranova radish (TR), Trical 102 winter triticale (TRT).

Planting Date 3

The third planting date had a significant ($P < 0.001$) variety effect that was a little more complicated (Table 3). The top DM yielding variety for this PD was WIN (2.0 ± 0.19 lb/acre) which was similar ($P > 0.05$) to NYT, DSK, PT, HUN, and PR. The two lowest DM yielding varieties were GR (0.83 ± 0.19 lb/acre) and TRT (0.64 ± 0.22 lb/acre). Time of harvest was significant for PD 3 ($P > 0.001$). Delaying harvest for an additional 30d increased DM yield at 90 d compared to 60d following planting (1.80 and 1.18 ± 0.08 lb/acre for the 90 and 60 d HD, respectively). However, there was no Variety by HD interaction observed for this PD ($P = 0.47$; Figure 3).

Table 3. 2009 Dry Matter Yields of BRAS, RAD, and TRT Varieties for the Third Planting Date.[1]

Variety	Dry Matter Yield	Standard Error
	Ton/acre	
WIN	2.00 [a]	0.19
NYT	1.83 [a,b]	0.18
DSK	1.81 [a,b]	0.18
PT	1.78 [a,b]	0.18
HUN	1.75 [a,b]	0.18
PR	1.59 [a,b.c]	0.18
CR	1.40 [b,c]	0.19
TR	1.25 [c,d]	0.19
GR	0.83 [d,e]	0.19
TRT	0.64 [e]	0.21

[1] Means with differing superscripts are different ($P < 0.05$).
[2]Pulsar rape (PR), Dwarf Siberian Kale (DSK), Winfed (WIN; turnip x kale hybrid), Purple Top White Globe turnip (PT), Graza radish (GR), Hunter (HUN; turnip x rape hybrid), New York turnip (NYT), Colonel radish (CR), Terranova radish (TR), Trical 102 winter triticale (TRT).

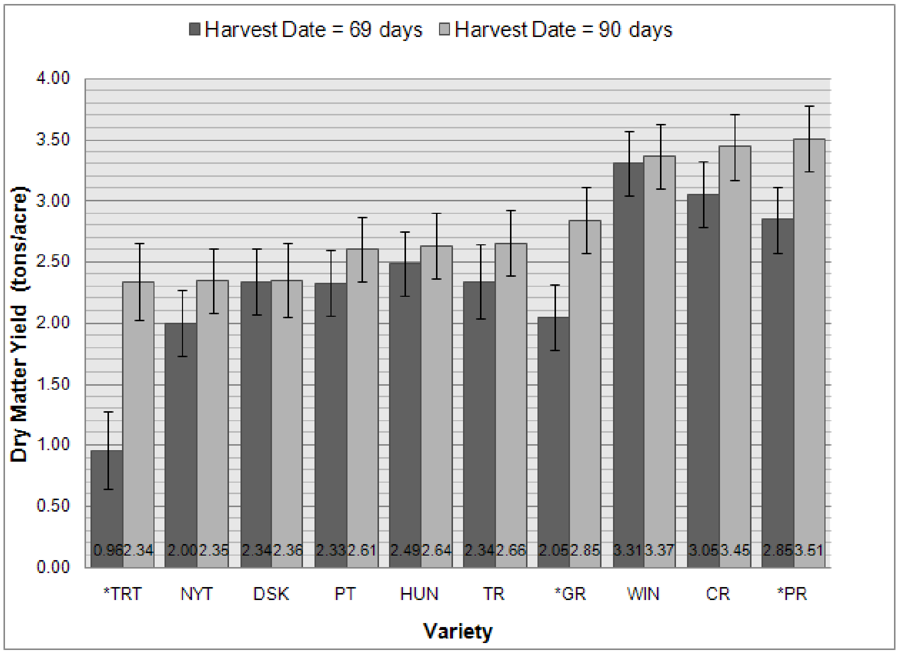

Figure 1. The effect of the interaction of variety by harvest date for BRAS, RAD, and TRT varieties on dry matter yield at 69 and 90 d following planting for the first planting date. An overall variety by harvest date interaction was not observed ($P = 0.26$). Within a variety, if denoted with an *, a difference was detected between the 69 and 90 d harvest date following planting ($P < 0.05$). Pulsar rape (PR), Dwarf Siberian Kale (DSK), Winfed (WIN; turnip x kale hybrid), Purple Top White Globe turnip (PT), Graza radish (GR), Hunter (HUN; turnip x rape hybrid), New York turnip (NYT), Colonel radish (CR), Terranova radish (TR), Trical 102 winter triticale (TRT).

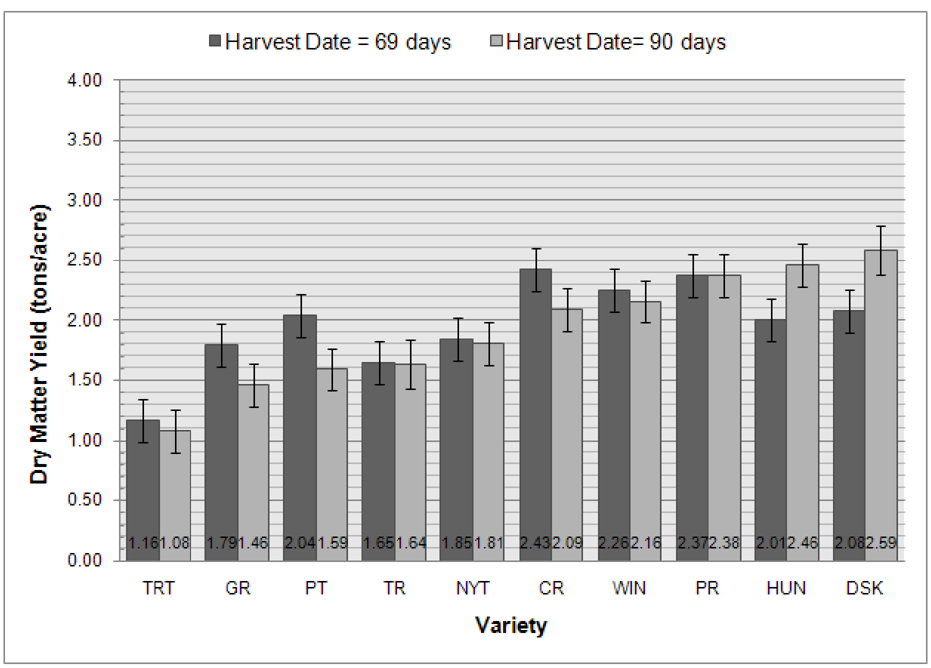

Figure 2. The effect of the interaction of variety by harvest date for BRAS, RAD, and TRT varieties on dry matter yield at 69 and 90 d following planting for the second planting date. An overall variety by harvest date interaction was not observed ($P = 0.16$). Within a variety, if denoted with an *, a difference was detected between the 69 and 90 d harvest date following planting ($P < 0.05$). Pulsar rape (PR), Dwarf Siberian Kale (DSK), Winfed (WIN; turnip x kale hybrid), Purple Top White Globe turnip (PT), Graza radish (GR), Hunter (HUN; turnip x rape hybrid), New York turnip (NYT), Colonel radish (CR), Terranova radish (TR), Trical 102 winter triticale (TRT).

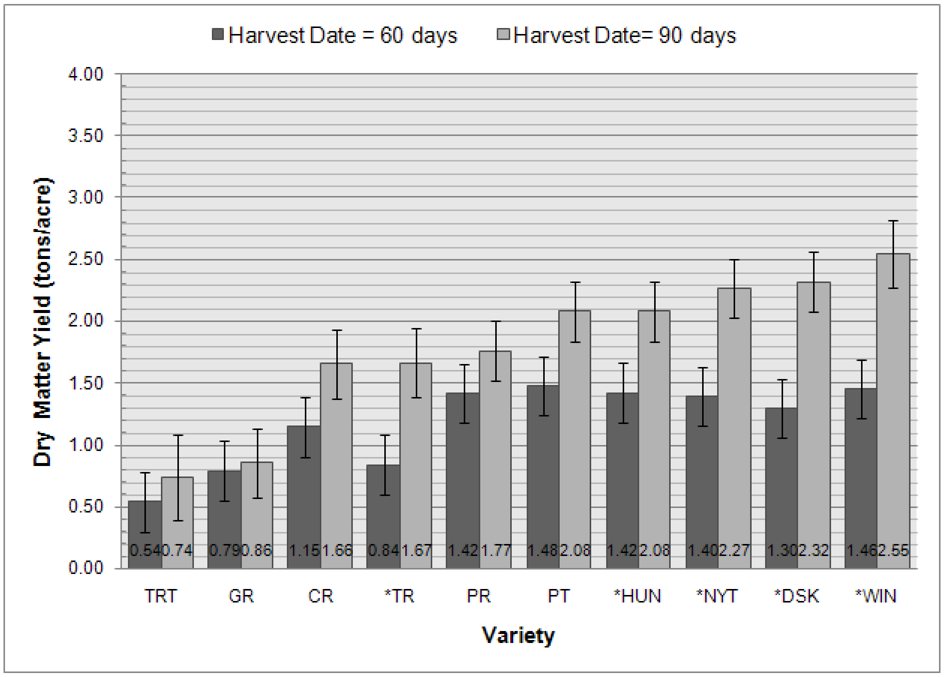

Figure 3. The effect of the interaction of variety by harvest date for BRAS, RAD, and TRT varieties on dry matter yield at 69 and 90 d following planting for the third planting date. An overall variety by harvest date interaction was not observed (P = 0.47). Within a variety, if denoted with an *, a difference was detected between the 69 and 90 d harvest date following planting ($P < 0.05$). Pulsar rape (PR), Dwarf Siberian Kale (DSK), Winfed (WIN; turnip x kale hybrid), Purple Top White Globe turnip (PT), Graza radish (GR), Hunter (HUN; turnip x rape hybrid), New York turnip (NYT), Colonel radish (CR), Terranova radish (TR), Trical 102 winter triticale (TRT).

Conclusions

An additional year of study is needed to confirm the results of this experiment and is currently in progress. Also, an economic analysis is necessary to determine economic feasibility. Thus, based on one year of results, across all three PD both BRS and RAD varieties produced good late season yields, and seem well-suited to extend the grazing season. Observed yields were comparable to typical yields for perennial forages grown in this area. The WIN variety, a hybrid BRS, consistently performed as a top variety among all three PD. Based on this year's data it would appear that by PD, variety selection is important and in general turnip varieties may not be the best choices for seeding dates similar to PD 1 and 2. However this is not true for turnip varieties at PD 3. For earlier PD, differences between varieties were as large as differences between species, but by PD3 the BRAS varieties all produced greater yields than other species. Some caution is warranted. The CR and TR varieties have been used as cover crop varieties, to suppress soil-borne nematodes, and may have anti-nutritional qualities that could be detrimental to animal health. Until this can be investigated further, these varieties should be used with caution for livestock grazing. Additionally, BRS and RAD varieties have potential to accumulate nitrates and should be tested prior to grazing.

Acknowledgements

This research study was financially supported by the Oregon Beef Council and through seed donations from Allied and PGG seed companies and Winema Elevators Inc. (Malin, OR).

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Oregon State University

BEEF045

Beef Cattle Sciences

Oregon Beef Council Report

Effects of Acclimation to Handling on Performance, Reproductive, and Physiological Responses of Replacement Beef Heifers [1]

Reinaldo F. Cooke [2] and David W. Bohnert [3]

Synopsis

Acclimation of Angus x Hereford heifers to human handling reduced circulating concentrations of stress-related hormones and metabolites, and hastened attainment of puberty.

Summary

Thirty-eight Angus heifers were initially evaluated, within 45 d after weaning, for body weight (BW) and puberty status (d 0 and 10), and temperament by measurements of chute score and exit velocity (d 10 only). On d 11, heifers were stratified by puberty status, temperament, BW and age, and randomly assigned to receive or not (control) the acclimation treatment. Acclimated heifers were exposed to a handling process 3 times weekly (Mondays, Wednesdays, and Fridays) for 4 weeks (d 11 to 39 of the experiment). The acclimation treatment was applied individually to heifers by processing them through a handling facility, whereas control heifers remained undisturbed on pasture. Heifer puberty status, evaluated via plasma progesterone concentrations, and BW were assessed again on d 40 and 50, d 70 and 80, d 110 and 120, d 140 and 150, d 170 and 180, and d 210 and 220 of the study. Blood samples collected prior to (d 10) and at the end of the acclimation period (d 40) were also analyzed for plasma concentrations of cortisol, haptoglobin, and ceruloplasmin. Heifer temperament was assessed again on d 40 and d 220. No treatment effects were detected for BW gain (P = 0.88). Acclimated heifers tended (P = 0.08) to have greater exit velocity after the acclimation process, but reduced (P = 0.02) exit velocity on d 220 compared to control cohorts. Acclimated heifers had reduced plasma concentrations of cortisol (P = 0.04) and haptoglobin compared to control heifers after the acclimation period (25.7 vs. 34.1 ng/mL for cortisol; 5.3 vs. 5.9 absorbance at 450 nm × 100 for haptoglobin). Puberty attainment was hastened in acclimated heifers compared to control (P = 0.01). At the end of the study, a greater (P = 0.02) number of acclimated heifers were pubertal compared to control cohorts (63.1 vs. 31.6 % of pubertal heifers). Results from this study indicated that acclimation to human handling after weaning reduced circulating concentrations of substances associated with behavioral stress and hastened puberty attainment in *B. taurus* replacement beef heifers.

Introduction

For optimal economic return and lifetime productivity, replacement heifers should attain puberty by 12 months of age, conceive early as yearlings, and calve as 2 year-olds. Given that $800 is a typical cost to develop a 2 year-old pregnant heifer and approximately 115,000 replacement heifers were introduced into the Oregon cow-calf industry in 2008,

1. This document is part of the Oregon State University – 2010 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://beefcattle.ans.oregonstate.edu.

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more than 90 million dollars are invested, with no immediate return, into heifer development programs by Oregon cow-calf producers every year. These expenses are further increased when replacement heifers fail to conceive during their first breeding season and have their first calf at 3 years of age. Therefore, management strategies that maximize the number of replacement heifers attaining puberty and conceiving as yearlings are vital for the efficiency of cow-calf operations.

Heifer reproductive development can be accelerated by intensive nutritional programs and/or exogenous reproductive hormones; however, these approaches are often costly and therefore unattractive to most beef producers. Recently, we determined that acclimation of heifers to human handling after weaning was an alternative to hasten puberty attainment and improve pregnancy rates without major financial commitments (Cooke et al., 2009a). We attributed this outcome to positive effects of acclimation on heifer disposition, given that excitable temperament is detrimental to heifer reproductive function (Cooke et al., 2009b). However, acclimation techniques were only evaluated in Brahman-crossbred heifers, whereas *Bos taurus* heifers, which represent the majority of replacement heifers in Oregon's cow-calf industry, are also expected to benefit from acclimation because they often exhibit excitable temperament. Thus, our main hypothesis is that Angus × Hereford (*B. taurus*) heifers exposed to handling acclimation procedures for 30 d after weaning will experience improved temperament, hastened puberty attainment, and improved reproductive performance compared to non-acclimated cohorts.

Materials and Methods

The experimental period was divided into a sampling phase (d 0 to 220) and a breeding phase (d 221 to 300). A total of 38 Angus × Hereford heifers were weaned at 7 months of age (September, 2009) and initially evaluated for body weight (BW), puberty status, and temperament score within 45 d after weaning (October; d 0 and 10). Heifer puberty status was evaluated via plasma progesterone concentrations (> 1.0 ng/mL; Perry et al., 1991). Heifer temperament was evaluated by chute score and exit velocity. Chute score was assessed by a single technician based on a 5-point scale, where 1 = calm, no movement, and 5 = violent and continuous struggling. Exit velocity was assessed by determining the speed of the heifer exiting the squeeze chute by measuring rate of travel over a 7-feet distance with an infrared sensor (FarmTek Inc., North Wylie, TX).

On d 11, heifers were stratified BW, puberty status, and temperament score, and randomly assigned to receive or not (control) the acclimation treatment. Heifers were maintained on separate meadow foxtail (*Alopecurus pratensis* L.) pastures according to treatment, and received supplemental mixed alfalfa-grass hay. The acclimation process (d 11 to 39) consisted of bringing assigned heifers to the cattle working facility three times weekly, where heifers were exposed to common handling practices, and returned to pasture within two hours. Control heifers remained undisturbed on pasture.

During the sampling phase, heifer puberty status and body weight were assessed twice monthly on a 10-d interval (d 40 and 50, November; d 70 and 80, December; d 110 and 120, January; d 140 and 150, February; d 170 and 180, March; d 210 and 220, April) in addition to the initial evaluation (d 0 and 10, October). Heifer body weight gain during the sampling phase was calculated by averaging the values obtained within the monthly 10-d interval sampling; whereas heifer shrunk body weight was collected on d 1 and 221 for calculation of heifer average daily gain. Blood samples collected on d 10 and 40 were evaluated for concentrations of plasma substances associated with behavioral stress response, such as cortisol (Endocrine Technologies Inc., Newark, CA, USA), ceruloplasmin and haptoglobin (Arthington et al., 2008). Heifer temperament was also evaluated on d 40 and 220 to evaluate treatment effects. During the breeding phase, heifers were assigned to an estrous synchronization + timed-AI protocol beginning on d 222, and then exposed to mature Angus bulls for 50 d, beginning on d 250.

Growth, temperament, and physiological data were analyzed using the MIXED procedure (SAS Inst. Inc., Cary, NC). The model statement used for analysis of temperament, BW gain, and physiological data contained the effects of treatment, time variables when appropriate, and the resultant interactions. Data were analyzed using heifer(treatment) as random variable. Puberty data were analyzed with the GLM and LOGISTIC procedures of SAS. The model statement contained the effects of treatment, time of estimated puberty establishment, and the appropriate interaction. Results are reported as least squares means and were separated using LSD. Significance was set at $P \leq 0.05$, and tendencies if $P > 0.05$ and ≤ 0.10.

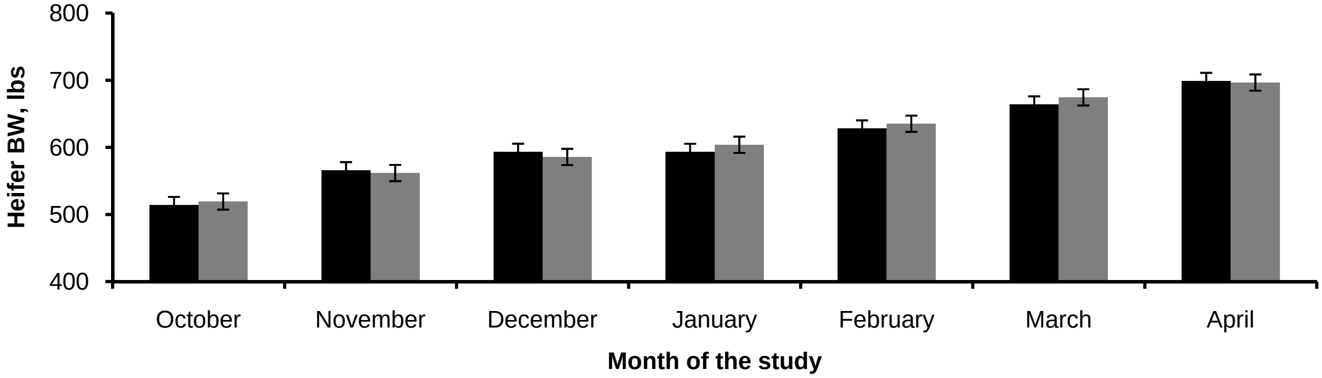

Figure 1. Body weight (BW) of heifers exposed or not (control) to handling acclimation procedures. A treatment effect was not detected (P = 0.88).

Results

No treatment effects were detected for average daily gain during the study (0.96 vs. 0.88 lbs/d for acclimated and control heifers, respectively; P = 0.31, SEM = 0.05), indicating that heifer growth was not affected by the acclimation process. Similarly, monthly BW did not differ between treatments (Figure 1). These outcomes were expected given that heifers from both treatments were assigned to the same nutritional regimen. Conversely, in our previous effort with Brahman-crossbred heifers (Cooke et al., 2009a), acclimated heifers had reduced growth rates compared to control cohorts. In that study, heifers had to walk nearly 1.3 miles in addition to the activity inside the handling facility during each of the acclimation procedures. In the present study, however, pastures were closer to the handling facility, and heifers had to walk 0.3 miles during each of the acclimation procedures. Therefore, the reduced amount of exercise required by acclimated heifers during the acclimation process prevented a similar decrease in growth rates as reported by Cooke et al. (2009a)

After the acclimation process, acclimated heifers had reduced plasma concentrations of cortisol and haptoglobin compared to control cohorts (Table 1). Supporting our results, previous research indicated that acclimation of cattle to handling procedures was an alternative to prevent elevated concentrations of cortisol in response to handling stress (Crookshank et al., 1979; Curley et al., 2006; Cooke et al., 2009a). Further, cortisol is known to elicit an inflammatory reaction and increase circulating concentrations of haptoglobin (Cooke et al., 2010), what may explain the reduced plasma haptoglobin concentrations in acclimated heifers compared to control cohorts.

A treatment x day interaction was detected for chute exit velocity because acclimated heifers tended (P = 0.08) to have greater exit velocity after the acclimation process, but reduced (P = 0.02) exit velocity on d 221 compared to control cohorts (Table 1). These results were unexpected because the acclimation process was expected to reduce chute score and chute exit velocity at the end of the acclimation period, and support the results detected for plasma cortisol and haptoglobin (Cooke et al., 2009a). Still, decreased exit velocity prior to breeding indicates that the acclimation process modulated, at least partially, temperament of acclimated heifers.

Table 1. Temperament and plasma concentrations of cortisol and acute-phase proteins in replacement heifers exposed or not (control) to handling acclimation procedures. Plasma samples collected on d 10 served as covariate; therefore, results reported for d 40 are covariately adjusted least squares means.

Item	Acclimated	Control	SEM	P-Value
Chute Score (1 to 5 scale)				
d 10	1.94	2.00	0.14	0.80
d 40	1.58	1.84	0.14	0.21
d 230	2.16	2.09	0.15	0.73
Exit velocity (yard/s)				
d 10	2.42	2.50	0.22	0.80
d 40	2.09	1.53	0.22	0.08
d 230	2.37	3.15	0.23	0.02
Ceruloplasmin (mg/dL)				
d 10	22.9	22.3	0.8	0.98
d 40	22.6	22.6		
Haptoglobin (450 nm x 100)				
d 10	5.3	5.3	0.2	0.01
d 40	5.3	5.9		
Cortisol				
d 10	37.0	33.7	4.3	0.04
d 40	25.7	34.1		

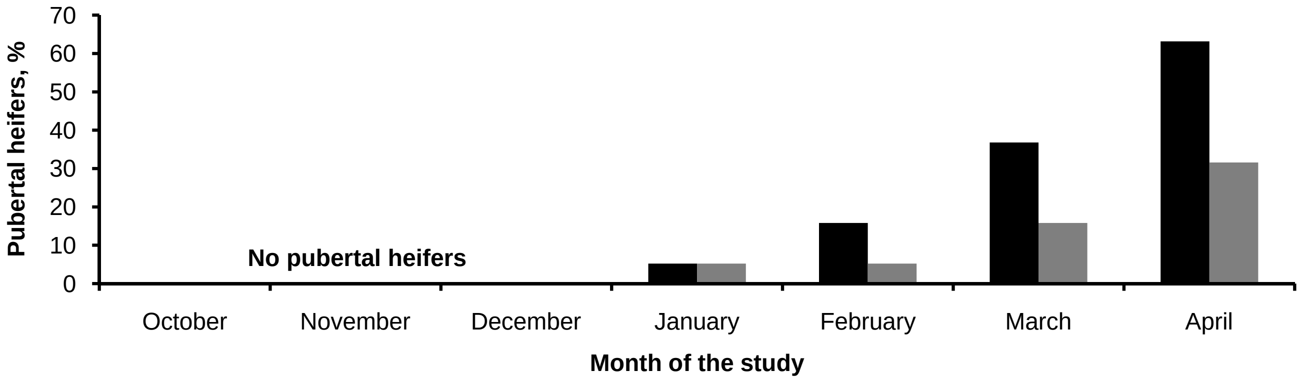

Figure 2. Puberty attainment, according to 10-d interval evaluations, of heifers exposed or not (control) to handling acclimation procedures. A treatment effect was detected (P = 0.01).

Puberty attainment was hastened (P = 0.01) in acclimated heifers compared to control cohorts. Prior to breeding, a greater (P = 0.02) number of acclimated heifers were pubertal compared to control cohorts (Figure 2). Supporting our main hypothesis and previous research (Cooke et al., 2009a), acclimated heifers in the present experiment had reduced cortisol concentrations and hastened onset of puberty compared with non-acclimated cohorts. Nevertheless, the mechanisms by which acclimation procedures hastened puberty attainment remain unclear. Based on our hypothesis, it can be speculated that reduced cortisol concentrations in acclimated heifers facilitated the initiation of the physiological events required for puberty attainment, particularly the first ovulatory LH surge (Smith and Dobson, 2002). Although concentrations of cortisol were only evaluated when heifers were handled and restrained for blood collection, one can speculate that acclimated heifers also had reduced cortisol concentrations compared to control heifers on a daily basis given that heifers from both groups were often exposed to brief human interaction, particularly because of feeding and traffic of personnel/vehicles within the research station. Still, additional research should be conducted to further address these assumptions.

Conclusions

Acclimation of *B. taurus* heifers to handling procedures and human interaction partially affected heifer temperament, but reduced circulating concentrations of stress-related hormones and metabolites, and hastened attainment of puberty. Therefore, acclimation of replacement heifers to human handling, independently of breed type (Cooke et al., 2009), after weaning may be an alternative to enhance their reproductive development and increase the efficiency of heifer development programs in cow-calf operations..

Acknowledgements

This research study was funded by the Oregon Beef Council and the Agricultural Research Foundation. We would like to thank Alexandre Scarpa, Frederico Nery, Lynn Carlon, Tony Runnels, Aaron Kennedy, Skip Nyman, and Flavia Cooke for their assistance in this study.

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Oregon State University

Beef Cattle Sciences

BEEF046

Oregon Beef Council Report

Effects of Temperament on Reproductive and Physiological Responses of Beef Cows [1]

Reinaldo F. Cooke [2], Chad Mueller [3], Tim DelCurto [4], and David W. Bohnert [5]

Synopsis

Excitable temperament is detrimental to reproductive performance of beef cows.

Summary

A total of 435 multiparous lactating Angus × Hereford cows, located at two different OSU research stations (Burns, n = 241; Union, n = 192) were sampled for blood and evaluated for body condition score (BCS) and temperament prior to the beginning of the breeding season. Temperament was assessed by chute score and chute exit velocity score, which were combined into a final temperament score (1 to 5 scale; 1 = calm temperament, 5 = excitable temperament). Cows were classified according to the final temperament score (≤ 3 = adequate temperament, > 3 = excitable temperament). Blood samples were analyzed for plasma concentrations of cortisol, haptoglobin, and ceruloplasmin. During the breeding season, cows were exposed to mature Angus bulls for a 50-day breeding season (1:18 bull to cow ratio). However, cows located at the Union station were also assigned to an estrus synchronization + timed-AI protocol prior to bull exposure. Pregnancy status was verified by detecting a fetus with rectal palpation approximately 180 days after the breeding season. Plasma cortisol concentrations were greater ($P < 0.01$) in cows with excitable temperament compared with cohort with adequate temperament (19.7 vs. 15.1 ng/mL, respectively). No effects were detected ($P > 0.15$) for BCS and plasma concentrations of haptoglobin and ceruloplasmin. Pregnancy rates tended to be reduced ($P = 0.10$) in cows with excitable temperament compared with cohort with adequate temperament (89.3 vs. 94.0 % as pregnant cows divided by total exposed cows, respectively). Further, the probability of cows to become pregnant during the breeding season was affected quadratically ($P = 0.05$) by temperament score (91.4, 95.0, 94.3, 87.6, and 59.3% of pregnancy probability for temperament scores of 1 through 5, respectively). Results from this study indicate that excitable temperament is detrimental to reproductive performance of *B. taurus* beef cows, independently of BCS and breeding system.

Introduction

The major objective of cow-calf operations is to produce one calf per cow annually. Therefore, management procedures targeted to enhance reproductive performance of the cowherd are required for optimal profitability of cow-calf operations. The development of such management strategies are based upon recognition of traits that affect reproductive function in cattle. Recently, we

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determined that behavioral and physiological measures associated with excitable temperament were detrimental to pregnancy rates of brood cows Cooke et al., 2009). However, this evaluation was only performed in Brahman-crossbred cows, whereas *B. taurus* cows, which make up the majority of Oregon's cowherd, also exhibit excitable temperament. Thus, our hypothesis was that reproductive performance of *B. taurus* cows is also influenced by temperament and the physiological events associated with this trait. Our objectives were to determine the effects of temperament, assessed at the beginning of the breeding season, on blood measurements and reproductive performance of *B. taurus* cows.

Materials and Methods

This experiment was conducted from April 2009 to April 2010 at the Eastern Oregon Agricultural Research Center – Burns and Union stations, in accordance with an approved Oregon State University Animal Care and Use Protocol.

A total of 435 multiparous lactating Angus × Hereford cows (Burns, n = 241; Union, n = 192) were sampled for blood and evaluated for body condition score (BCS) and temperament within 2 weeks prior to the beginning of the breeding season. Temperament was assessed by chute score and exit velocity. Chute score was assessed by a single technician based on a 5-point scale, where 1 = calm, no movement, and 5 = violent and continuous struggling. Exit velocity was assessed by determining the speed of the cow exiting the squeeze chute by measuring rate of travel over a 7-feet distance with an infrared sensor (FarmTek Inc., North Wylie, TX). Further, cows were divided in quintiles according to their exit velocity, and assigned a score from 1 to 5 (exit score; 1 = slowest cows; 5 = fastest cows). Individual temperament scores were calculated by averaging cow chute score and exit score (1 to 5 scale; 1 = calm temperament, 5 = excitable temperament). Cows were classified according to the final temperament score (≤ 3 = adequate temperament, > 3 = excitable temperament).

Blood samples were harvested for plasma (centrifuged at 2,400 × g for 30 min), and frozen at -80°C on the same day of collection. Concentrations of cortisol were determined using a bovine-specific ELISA kit (Endocrine Technologies Inc., Newark, CA, USA). Concentrations of ceruloplasmin and haptoglobin were determined according to procedures described by Arthington et al. (2008).

During the breeding season, cows were exposed to mature Angus bulls for a 50-day breeding period (1:18 bull to cow ratio). However, cows located at the Union station were also assigned to a estrus synchronization + timed-AI protocol prior to bull exposure. Pregnancy status was verified by via rectal palpation 180 days after the breeding season.

Effects of temperament on blood parameters and pregnancy rates were analyzed with the MIXED and GLIMMIX procedures of SAS (SAS Inst., Inc., Cary, NC), respectively. The model statements contained the effects of temperament (1 to 5, or adequate vs. excitable temperament), herd, and the interaction. Blood data were analyzed using cow(temperament class × herd) as the random variable. The probability of cows becoming pregnant during the breeding season was evaluated according to temperament with the LOGISTIC procedure of SAS. Significance was set at $P \leq 0.05$ and tendencies were determined if $P > 0.05$ and $P \leq 0.10$.

Results

During the study, temperament score of 5 was not detected in any of the animals evaluated, given that cows with temperament extremely excitable are normally culled from the herd. Plasma cortisol concentrations were greater ($P < 0.01$) in cows with excitable temperament compared with cohort with adequate temperament (Figure 1). Similarly, cortisol concentrations increased as temperament score increased (Figure 2). These findings support previous data indicating that cattle with excitable temperaments experience elevated concentrations of cortisol during handling procedures, likely due to the stress of human handling (Cooke et al., 2009).

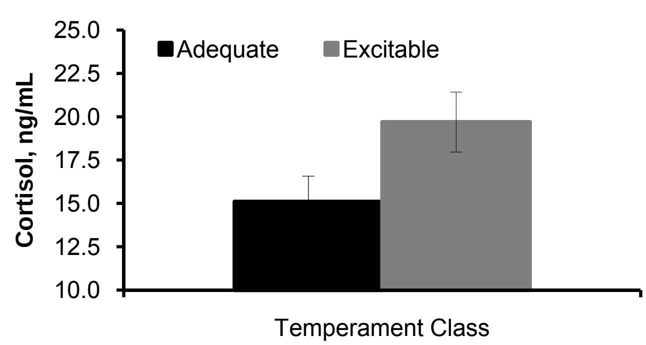

Figure 1. Plasma cortisol concentrations of cows classified according to temperament score (≤ 3 = adequate temperament, > 3 = excitable temperament). A temperament effect was detected ($P < 0.01$).

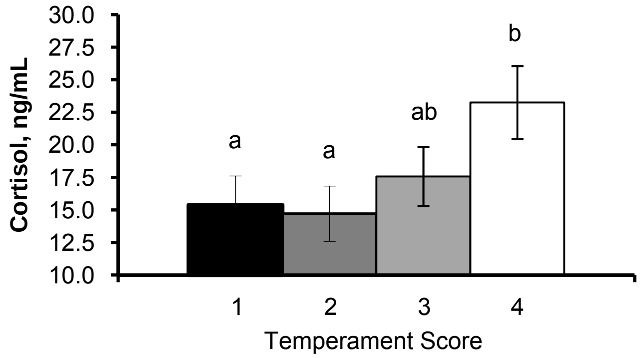

Figure 2. Plasma cortisol concentrations of cows according to temperament score (1 to 5 scale; 1 = calm temperament, 5 = excitable temperament). Values bearing a different letter differ (P < 0.05).

Pregnancy rates tended to be reduced (P = 0.10) in cows with excitable temperament compared with cohort with adequate temperament (Figure 3). No temperament effects were detected (P > 0.26) for BCS and plasma concentrations of haptoglobin and ceruloplasmin (Table 1), therefore, temperament effects detected on pregnancy rates were not associated with cow nutritional or health status (Cooke et al., 2009). Further, the probability of cows to become pregnant was affected quadratically (P = 0.05) by temperament score (Figure 4).

Table 1. Effects of temperament (score or class), assessed at the beginning of the breeding season, on BCS and plasma concentrations of haptoglobin (450 nm × 100) and ceruloplasmin (mg/dL) in beef cows.

Item	BCS	Haptoglobin	Ceruloplasmin
Temp. score			
1	4.7	7.1	11.8
2	4.6	6.2	11.7
3	4.6	6.8	12.1
4	4.6	6.9	12.5
SEM	*0.12*	*0.48*	*0.64*
P-Value	*0.93*	*0.17*	*0.82*
Temp. class			
Adequate	4.7	6.5	11.5
Excitable	4.6	7.0	12.5
SEM	*0.11*	*0.42*	*0.58*
P-Value	*0.45*	*0.21*	*0.15*

These results indicate that excitable temperament is detrimental to reproductive function of beef cows, independently of breeding system (AI or natural breeding) and breed type (*B. indicus* or *taurus*; Cooke et al., 2009). However, the biological mechanisms responsible for this effect are not completely understood. As reported herein, cattle with excitable temperament have increased plasma concentrations of cortisol, and this hormone directly impairs the synthesis and release of substances required for adequate reproductive function in cattle, such as GnRH and gonadotropins (Dobson et al., 2000). Further, the genetic relationship among behavioral and reproductive traits is still unknown, whereas a genetic evaluation might help explain why pregnancy rates are reduced in temperamental cattle. Therefore, additional research is required in to better understand the relationship between temperament and reproduction in beef cattle.

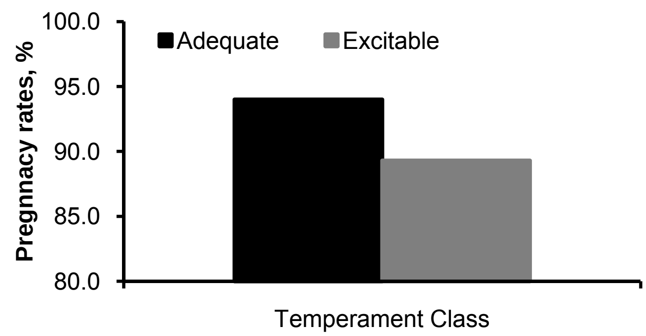

Figure 3. Pregnancy rates (pregnant cows / total cows) according to temperament score (≤ 3 = adequate temperament, > 3 = excitable temperament) in beef cows. A tendency for a temperament class effect was detected (P = 0.10).

Conclusions

Temperament is detrimental to reproductive performance of *B. taurus* beef cows, independently of BCS and breeding system. Therefore, management strategies that improve temperament of the cowherd will benefit reproductive efficiency and consequent productivity of cow-calf operations.

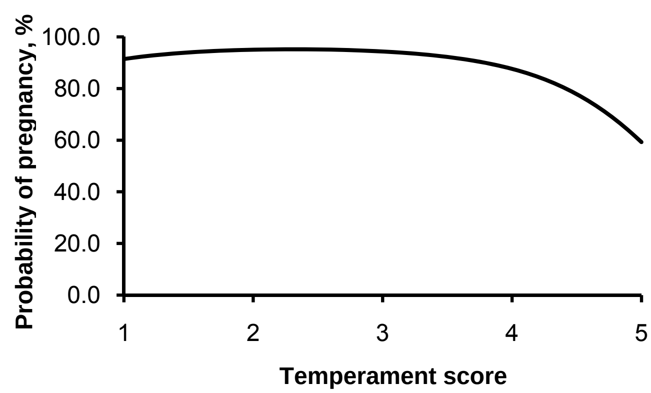

Figure 4. Effects of temperament score (1 to 5 scale; 1 = calm temperament, 5 = excitable temperament) on the probability of beef cows to become pregnant. This statistical analysis simulated probability of pregnancy in cows with temperament score of 5. A quadratic effect was detected (P = 0.05).

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Oregon State University

Beef Cattle Sciences

BEEF050

Oregon Beef Council Report

Preliminary Evaluation of Grandsire Marbling Potential and Ultrasound Use on Backgrounding and Finishing Performance, and Carcass Merit [1]

C. J. Mueller [2], T. DelCurto [3], R. R. Mills [4], C. P. Sullivan [5] and G. L.Tschida [5]

Synopsis

Grandsire marbling potential seems to influence carcass merit, but the magnitude of the impact seems gender-biased. The efficacy of carcass ultrasound to predict carcass merit prior to feedlot arrival seems inconclusive overall, but also gender-biased.

Summary

Forty-one crossbred calves were backgrounded and finished to determine the impact of grandsire marbling potential and ultrasound use on predicting carcass merit. Dams were sired by either a high marbling EPD (HIGH) or a low marbling EPD (LOW) Angus bull as evaluated by the American Angus Association, then bred to a common sire. Weaned calves were backgrounded for 60 d. Ultrasonography for marbling (UMARB), muscle depth (UMD), and backfat (UBF) took place at the beginning (d0) and end of the backgrounding period (d60), and again 72 days into the feedlot phase (d135). Daily gain was similar ($P > 0.10$) between grandsire groups during both phases. Heavier carcass weights, increased backfat, and larger ribeye area ($P < 0.05$) were evident in HIGH calves. A strong ($r > 0.50$) positive relationship between UBF, carcass backfat, and yield grade at d60 and d135 ($P < 0.05$) emerged across grandsires. Final marbling score had a weak positive relationship with UMARB at d0 and d60 ($P < 0.05$), but a strong positive relationship at d135 ($P < 0.05$). HIGH calves had stronger positive relationships between UMARB and final marbling score during both the backgrounding and finishing phases as compared to LOW calves. Though this data set is limited, it indicates that grandsire marbling potential may impact carcass merit through factors other than marbling, and use of ultrasound during the backgrounding phase to predict final carcass merit may be limited and dependent on marbling predisposition.

Introduction

Over the past decade or so consumer acceptance and subsequent preference for high marbled beef cuts have resulted in “value-added” premiums for beef cattle producers that supply highly marbled cattle (NCBA, 2005). As a result beef cattle producers have begun using sires proven to produce calves that have higher marbling potentials. Typically research has evaluated the terminal calf crops from these breeding selections, but less is known about the influence of carcass traits on retained heifer production and their

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Table 1. Summary of gain performance and carcass characteristics based on grandsire and gender influences.

Item	Grandsire		Gender		P values [a]		
	LOW	HIGH	Steers	Heifers	Grand sire	Gender	Grand sire x Gender
Background ADG, lb/d	2.19	2.48	2.38	2.29	NS	NS	NS
Finishing ADG, lb/d	3.82	4.00	4.06	3.76	NS	0.07	0.05
Carcass weight, lb	756	816	817	755	<0.01	<0.01	0.03
Backfat, in.	0.55	0.66	0.58	0.62	0.02	NS	NS
Ribeye area, in^2	13.4	14.3	14.6	13.1	0.01	<0.01	0.06
KPH, %	2.20	2.26	2.25	2.21	NS	NS	NS
Marbling score [b]	491	483	465	510	NS	0.06	NS
Yield grade [c]	2.89	3.13	2.85	3.17	NS	0.05	NS
Carcass value, $/100 lb [d]	130.25	128.49	128.37	130.37	NS	NS	NS

[a] NS = *$P > 0.10$.*
[b] 300 = slight (Se), 400 = small (Ch^-), 500 = modest (Ch^0), 600 = moderate (Ch^+).
[c] Calculated as: yield grade = 2.5 + (2.5*backfat) + (0.0038*carcass weight) + (0.2*KPH) – (0.32*ribeye area).
[d] Calculated as sale price plus/minus premiums/discounts for carcass weight, quality grade, yield grade, and value-added programs.

subsequent calf crops. Feedlot data (Vieselmeyer et al., 1996) indicates that marbling potential has minimal impact on feedlot feed conversions, but differences in growth potential can differentially impact feed conversions (Streeter et al., 1999). From that aspect, how do these carcass traits potentially influence the growth efficiency of retained daughters? If these daughters have lower feed conversions then that could result in a cowherd that requires more supplemental feed to maintain reproductive performance and pounds of calf weaned. The current study would be considered a case study and is evaluating the impact of two Angus grandsires with different marbling potentials (based on EPD's) on their daughter's initial calf crop.

Materials and Methods

All procedures involving animals were approved by the Oregon State University Institute of Animal Care and Use Committee. The calf crop used in the trial originated from dams sired by either a high marbling EPD Angus bull (HIGH; Marbling EPD: +0.90, Acc: 0.40) or a low marbling EPD Angus bull (LOW; Marbling EPD: +0.07, Acc: 0.46) as evaluated by the American Angus Association. These dams were then bred to a common sire and the resulting offspring's performance was evaluated during a 60d backgrounding and subsequent finishing phase. Forty-one head (n = 19 steers, 22 heifers; 629 ± 71 lb) were fed in a common pen during both phases. During the backgrounding period calves received a barley-based diet twice a day to ensure an ADG of 2.0 lb or greater (NRC, 1996). Gain performance was based on BW obtained at the beginning (d0) and conclusion (d60) of the backgrounding phase, midway (d135) through the finishing phase and at time of harvest (based on carcass weight). Calves were harvested when more than half the pen was determined to have 0.4 inches of backfat cover, based on visual appraisal by management.

Ultrasonography was used to evaluate efficacy of predicting carcass merit prior to the finishing phase. On d0, 60, and 135, measurements for intramuscular fat or marbling (UMARB), longissimus muscle depth (UMD), and subcutaneous fat or backfat (UBF) were obtained at the 12th to 13th-rib interface by an experienced technician. Ultrasound images were generated using an Aloka 500V (Aloka Co., Ltd, Wallingford, CT) B-mode instrument equipped with a 3.5-MHz, 125 mm general purpose transducer array (UST-5011U-3.5). Images were collected by a single technician with software from the Cattle Performance Enhancement Company (CPEC, Oakley, KS). Estimates of UBF, UMD, and UMARB were based on image analysis programming (Brethour, 1994) contained within the CPEC software program.

Table 2. Correlation coefficients of ultrasound measurements on d0, 60, and 135 with carcass traits based on grandsire marbling EPD.

	LOW				HIGH			
	Backfat	REA [a]	Marbling score	Yield grade [b]	Backfat	REA [a]	Marbling score	Yield grade [b]
				day 0 [c]				
UBF [f]	0.13			0.16	0.33			0.35
p-value	*0.65*			*0.58*	*0.10*			*0.08*
UMD [g]		0.32		0.70		0.38		0.12
p-value		*0.25*		*<0.01*		*0.06*		*0.54*
UMARB [h]			0.48	0.43			0.41	0.49
p-value			*0.07*	*0.11*			*0.04*	*0.01*
				day 60 [d]				
UBF [f]	0.70			0.77	0.49			0.56
p-value	*<0.01*			*<0.01*	*0.01*			*<0.01*
UMD [g]		0.49		0.24		0.30		0.06
p-value		*0.06*		*0.40*		*0.14*		*0.75*
UMARB [h]			0.44	0.37			0.41	0.26
p-value			*0.10*	*0.18*			*0.04*	*0.20*
				day 135 [e]				
UBF [f]	0.46			0.47	0.63			0.46
p-value	*0.10*			*0.09*	*<0.01*			*0.02*
UMD [g]		0.66		0.71		0.14		0.32
p-value		*0.01*		*<0.01*		*0.50*		*0.11*
UMARB [h]			0.55	0.47			0.71	0.40
p-value			*0.04*	*0.09*			*<0.01*	*0.05*

[a] Ribeye area.
[b] Calculated as: yield grade = 2.5 + (2.5*backfat) + (0.0038*carcass weight) + (0.2*KPH) – (0.32*ribeye area).
[c] Start of backgrounding phase.
[d] Completion of backgrounding phase.
[e] Finishing phase (72 days on feed).
[f] Ultrasound estimate of subcutaneous fat depth.
[g] Ultrasound estimate of longissimus dorsi muscle depth.
[h] Ultrasound estimate of intramuscular fat deposition (marbling).

Gain and carcass data were evaluated as a 2x2 factorial design with grandsire marbling EPD and sex as main effects and calf age as a covariate using the General Linear Model procedures of SAS (SAS Inst. Inc., Cary, NC). Pearson Correlation Coefficients between ultrasound measurements and carcass data were developed using the Correlation procedures of SAS.

Results

Grandsire data

Table 1 summarizes both performance and carcass merit for both LOW and HIGH calves. No differences ($P > 0.10$) were detected for ADG during either the background or feedlot phases. The HIGH calves had heavier carcass weights, increased backfat and greater ribeye area ($P < 0.05$). No differences ($P > 0.10$) were detected for KPH, marbling score, or calculated yield grade. The carcass data suggests that differences in grandsire marbling EPD's may not translate into daughters that produce calves with higher or lower marbling potential.

Table 3. Correlation coefficients of ultrasound measurements on d0, 60, and 135 with carcass traits based on gender.

	Steers				Heifers			
	Backfat	REA [a]	Marbling score	Yield grade [b]	Backfat	REA [a]	Marbling score	Yield grade [b]
				day 0 [c]				
UBF [f]	0.29			0.18	0.39			0.39
p-value	*0.23*			*0.45*	*0.07*			*0.07*
UMD [g]		0.33		0.38		0.60		0.52
p-value		*0.17*		*0.11*		*<0.01*		*0.01*
UMARB [h]			0.22	0.27			0.63	0.73
p-value			*0.37*	*0.27*			*<0.01*	*<0.01*
				day 60 [d]				
UBF [f]	0.42			0.58	0.81			0.77
p-value	*0.07*			*<0.01*	*<0.01*			*<0.01*
UMD [g]		0.09		0.26		0.52		0.19
p-value		*0.72*		*0.29*		*0.01*		*0.40*
UMARB [h]			0.25	0.35			0.44	0.26
p-value			*0.30*	*0.14*			*0.04*	*0.24*
				day 135 [e]				
UBF [f]	0.64			0.69	0.61			0.47
p-value	*<0.01*			*<0.01*	*<0.01*			*0.03*
UMD [g]		0.36		-0.04		0.21		0.67
p-value		*0.16*		*0.88*		*0.34*		*<0.01*
UMARB [h]			0.45	0.20			0.63	0.58
p-value			*0.07*	*0.43*			*<0.01*	*<0.01*

[a] Ribeye area.
[b] Calculated as: yield grade = 2.5 + (2.5*backfat) + (0.0038*carcass weight) + (0.2*KPH) – (0.32*ribeye area).
[c] Start of backgrounding phase.
[d] Completion of backgrounding phase.
[e] Finishing phase (72 days on feed).
[f] Ultrasound estimate of subcutaneous fat depth.
[g] Ultrasound estimate of longissimus dorsi muscle depth.
[h] Ultrasound estimate of intramuscular fat deposition (marbling).

Table 2 summarizes the pre-planned correlation coefficients between ultrasound timing and carcass merit based on grandsires. A moderate to high positive relationship was demonstrated between UMARB and carcass marbling score throughout the backgrounding and finishing phases for both grandsire groups. The stronger relationship (*0.55 vs. 0.71*) at d135 between UMARB and carcass marbling score in HIGH calves suggests that calves with a predisposition to deposit intramuscular fat may do so later in development and therefore are detected via ultrasonification during the finishing phase. The data also suggests that using ultrasound during the finishing period (and thus sorting cattle for different marketing windows) is strongly correlated with final carcass merit (especially backfat and marbling score). Due to the small size of this dataset some relationships resulting from grandsire influence may not be apparent at this time.

Gender data

Table 1 summarizes both performance and carcass merit for steers and heifers. As expected steers tended ($P < 0.10$) to have higher ADG during the finishing period, and produced a heavier carcass ($P < 0.05$). The steer calves also had larger ribeye area and better yield grade. Even with a small dataset the heifers tend ($P < 0.10$) to have higher marbling scores versus the steers.

Table 3 summarizes the pre-planned correlation coefficients between ultrasound timing and carcass merit based on gender. Unlike the grandsire data stark differences were detected in using ultrasound to predict final carcass merit early in the post-weaning period. The heifer data indicates strong relationships (*r* > *0.50*) between UMD and ribeye area, UMARB and marbling score, and both UMD and UMARB with yield grade early in the backgrounding period (d0). By the end of the backgrounding period (d60) the data still indicates a strong relationship between UMD and REA, but also between UBF and both backfat and yield grade. Though not as strong (*r* = *0.44*), UMARB was still highly associated with marbling score. These same relationships were not seen in the steer calves early in the feeding period. By d135 the relationships between UBF and backfat, UMD and REA, and UMARB and marbling score were becoming consistently stronger (*r* > *0.30*) across both steers and heifers, but the relationship was much more consistent and strong (*r* > *0.50*) for heifers. The one inconsistency with the heifer data is the relationship between UMD and REA during d135 (*r* < *0.30*). Many of these inconsistencies are probably due to the small size of the dataset, and therefore more cattle need to be added to determine reliable relationships, along with timing.

Implications

Though the dataset is small and represents only two different grandsires, the results suggest that grandsire selection can influence performance of calf crops from the retained daughters. Further research must be conducted to better understand how selection of sires based on carcass merit traits influence daughters that are retained in the cow herd and their subsequent calf crops. This data also suggests that the use of ultrasound prior to feedlot entry to predict and sort calves for marketing outcomes is possible, but may be influenced by genetics, gender, and their independent and/or complementary impact on compositional development (i.e., rate and site of fat deposition, etc.).

Acknowledgements

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Oregon State University

BEEF048

Beef Cattle Sciences

Oregon Beef Council Report

Selenium supplementation and retention in beef cattle [1]

Gene Pirelli [2] and Jean Hall [3]

Synopsis

Cows grazing selenium fertilized forage had significantly higher whole blood levels as compared to cows on mineral supplements. After the selenium was removed from the diet, the cows which grazed the selenium forage showed higher whole blood selenium levels for a longer period of time.

Summary

The purpose of this study was to evaluate Se supplementation strategies in mature beef cattle by measuring changes in whole-blood Se (WB-Se) status. Mature beef cows (n=45) were randomly assigned to 1 of 3 supplementation groups that received different Se species compared to a control. Supplementation treatment groups were provided a 6 week access to either sodium selenite (200 mg/kg Se; LSe, limited Se) or Se-fertilized pasture (FSe) and subsequently had no additional Se in their mineral supplement for the study duration. The LSe group cows grazed non-Se-fertilized pasture. The control supplementation group (CSe) grazed non-Se-fertilized forage and continuously received a mineral supplement (120 mg/kg Se from sodium selenite). Cows were bled pre and post grazing and then every 4 weeks thereafter for approximately 5 months. Cows in the FSe group had higher ($P<0.0001$) WB-Se concentration (186 ± 5 ng/mL) immediately post-grazing (42 d) compared to LSe (117 ± 5 ng/mL) and CSe cows (130 ± 5 ng/mL). WB-Se concentration in FSe cows remained higher ($P=0.02$ to $P<0.0001$) over the next 4 (CSe) and 5 (LSe) months. Higher ($P<0.05$) WB-Se concentrations were observed in CSe compared to LSe cows over the last 4 months of the study. Short-term exposure of cattle to Se-fertilized forage elevates WB-Se and is sufficient to maintain adequate concentrations throughout grazing periods when there is limited access to Se supplements.

Introduction

Selenium is an essential trace element with recognized nutrient-specific deficiency and toxicity diseases. Many parts of the world, including Oregon, are known to have soil conditions conducive to deficient forage Se content, potentially leading to clinical signs of Se deficiency in livestock grazing or fed crops raised on them (Stevens et al., 1985). This knowledge was gained through studies of a troublesome myopathy, called "white muscle disease" which annually killed or debilitated large numbers of calves in many Oregon counties. Other selenium deficiency symptoms include poor fertility, poor growth and lower immune responses. Although the essentiality of Se has been known for five decades, the most effective method of Se delivery to cattle is unclear. Se may be administered as an injection or in feed and mineral supplements, with Se provided as inorganic sodium selenite or selenate. One limitation of supplementing with inorganic Se

1. This document is part of the Oregon State University – 2010 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://beefcattle.ans.oregonstate.edu.
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in salt or feed is the apparent short duration of Se storage in the animal (Surai, 2006a, 2006b).

Natural Se sources in plants are organic forms, e.g., selenomethionine, selenocysteine, or Se-methylselenocysteine. When inorganic Se is fed to animals, selenocysteine is the main seleno-compound formed (Rayman et al., 2008). Following ingestion of organic Se, protein-bound selenomethionine is also formed from the non-specific incorporation of plant-derived selenomethionine in place of the amino acid methionine. Thus, Se accumulates in muscle by non-specific incorporation into proteins, and subsequently becomes available with protein catabolism. Both organic and inorganic forms of Se appear to be utilized in the body to produce specific selenoproteins, but Se enters at different points in cellular metabolism depending upon its chemical form (Rayman et al., 2008). With organic Se, it is possible to build Se reserves in the body, which are subsequently available in stress conditions when the Se requirement is increased but feed consumption is decreased (Surai 2006b).

Agronomic biofortification is defined as increasing the bioavailable concentrations of essential elements in edible portions of crop plants through the use of fertilizers. The potential for using Se-containing fertilizers to increase forage Se concentrations and, thus, dietary Se intake has been demonstrated in Finland, New Zealand, and Australia where it has proven to be both effective and safe (reviewed in Broadley et al., 2006; Makela et al., 1993; Whelan, 1989; Whelan et al., 1994a; Whelan et al., 1994b). We have recently shown in sheep that short-term exposure to Se-fertilized forage results in whole-body Se status sufficient to maintain adequate whole-blood Se (WB-Se) concentrations throughout grazing periods when there is limited access to Se supplements (Hall et al., 2009). The objectives of the current study were to evaluate changes in WB-Se status in beef cattle that received different Se supplementation programs.

Materials and Methods

Animals and Study Design

This was a trial of approximately 6-months duration involving 45 mature beef cows, primarily Angus, ranging in age from 5-to-11-years and originating from the Oregon State University Beef Ranch. Body weights ranged from 661 to 782 kg (729 ± 16 kg, mean ± SEM); body condition scores ranged from 7-to-8 (1-9 scale).The experimental protocol was reviewed and approved by the Oregon State University Animal Care and Use Committee.

Cows were randomly assigned to one of three treatment groups of 15 cows each, balanced by age. Ear tags were used to identify the cows. One group of cows (n=15) grazed Se-fertilized forage (FSe) for 6 weeks and had no additional Se in their mineral supplement. The mineral supplement contained 57.0 to 64.0 g/kg calcium; 30.0 g/kg phosphorus; 503 to 553 g/kg salt (NaCl); 50.0 g/kg magnesium; 50 mg/kg cobalt; 2,500 mg/kg copper; 200 mg/kg manganese; 200 mg/kg iodine; 6,500 mg/kg zinc (Wilbur-Ellis Company, Clackamas, OR). A second limited Se supplementation group (LSe; n=15) had free-choice access for 6 weeks to a custom-made mineral supplement that contained 200 mg/kg Se from sodium selenite. Other components of the mineral supplement were identical to the mineral supplement offered to the FSe cows (Wilbur-Ellis Company, Clackamas, OR). Average intake of the mineral supplement over the 6-week period for the 15 LSe cows was 24.0 g/day, thus providing 4.8 mg Se/day. These cows grazed on an identical pasture that was not Se-fertilized. Following the 6-week treatment period, FSe and LSe cow groups were combined and grazed a non-Se-fertilized pasture with no Se in their mineral supplement. The third supplementation group (control Se group, CSe; n=15) grazed non-Se-fertilized forage of similar composition but had continuous access to a free-choice mineral supplement containing 120 mg/kg Se from sodium selenite. Other components of the mineral supplement were identical to the mineral supplement offered to the FSe cows (Wilbur-Ellis Company, Clackamas, OR). Average mineral intake per cow in the CSe group was 26.4 g/day, thus providing 3.2 mg Se/day. After the 6 week treatment period all cows grazed non-Se-fertilized pasture until the forage dried up and then they were fed hay in addition to pasture (over the last 2 months of the study) that had been previously harvested from the same type of non-Se-fertilized pasture. The National Research Council beef cattle software (NRC, 2000) was used to generate estimated dry matter intake values for the cows using averaged body weight and measured forage analysis, with adjustment for NDF intake capacity. Estimated dry matter intake ranged between 14.8 and 16.4 kg/cow/day. Routine farm management practices were not altered.

Fertilized-Forage Pasture

The pasture type was primarily a subclover-tall fescue sward. Nitrogen was applied in the form of urea-sol fertilizer at a rate of 89.6 kg of actual nitrogen per hectare to 5.2 hectares in early spring. Sodium selenate (Selcote Ultra®; 10 g Se/kg as sodium selenate; Terralink, Vancouver, British Columbia, Canada) was mixed with the nitrogen fertilizer and applied at a rate of 3.4 kg/ha (34 g Se/ha). Pasture forage samples were obtained for Se analysis prior to fertilization and on days 1 and 42 relative to the grazing period, using a systematic grid pattern with one sample generated from 25 subsamples. Forage samples were submitted to a commercial laboratory (Center for Nutrition, Diagnostic Center for Population and Animal Health, Michigan State University, E. Lansing, MI) for forage Se levels.

Whole-Blood Selenium Assay

All cows were bled 7 days prior to study initiation (covariate value), at the end of the 6 week treatment period, and then every 4 weeks thereafter for approximately 5 months to collect whole blood for Se analysis. A subset of FSe cows (n=5) were also bled weekly during the treatment grazing period. Blood was collected into evacuated EDTA tubes and shipped on ice to a commercial laboratory (Center for Nutrition, Diagnostic Center for Population and Animal Health, Michigan State University, E. Lansing, MI) where WB-Se concentrations were determined using an ICP-MS method described by Wahlen et al. (2005) with modifications.

Statistical Analyses

Whole-blood Se concentrations were evaluated, after testing for normality, using an ANOVA method (Proc Mixed) for repeated measures accounting for covariance structure between time measurements (Statistical Analysis Software [SAS], ver. 9.1, Cary, NC). Cows in the CSe group tended ($P=0.11$) to have higher WB-Se concentrations at study initiation (135 ng/mL) compared to the other cows (107 ng/mL, FSe; 108 ng/mL, LSe) therefore, initial WB-Se concentrations were used as a covariate in all models. Model main effects were treatment group, time, and their interaction. For main effects found to be significant, mean differences were determined by pairwise differences or probability values for differences of the least-squares means (PDIFF) for preplanned comparisons.

Results

Forage Se concentration pre-fertilization was 0.11 mg/kg (DM basis). Forage Se concentration collected 62 days following fertilization, the day cows began grazing the pasture, was 1.52 mg/kg, and 42 days later, the day cows were removed from the pasture, it was 1.06 mg/kg. We reported a similar increase in Se concentration of forage (1.52 mg/kg) in response to application of the same rate of Selcote Ultra® in a previous study (Hall et al., 2009). Others have shown that Selcote Ultra® (10 g Se/kg as 1:3 sodium selenate:barium selenate) increased crop Se concentration from 0.067 to 0.187 mg/kg and 0.220 mg/kg at 5 and 10 g Se/ha, respectively (Gupta, 1995). A comparison across a limited number of studies that had varying amounts of Se applied per hectare demonstrates that there is a seemingly consistent linear response to Se dosage (Hall et al., 2009), although more studies are required to validate this relationship especially in light of known effects of soil pH, iron content, and other factors influencing Se availability to plant tissues (NRC, 1983).

Whole-blood Se concentrations were influenced ($P<0.0001$) by supplementation group, time and their interaction (Figure 1). Cows in the FSe group had higher ($P<0.0001$) WB-Se concentration (186 ± 5 ng/mL) immediately post-grazing (6 weeks) compared to cows in the LSe group (117 ± 5 ng/mL) and CSe group (130 ± 5 ng/mL). Whole-blood Se in FSe cows remained higher ($P=0.02$ to $P<0.0001$) over the next 4 (CSe) and 5 (LSe) months. Higher ($P<0.05$) WB-Se concentrations were observed in CSe cows compared to LSe cows over the last 4 months of the study. Within the subset of FSe cows, WB-Se concentrations were higher ($P<0.0001$) by 1 week of grazing compared to initial values and reached a peak within 4 weeks of initiating supplementation.

Based on average body weights and estimated dry matter intake, cows grazing Se-fertilized forage received approximately 15.6 to 24.9 mg organic Se/day. This is noticeably higher than the other groups. (LSe cows received 4.8 mg inorganic Se/day and CSe cows received 3.2 mg inorganic Se/day.) Inorganic Se intake for the LSe and CSe cow groups were based on calculated averages, because even though all cows had equal access to the salt-mineral mixtures, typical of free-choice mineral products, there potentially is significant individual variation in intake.

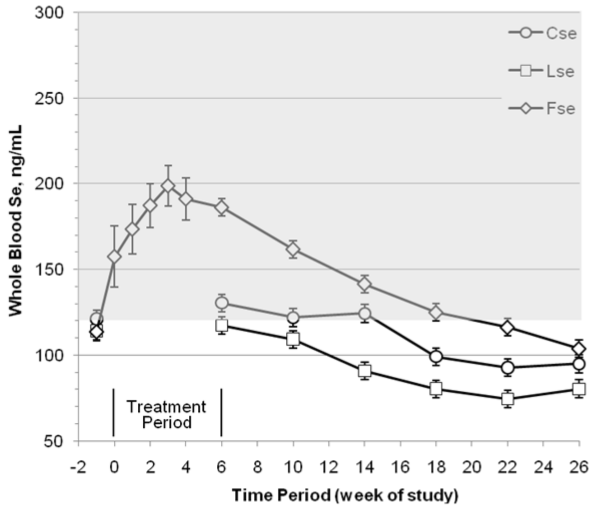

Figure 1. Comparison of whole-blood Se concentrations in cows consuming Se-fertilized forage (FSe) with no Se in mineral supplement (n=15), or limited Se (LSe, 200 mg/kg as selenite) in a mineral supplement (n=15) for 6 weeks. After 6 weeks the FSe and LSe cow groups were combined and grazed non-Se-fertilized forage. A control group of cows (n=15) received a continuous source of Se (CSe) from mineral supplement (120 mg/kg as selenite) throughout the study. Treatment periods began in May 2009 and lasted for 6 weeks (arrows). The normal reference interval for WB-Se concentrations of adult cows is shaded (120 to 300 ng/mL).

Although Se intake was higher for FSe cows, whole-blood Se concentrations did not exceed the laboratory's normal range. Nevertheless, the goal of this study was not to match Se intake between treatment groups, but rather to show that cows fed high-Se fertilized forage by itself (with no additional Se in their mineral supplement) benefited from higher Se intake compared with variable Se intake of cows receiving typical selenized salt-mineral mixtures. Indeed, WB-Se concentrations were higher, albeit within the normal reference interval, for a longer period of time in FSe cows that received no Se containing salt-mineral supplement compared with LSe cows that received the salt-mineral supplement containing Se. (The normal reference interval for WB-Se of adult cows at the Michigan State University diagnostic laboratory is 120 to 300 ng/mL [RVS, personal communication]). Short-term exposure of cattle to Se-fertilized forage elevated WB-Se within several weeks and levels were sufficient to maintain adequate concentrations throughout grazing periods when there would be limited access to Se supplements. Short-term exposure to higher levels of inorganic Se supplementation (200 mg/kg) was not equivalent to ongoing inorganic Se supplementation at lower rates (120 mg/kg).

The salt-mineral supplement containing 200 mg/kg Se as sodium selenite is normally diluted with salt to provide 120 mg/kg Se as per Food and Drug Administration (FDA, 2009) regulations for a free-choice salt-mineral mixture, and consumed at a rate not to exceed an intake of 3 mg/head/day. In the United States, the FDA (2009) also regulates Se supplementation to ruminant diets at a level of 0.3 mg/kg Se from either sodium selenite or selenate. An organic source of supplemental Se was cleared by the FDA for dairy and beef cattle in 2003; again, dietary inclusion was set at 0.3 mg/kg. Although the use of feedstuffs naturally high in Se to deliver supranutritional levels of Se is not regulated, Se fertilization is not permitted in the United States, with one exception. In Oregon, similar to in Finland, New Zealand, and Australia (reviewed in Broadley et al., 2006; Makela et al., 1993; Whelan, 1989; Whelan et al., 1994a; Whelan et al., 1994b), the Department of Agriculture does not control the use of Se as a plant fertilizer; therefore, it is possible to produce feedstuffs with increased Se concentrations by applying Se as a fertilizer.

In general, organic forms of Se are absorbed and retained more readily by ruminants than inorganic forms (Qin et al., 2007). Selenomethionine, the major dietary form of organic Se, can undergo several different metabolic fates. Cells do not distinguish between methionine and selenomethionine during protein synthesis, so selenomethionine is incorporated into general body proteins in place of methionine depending on the pool size of methionine and the number of methionine residues in protein (Shiobara et al., 1998). Selenomethionine incorporated into proteins in this manner is not regulated and reflects dietary intake of selenomethionine. On the other hand, inorganic selenite is rapidly taken up by red blood cells (RBC), and then released into plasma after reduction to hydrogen selenide (H_2Se), which is the key central molecular form of Se in regulated Se-metabolic pathways (Fairweather-Tait et al., 2010). Organic selenomethionine also functions as a source of Se for the synthesis of selenoproteins (after being metabolized to H_2Se), but because of its interchangeability with methionine during protein synthesis, a major difference between organic and inorganic Se supplements is that the half-life of Se as selenomethionine, at least in humans, is twice that of Se from sodium selenite (Swanson et al., 1991). Also, with organic Se, it is possible to build Se reserves in the body, which are subsequently available in stress conditions when the Se requirement is increased, but feed consumption is decreased (reviewed in Surai, 2006b).

Conclusions

Short-term exposure of cattle to Se-fertilized forage elevates WB-Se within several weeks and levels are sufficient to maintain adequate concentrations throughout grazing periods when there is limited access to Se supplements. This procedure would have practical and useful applications for beef operations which cannot provide mineral supplements for cattle for extended periods of time. The retention of selenium in the animal from a short duration supranutritional dose such as a selenium fertilized pasture results in adequate levels for many months.

Short term exposure to higher levels of inorganic Se supplementation is not equivalent to ongoing inorganic Se supplementation at lower rates.

Acknowledgements

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Beef Cattle Sciences

Oregon Beef Council Report

Progress Reports – Animal Sciences

A pilot study to evaluate the association of metabolic disorders in early lactation and the incidence of anoestrus in dairy cows

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Project Objectives: To objectively measure the association between early metabolic disease and the incidence of anoestrus in dairy cattle.

Project Start Date*:* August 2010
Expected Project Completion Date: July 2011

Project Status: As of the end of October 2010 a total of 55 cows will have been enrolled in the study. Blood samples have been collected from all of these animals for 7 days after calving and the CBC and chemistry parameters have been assessed. Data on milk composition, body weight, activity and resting time are being continuously collected by our on-farm monitoring system on a twice daily basis. The next step is to categorize the animals into a group of cows that have had clinical metabolic post-partum disease, a group of cows with sub-clinical metabolic disease and a group of cows that have not had metabolic disease. Then data from the blood analyses, milk composition, body weight, activity and resting data will be statistically analyzed for possible correlations with reproductive data collected up to conception time for each cow. Data is expected to be published in the next edition of the Oregon Beef Council Report, and presented at extension and scientific meetings.

Effects of disposition and acclimation to human handling on feedlot performance and carcass characteristics of feeder steers

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Project Objectives: This study will be divided into two experiments. The objective of experiment 1 is to determine the effects of disposition on feedlot performance and carcass quality of feeder steers originated from a typical Oregon cow-calf operation. The objectives of experiment 2 are to compare disposition, blood measurements associated with behavioral stress response, feedlot performance, and carcass characteristics of feeder calves exposed or not to handling acclimation procedures after weaning.

Project Start Date: September 2010
Project Completion Date: July 2012

1. This document is part of the Oregon State University – Beef Research Reports. Published in November 2009. Please visit the Beef Cattle Sciences website at http://beefcattle.ans.oregonstate.edu.

Project Status:
Experiment 1: In September 2010, 115 steers and heifers from the EOARC-Burns were weaned and evaluated for disposition by measurement of chute score (1 to 5 scale, where 1 = calm behavior and 5 = aggressive behavior while restrained in the chute) and exit velocity (in feet/second using infrared sensors). Calves remained at the EOARC-Burns for 30 days for preconditioning, and shipped to a feedyard in Echo, OR. **To date, calves have been on feed for approximately 60 days.** In the feedyard, mortality and morbidity incidences are being monitored daily until slaughter. Calf body weight gain will be calculated using values obtained at weaning, shipping, and slaughter. Calves will be harvested at a commercial packing facility next summer (Tyson Fresh Meats, Pasco, WA). The following carcass characteristic will be obtained 24 h post-harvest: USDA Yield Grade, hot carcass weight, 12th-13th rib adjusted fat thickness, longissimus area, KPH%, USDA Quality Grade, and USDA marbling score. Dark cutting will be scored for severity in units corresponding to quality grade discounts (no discount, 1/3, 2/3, and full grade discount). Carcass bruises will be assessed based on the number (0, 1, 2, 3, 4, and 5 or more), location (round, loin, rib, chuck, and flank plate or brisket), and severity (minor, major, critical, and extreme). *The same experimental procedures will be applied to 115 weaned calves in 2011 to complete the proposed 2-year data collection.* Data from 2010 will be published in the next edition of the Oregon Beef Council Report as a full article, and presented at extension and scientific meetings. Data from both years will be combined, analyzed, and published into extension materials and scientific literature.

Experiment 2: In 2011, 60 Angus × Hereford steers will be weaned at 7 months of age (September 2011), and utilized in this experiment. More information about this project will be provided as a progress report in the 2011 edition of the Oregon Beef Council Report.

Impact of nutrient resources during bull development on calf crop growth through slaughter

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Project Objectives: Approximately 100 to 120 head of the 2010 calf crop (approximately 50 to 60 head from each sire group, see below) will be used to evaluate carbohydrate intake on GRAIN versus GRASS growth performance during the backgrounding/growing period, and subsequent impact on feedlot performance and carcass merit. At time of weaning all calves will be sorted by sire then randomly allotted to backgrounding management (FIBER = forage-based diet, STARCH = grain-based diet). Each pen of calves will be backgrounded for approximately 60 days, at which time all calves will be transported to an area feedlot for finishing.
Sire groups: GRASS: Pinebank Waigroup 41/97 (a New Zealand born and developed registered Angus bull), GRAIN: CRA Bextor (American Angus Sire; U.S. born and developed "middle of the road" registered Angus bulls).

1) Evaluate the impact of sire selection on calf performance during the backgrounding period when fed either a starch-based diet or a fiber-based diet.
2) Evaluate the carryover effects (i.e. feedlot gain, health, etc.) of backgrounding diet on feedlot performance and carcass merit across both sire sources.
3) Compare cost analyses of both sire sources across backgrounding programs and against each other.

Project Start Date*:* November 2010
Expected Project Completion Date: October 2011

Project Status: As of this report we are approximately 2 weeks from weaning calves that will partake in this project. We are tentatively scheduled to begin the backgrounding phase the 2nd week of November (2010), followed by finishing all calves starting approximately the middle of January 2011. Based on past feedlot records, calves should begin to be harvested around the end of June 2011 (finished by end of July 2011).

Improving calf performance, carcass characteristics, and ranch profitability by extending the grazing season with warm season grasses and *Brassica* forages

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Project Objectives: The main objective of this research is to determine whether use of warm season grasses and brassicas can extend the grazing season by improving forage quality into the summer months and positively affect calf weaning weights, feedlot performance, carcass characteristics, and ranch profitability. Since the OSU Soap Creek Ranch will be used to conduct this research, another objective includes providing a demonstration, teaching, and learning venue for faculty, students, and beef industry producers and service providers. The overall goal of this project is to meet a current need for recommendations on production methods and economic information for decision making on effectively utilizing improved forages in Oregon's beef production systems.

Project Start Date*:* May 2010
Expected Project Completion Date: March 2013

Project Status: In May 2010, two treatments (pasture type) were set up. One 15-ac field was disked, rototilled, and planted to Sorghum x Sudangrass (SxS) and brassica forages (forage turnips and grazing radishes) to establish an extended (EXT) season grazing pasture while soil moisture conditions were favorable at that site. An existing 15-ac field with cool season forages such as fescue, ryegrass, subterranean clover, and meadow foxtail was maintained as a control pasture (CON). Each pasture (treatment) was divided into 3, 5-ac paddocks (replicates of experimental unit) via electric fence. Because of the unusually cool spring weather, SxS grasses grew slowly and EXT was not ready to graze until late July. Each paddock was then subjected to strip-grazing by 5 cow-calf pairs (cows with steer calves only) selected from the spring-calving herd. Calves were stratified across treatments and replicates by weight and age. Forage was monitored for nitrate and prussic acid levels and found to be safe for grazing. Cattle were acclimated slowly to treatments and, using additional electric fencing, allowed to strip-graze the paddocks until calves were weaned at the end of August. Forage samples were collected periodically for determination of yield (availability and residual dry matter, DM) and indicators of quality (protein and fibers), weighed, dried, and stored for future laboratory analyses. Initial, intermediate, and final calf weights and cow body condition scores were recorded. After weaning, calves were preconditioned for 45 days and sent to the feedlot where performance data is being collected. At harvest, carcass characteristics will be evaluated. Economic analysis on cost of production will then be determined. As soon as all the 2010 data is available, it be statistically analyzed, published in the next edition of the Oregon Beef Council Report, and presented at extension and scientific meetings. The same research protocol will be conducted in 2011, except that the SxS will be planted when soil temperatures are 60 degrees (regardless of anticipated soil moisture). As indicated in other plantings around western Oregon, this should improve growth and allow for an earlier start and longer duration of the experimental grazing period. Data from both years will be combined, analyzed, and published into extension materials and scientific literature.

Outreach, technical assistance and general project facilitation for farm-based livestock manure/biogas production systems

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Project Objectives: This project is meant to assist producers in the development of renewable energy projects. Often the work is with developers and agencies willing to build or fund anaerobic digesters.

Project Start Date*:* August 2007
Expected Project Completion Date: December 2011

Project Status: To date, information on anaerobic digesters and energy conservation has been delivered to 30 producers. Some of these producers are now working with Revolution Energy Solutions (RES) of Washington, D.C.; Andgar Corporation, Ferndale, WA; GHD, Inc., Chilton, WI; and Farm Power Northwest, Mount Vernon, WA identified as developers willing to design, fund, and operate digesters in Oregon. RES has been successful in siting a digester on a dairy near Junction City and signed the power purchase agreement with the Emerald Public Utility District. The digester will be operational in November. RES has 5 other operations in the Willamette Valley going through permit approvals now, with ground-breaking on a Salem dairy due in December. The power from these will be sold to Pacific Power and Light and Portland General Electric. Farm Power is developing a design and starting permitting for a digester in Tillamook that will use the manure from 2 or 3 farms.

Production value and efficiencies of replacement beef heifers sired by either high or low-marbling bulls

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Project Objectives: This is a 2-year study evaluating the impact of sire-marbling traits on replacement heifer production efficiencies and subsequent calf crops. This project is designed to evaluate reproductive performance, growth and maintenance of body condition in heifers sired by either a high-marbling (HIGH) bull or a low-marbling (LOW) bull. The impact of grandsire marbling traits on calf crop performance (gain and health) and value (carcass) will also be evaluated.

Project Start Date*:* May 2008
Expected Project Completion Date: December 2010

Project Status: Previous report: Ninety-two (from an original 102 head) replacement heifers were initially ultrasonographed in May 2008. At the time of ultrasound, a blood sample was also collected from each heifer for analysis of growth hormone (GH), insulin-like growth factor 1 (IGF-1), leptin and ghrelin. Samples for leptin and ghrelin analysis were sent to South Dakota State University, but due to a backlog of samples they were not able to start analyzing the samples until February 2009. Reproductive performance and maintenance of body condition starting in May 2009 have been collected and analyzed. The gain performance and carcass merit of the first calf crop is currently being summarized.

Update: South Dakota State University was not able to finish analyzing my blood samples for GH, IGF-1, or Leptin. All samples were sent to Duane Keisler at Univ. of Missouri over the summer (2010) and were completed as of October 10th, 2010. Currently all data has been collected and a full summary and report is being prepared. Due to the delay in blood metabolite assays I was not able to finish the full report by the Fall report deadline, but will be completed by December 2010.

Protein supplementation of low-quality forage: Effects of amount and frequency of protein supplementation on ruminant performance and nutrient utilization

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Project Objectives: The objective of this research is to determine the influence of amount and frequency of protein supplementation on utilization of low-quality forage by ruminants. The treatments will be provision of a CP supplement at one of two levels of CP every day, every fifth day, or every tenth day. It is possible that ruminants consuming low-quality forage may be able to adapt to infrequent supplementation of CP by increasing their ability to recycle nitrogen, thereby improving efficiency of CP use. We hypothesize that as the supplementation interval increases ruminants will become more efficient in their use of supplemental CP. As a result, we should be able to provide LESS total CP and maintain performance comparable to more frequent supplementation of MORE total CP. This will not only save time and labor, but may decrease the amount and cost of supplement provided to beef cows consuming low-quality forage, and therefore increase economic returns of Oregon's beef producers.

Project Start Date: November 2010
Project Completion Date: November 2011

Project Status: Experimental protocol has been approved by Oregon State University's Animal Care and Use Committee. Steers have been fitted with ruminal fistulas and feedstuffs have been obtained. The metabolism and intake study is anticipated to begin in November of 2010 and conclude in March 2011. Also, the cow performance study is scheduled to take place during the last third of gestation (January through March 2011). We plan on providing the final progress report to the Oregon Beef Council in December of 2011.

Rumen characteristics and forage digestibility of low, medium and high quality forages supplemented with various levels of dietary glycerol

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Project Objectives: This study is designed to evaluate total tract digestibility, rate of ruminal nutrient digestibility, and rumen fermentation characteristics of various glycerol inclusion levels fed with low-, medium-, or high-quality forages.

Project Start Date*:* February 2009
Expected Project Completion Date: December 2010

Project Status: The animal collection portion of this project commenced in late February 2009. Four ruminally-fistulated steers were started on the 'LOW' period in February and concluded the first part of June 2009. During the 'LOW' phase steers received a wheat straw-based diet with either 0%, 5%, 10% or 20% feed grade glycerol (DM basis). Over four collection periods each steer was exposed to each forage-glycerol combination. During each collection period the steers were given 10 days to adapt to the diet, followed by a 5-day sampling period. During the sampling period each steer was fitted with a fecal collection bag to determine diet digestibility, and rumen fluid samples and in-situ bags were utilized to determine rumen fermentation characteristics and rate of fiber digestibility. Starting in early July 2009 the steers were switched to the 'HIGH' phase; which was based on alfalfa hay. Similar to the LOW phase, each steer was exposed to either 0, 5, 10 or 20% glycerol. Starting in mid-September 2009 the steers were switched to the 'MED' phase; which was based on a mixed-grass hay.

Update: Upon summarizing the data this summer it was discovered that some of the lab analyses were compromised due to faulty equipment. All analyses in question have been re-analyzed and are currently being summarized. The full report should be completed by December 2010.

Oregon State University

BEEF051

Oregon Beef Council Report

Beef Cattle Sciences

Spatial-temporal Interactions of Beef Cattle and Wolves on a Western Idaho Rangeland[1]

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Synopsis

Positions of one member of a wolf pack and 10 members of a beef cattle herd on a western Idaho rangeland were monitored using GPS collars logging at 15- and 5-minute intervals, respectively. Data were analyzed to determine the timing, frequency, duration, and landscape position of wolf-cow interactions at 500, 250, and 100 m (547, 273, and 109 yd).

Summary

The objective of this experiment was to detect and evaluate interactions between free-roaming beef cattle (*Bos taurus*) and wolves (*Canis lupus*) using GPS technology. Ten mature, lactating beef cows from a herd of about 450 cow-calf pairs and 1 wolf from a pack of 13 wolves were GPS collared and tracked to determine spatial movement and interactions. Between 23 May and 30 November 2009 the collared 41 kg (90 lbs) male wolf occupied about 54,600 ha (211 mi^2) of land while the collared cows occupied about 6,500 ha (24.5 mi^2) during the grazing season. The wolf traveled an average of 18 km/day (11.3 mi/day) while collared cows traveled about 11 km/day (6.8 mi/day) on average. The collared wolf was recorded within 500 m (547 yd) of a collared cow 783 times during 137 days of interaction. Collared cows and wolf were within 250 m (273 yd) of each other 244 times and within 100 m (109 yd) 53 times during this same period. The wolf was in close proximity to cattle mostly between 10 PM and 6 AM. Interaction sites were mapped and compared to locations of confirmed wolf depredations. Proximity to roads or human habitations did not appear to exhibit any effect on the spatial location of wolf-cattle interaction or wolf depredation sites. It appears that human presence alone is not a strong deterrent to wolf depredation.

Introduction

Since the reintroduction of 31 gray wolves (*Canis lupus*) in central Idaho from southwestern Canada in the mid-1990s both wolf population and range have dramatically increased (U.S. Fish and Wildlife Service 2009). Wolves are now common in the northern Rocky Mountains with at least 1,706

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1. This document is part of the Oregon State University – 2010 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://beefcattle.ans.oregonstate.edu.

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wolves in 242 packs and 115 breeding pairs (U.S. Fish and Wildlife Service 2009). As wolves move into areas with cattle and sheep ranches the number of livestock killed or injured by wolves has increased. Ranchers report that livestock death and injury losses from wolves are difficult to find and confirm because livestock rearing occurs over large, often remote areas. They further report that depredation seriously impacts ranch income and harassment of livestock by wolves complicates ranch operations increasing livestock monitoring and health care workloads.

Accurate, rigorously collected information regarding the timing, frequency, duration and landscape position of wolf-cattle interactions is needed to fully assess the impacts of wolves, develop viable mitigation strategies that reduce wolf depredation, and formulate rational management and regulatory policies that protect ranching enterprises while simultaneously meeting national wildlife goals.

Materials and Methods

Study Area

The study area discussed in this report is one of 6 study areas located in western Idaho (3) and northeastern Oregon (3) that are involved in a large, long-term study of wolf presence effects on range cattle production. The focal study area is located in Adams County, Idaho (45.03°N, 116.65°W) where the topography consists of rugged mountains, steep canyons, and plateaus divided by dendritic stream drainages. Elevation of the study area ranges from 650 m (2,130 ft) to 2,310 m (7,580 ft). The 30-year average annual precipitation is about 710 mm (28.0 in) (Daley et al. 2010) with about 60% falling between November and March. The site has a continental/microthermal climate (Köppen Dsb) with the warmest month averaging below 22° C, but with at least 4 months averaging above 10°C (State Climate Services for Idaho 1999).

Vegetation on the study area consists of upland grassland, upland shrub/grassland, coniferous forest, and riparian dry and wet meadows. Deeper soils support coniferous forest while upland grasslands and upland shrub/grass communities occur on shallower, rocky sites with drier aspects. The complex interaction of topography and soils form a landscape where the lower elevations are grass-dominated, highest elevations are conifer-dominated and the mid elevations are occupied by repeating bands of grass and conifer-dominated vegetation which parallel drainages.

Animals and GPS Collars

Ten randomly-selected, mature, commercial cows from a herd of 450 cow-calf pairs were fitted with Clark GPS tracking collars (Clark et al. 2006) which logged collar locations every 5 minutes throughout the grazing season. Each collar location record included the collar latitude, longitude, elevation, speed, universal (GMT) date and time of acquisition, and information concerning the expected spatial accuracy of GPS locations. These location data were stored on the collar in a secure digital™ memory card immediately following each GPS acquisition. Cows were tracked on the study area from 4 April 2009 until mid November 2009. These custom-design collars produced approximately 60,000 locations per subject cow over the course of the grazing season.

On 22 May 2009 a 41 kg (90 lb) male gray wolf designated B446, was captured and fitted with a Clark GPS tracking collar augmented with a VHF radio transmitter. This collar recorded the wolf's locations at 15-minute intervals and continuously transmitted an audible beacon for use in traditional VHF radio tracking using directional antennas from aircraft or on the ground. The collared wolf, a member of the 13-member Snake River Pack, was tracked from 22 May 2009 to 12 December 2009 which yielded about 20,000 GPS locations

Data Processing

Upon retrieval of the GPS collars, data were downloaded, compiled and screened for errors using a variety of commercial (Microsoft Excel®, ArcGIS®, and Global Mapper®) and custom software analysis packages and a standardized protocol. Data were clipped to remove locations acquired before or after animals were on the study site or, in the case of the wolf, 1 day after collaring. Location data for the cattle and wolf were attributed with continuous topographic (elevation, slope, and aspect) variables using GIS and USGS source layers

Data Analysis

Cattle and wolf location data were used to determine minimum daily travel distance (MDTD) and minimum hourly travel distance (MHTD) which were calculated as the cumulative straight line distances between pairs of sequential GPS locations during each of the respective time periods. Location data were also used to derive minimum convex polygon (MCP) home range for wolf B446. Finally, the Euclidian distance from each wolf location to all collared cow locations of the same date and time (within 2.5 minutes) was calculated using a custom software program we wrote in Microsoft Visual Basic 6.0®. Output from this program was a comma separated values file with each date/time stamped wolf position attributed with the distance to each collared cow. These distance values were used to identify times and locations when wolf B446 was within 500, 250, and 100 m (547, 273, and 109 yd) of GPS collared cattle. Descriptive statistics for wolf-cattle interactions were calculated using Microsoft Excel®.

Table 1. Mean minimum daily travel distance† of collared cattle for the 2009 grazing season.

Animal	Mean Daily Travel Distance For 2009 (km)	Standard Deviation (km)
Collared Cow 1	10.34	3.84
Collared Cow 2	9.51	3.01
Collared Cow 3	13.31	6.03
Collared Cow 4	8.59	3.10
Collared Cow 5	9.91	4.15
Collared Cow 6	9.24	3.57
Collared Cow 7	13.57	6.79
Collared Cow 8	11.23	5.85
Collared Cow 9	13.61	6.03
Collared Cow 10	10.75	4.65
Collared Cow Mean	11.06	3.49

†Calculated as the cumulative straight line distance between sequential GPS location pairs recorded during each respective day.

Results

Wolf Monitoring

Between 23 May and 30 November 2009, wolf B446 traveled on average 18.34 km (11.4 mi) per day (MDTD) and occupied about 54,600 ha of land (211 mi^2) (Figure 1). Wolf B446 traveled substantially farther than collared cows which covered about 11 km (6.8 mi) per day (MDTD) (Table 1). Wolf B446 ranged from an elevation of 780 m (2,560 ft) near the Snake River to 1790 m (5,870 ft). Travel routes of this wolf were frequently on roadways or along ridgelines (Figure 1). Daily travel of B446 varied substantially (standard deviation = 7.65 km/day or 4.75 mi/day) from a minimum of 3.59 km (2.23 mi) to a maximum of 44.16 km (27.44 mi). Figure 2 reveals a roughly cyclic pattern in the variability of daily travel distances for wolf B446 between late May and late July 2009.

Table 2. Number of times GPS-collared wolf B-446 came within 500, 250, and 100 m (547, 273,109 yd) of GPS-collared cattle between 23 May and 3 November 2009 (duration of 137 days). Wolf B446 was being tracked at 15-min intervals while cattle were tracked at 5-min intervals. Logging times of the GPS collars were not synchronized.

Animal	500 m	250 m	100
Cow Collar 1	73	24	3
Cow Collar 2	121	43	5
Cow Collar 3	41	14	3
Cow Collar 4	61	10	0
Cow Collar 5	99	36	7
Cow Collar 6	140	37	12
Cow Collar 7	93	20	5
Cow Collar 8	23	4	1
Cow Collar 9	52	15	2
Cow Collar 10	80	41	15
Total	783	244	53

Hourly travel patterns of this wolf during the study period are presented in Figure 3. Wolf B446 was most active at night and traveled least in the late afternoon. Hourly travel distance increased sharply after 7 PM, peaked near midnight, and remained elevated until about 8 AM local standard time. This propensity toward night-time travel was also observed by Young and Goldman (1944).

Plotting the travel paths of wolf B446 (Figure 4) reveals focal areas where B446 returned numerous times during the course of the grazing season. We hypothesize these focal areas are likely to be den, rendezvous, and large-animal kill or scavenging sites. The wolf biology literature (Young and Goldman 1944, Ballard and Dau 1983, and Mech et al. 1988) indicate den and rendezvous sites function as hubs within wolf daily travel patterns. Similarly, we observed it was not unusual for wolf B446 to travel 10 km (6 mi) or more on a sojourn then return directly to what appear to be den and rendezvous sites (Figure 4).

Another one of these focal areas for wolf B446 was a group of 3 adjacent, relatively small cattle pastures of 489 ha (1208 acres) total where 14 confirmed and probable cattle depredations occurred in May and June 2009 despite frequent human presence (Figures 4 and 5). These pastures (hereafter referred to as the calving pastures) are located on an open hillside close to ranch buildings and homes so cattle can be easily observed during calving. The herd occupying the calving pastures in 2009 consisted of 317 first and second-calf heifers and was not part of the GPS tracking experiment, thus none of the herd was GPS collared. These cattle were visually monitored every few hours by the ranch calving crew who moved through the herd looking for birthing problems. As none of these cattle were GPS collared, we cannot rigorously detect and evaluate wolf-cattle interactions that may have involved B446 in this pasture. We can, however, use the B446 movement paths within and around the calving pastures to better understand this wolf's movement behavior when occupying an area of high prey density (Figures 4 and 5). On days when a confirmed depredation occurred in the calving pastures, it appears B446 tended to move directly over long distances from suspected den/rendezvous locations to the calving pasture (Figure 4), exhibited circular movement patterns within the pasture (Figure 5), and then returned directly to the suspected den or rendezvous sites. This hunting pattern was also noted by Young and Goldman (1944). We hypothesize these circular movement patterns indicate wolf interactions with the prey. We have also seen these circular movements by B446 at other locations within the study area and there seems to be correspondence between this pattern and confirmed wolf depredations. Consequently, we have begun investigating whether we can successfully identify undocumented wolf depredation sites in the study area based, at least in part, on these circular movement patterns in the wolf GPS data. In any case, examinations of wolf B446 travel paths clearly demonstrate human presence and activity were not strong deterrents to repeated wolf use of this focal area. Thiel et al. 1998 also reported tolerance of wolves to human disturbance.

When a depredation was observed on the ranch, it was reported to USDA/APHIS Wildlife Services and the calf carcass or injured animal was immediately removed from the pasture. The ranch reported 255 calves were weaned in 2009 or 80.4% from the 317 cow first- and second-calf heifer herd. They further reported a normal (prior to wolf presence) weaning percentage of 95%. Because the level of depredation on this herd was so high, 11 wolves were removed by Wildlife Services from the study area between 15 May and 15 Aug 2009.

Cattle Monitoring

During the grazing season, GPS-collared cattle occupied approximately 6,500 ha (24.5 mi^2) of land. Visually, we observed cattle of this herd typically moved in subgroups of 16 head or less and each subgroup functioned as a relatively independent social unit. A similar observation was made by Harris et al. (2004) on California foothill rangelands. It appears evident from 2009 cattle GPS tracking data that the collared cows tended to be members of differing subgroups. These data indicate collared cows typically remained widely separated from each other and only on rare occasions would 2 or more collar cows come together for a time. When cattle were periodically herded from pasture to pasture, they were often moved as subgroups thus different collared animals were typically moved on different days. Consequently, we suggest collared cows, for the most part, represent functionally independent experimental units in terms of our analysis design. We intend to confirm this assumption with a Durbin-Watson or similar test before we proceed with more complete analyses.

Potential Wolf-Cattle Interactions

The herd containing the GPS-collared cattle passed from low elevation pastures to higher pastures as the grazing season progressed, eventually moving into an area heavily occupied by wolves (i.e., Snake River, Hornet Creek, and Lick Creek packs) on about 23 May 2009 (Figure 6). Using custom software noted above and GPS tracking data, we identified potential interactions between collared cattle and wolf B446. We considered a potential wolf-cow interaction to be where a location record for wolf B446 was within a 500 m (547 yd) and plus or minus 2.5 minutes from any collared cow location record. An example of a proximity diagram is shown in Figure 7 which illustrates multiple potential interactions during the first 15 days of July. The diagram also illustrates B446 was sometimes more than 10 km (6 mi) from collared cattle but could close that distance quite rapidly. At times the recorded distance between collared cattle and B446 was obviously very close. It should be remembered, however, that the cattle GPS locations are logged at 5-minute intervals while at 15-minutes for the wolf. Consequently, we are not necessarily identifying the closest wolf-cattle interactions since the respective collars would only rarely log locations simultaneously. Closer interactions could, therefore, occur within a 2.5 minute maximum time offset between wolf and cattle location records

All potential collared wolf-cattle interactions of less than 500, 250, and 100 m (547, 273,109 yd) for the 2009 grazing season are presented in Table 2. The 10 collared cattle were within 500 m of wolf B446 a total of 783 times during the 2009 grazing season. The first potential interaction at < 500m occurred on 23 June 2009 and the last was on 3 November 2009 with the bulk of these potential interactions occurred before 15 Aug 2009. During the full 137-day period, there were 50 separate days when one or more potential interactions between B446 and collared cattle occurred at 500 m (547 yd), 37 days that had a potential interaction at 250 m (273 yd), and 16 days at 100 m (109 yd)). The frequency of wolf B446-cattle potential interactions at < 100 m (109 yd) relative to time of day are illustrated in Figure 8. Nearly all these close interactions occurred during the night or early morning hours. The spatial locations of these 53 close potential interactions and confirmed wolf depredations on cattle are presented in Figure 9.

Sometimes more than one collared cow was involved in a single, potential interaction with B446. When multi-cow interactions in 2009 were tallied as single events, there were 448 separate, potential interactions at < 500 m (547 yd). The maximum number of collared cows involved in a single interaction event was 6. This seems to indicate recurrent wolf-cattle interactions induce bunching of cattle into larger groups. We intend to evaluate this hypothesis in due course. Examination of wolf and cattle GPS track logs also revealed that often when a potential interaction occurred, the collared cow moved off in one direction and the wolf in another. These data suggest a short-term flight response in cattle may also be occurring relative to the potential wolf-cattle interactions. We intend to evaluate whether these apparent responses, bunching and flight, can be used to help identify and separate actual wolf-cattle interactions (i.e., sensory contact occurred) from potential interactions. To augment this effort we also intend to use DEMs, vegetation map layers, and viewshed analyses in a GIS to identify line-of-sight wolf-cattle interactions from those without line-of-sight.

Wolf-cattle potential interactions often seem to be associated with suspected wolf rendezvous sites or areas used by B446 when resting (i.e., recorded stationary for at least 2 hours). We have begun to evaluate the topography, vegetation, and other characteristics of these focal areas. Our intent in doing so is to determine whether a predictive predation risk map can be developed based on readily available GIS data layers. If we can accurately map predation risk, this will likely be a valuable tool for livestock producers and natural resource managers to use in mitigating wolf depredation.

Confirmed or Suspected Depredation and Unknown Death Loss

Two of the collared cows lost their calves to unknown causes by the time this herd was gathered and completely removed from the grazing area in November 2009. In this herd of 450 cows, the ranch reported loss of 45 calves, 5 cows, and 2 yearlings while animals were on summer range. Prior to documented wolf presence on the study area, death losses for this herd were normally about 2% or about 9 calves per grazing season.

Ranch personnel also report the behavior of this herd has changed since wolves established in the area. Cattle are much more aggressive, anxious, difficult to herd and handle, and do not tolerate herding dogs as they did prior to wolf presence. These behavioral changes substantially complicate normal ranching operations such as gathering and moving (trailing), increasing work load and costs.

Conclusions

Interim results from this long-term study indicate wolf B446 averaged more than 18 km/day through this rugged landscape during the summer and fall off 2009 while collared cattle moved on average 11 km/day. Wolf B446’s daily travel was variable and cyclic with periodic short travel days followed by long travel days. Most of this travel occurred at night. Landscape use was not uniform by this wolf with some sites highly preferred. We interpreted these locations as den/rendezvous locations. Wolf B446, and likely some or all of the Snake River pack, interacted frequently with beef cattle when occupying the same rangelands. However, at least in the case of wolf B446, proximity to human activity was not a strong deterrent to recurrent wolf use. Wolf-cattle interactions were more frequent near suspected den/rendezvous sites but could be at substantial distances from these foci. At known cattle depredation locations, Wolf B446 demonstrated a circular movement pattern which may be a key for identifying locations of undocumented depredation. Further analysis of GPS tracking collar data and GIS data layer relative to focal areas such suspected wolf rendezvous sites and resting areas hold promise for developing tools, such as predictive predation risk maps, for helping to mitigate wolf depredation on beef cattle grazing extensive rangeland.

Acknowledgments

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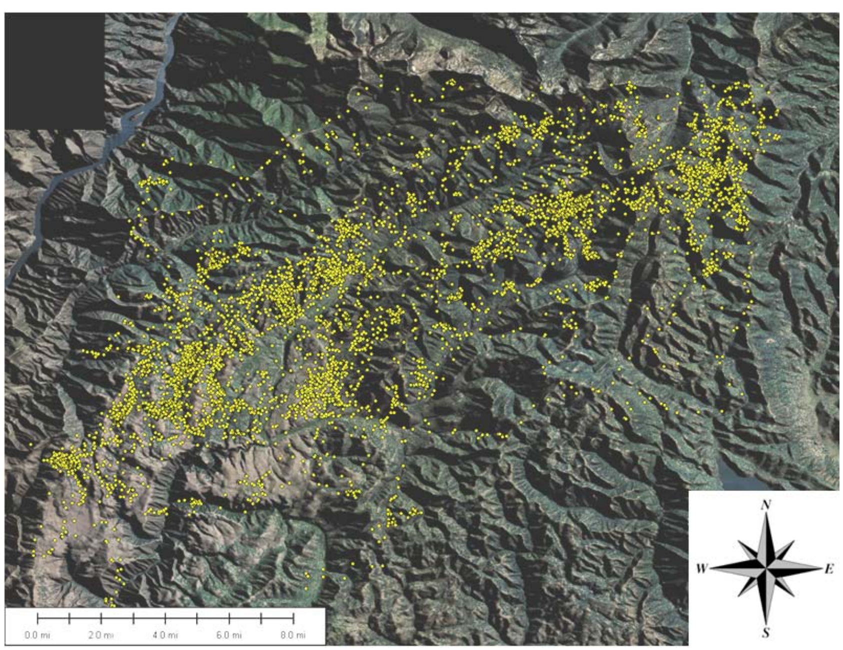

Figure 1. The 17,954 positions of Wolf B446, a 41 kg (90 lb.) male member of the Snake River Pack, between 23 May 2009 and 30 November 2009.

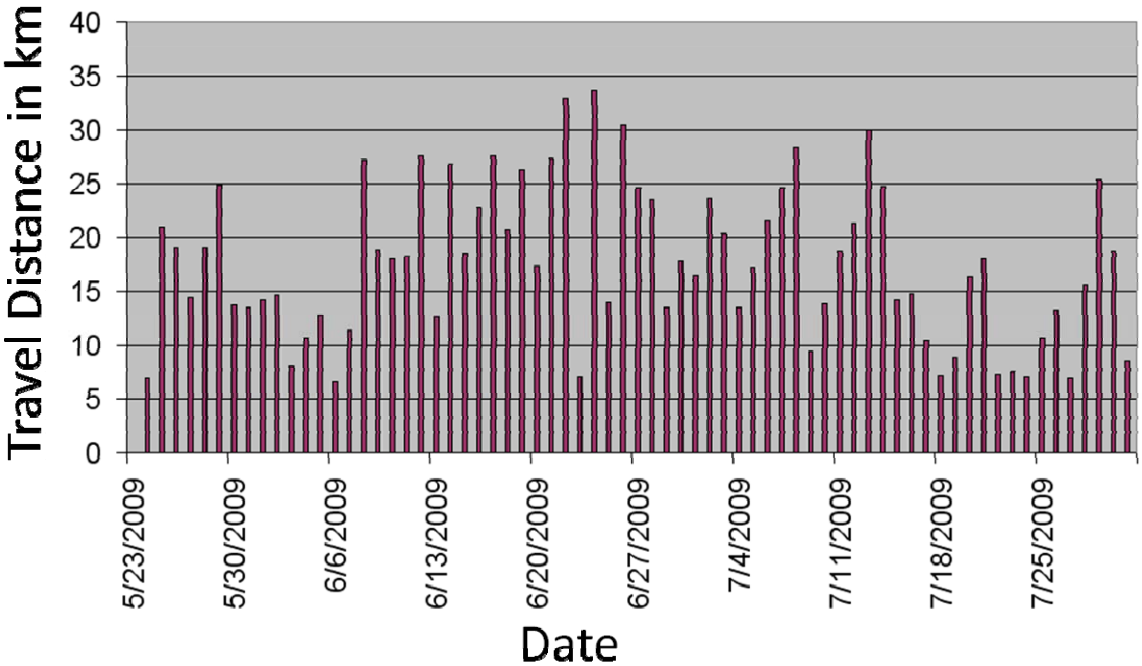

Figure 2. Mean daily minimum travel distance of GPS-collared wolf B446 between 23 May and 30 November 2009 calculated as the cumulative straight line distance between sequential GPS location pairs recorded during each respective day.

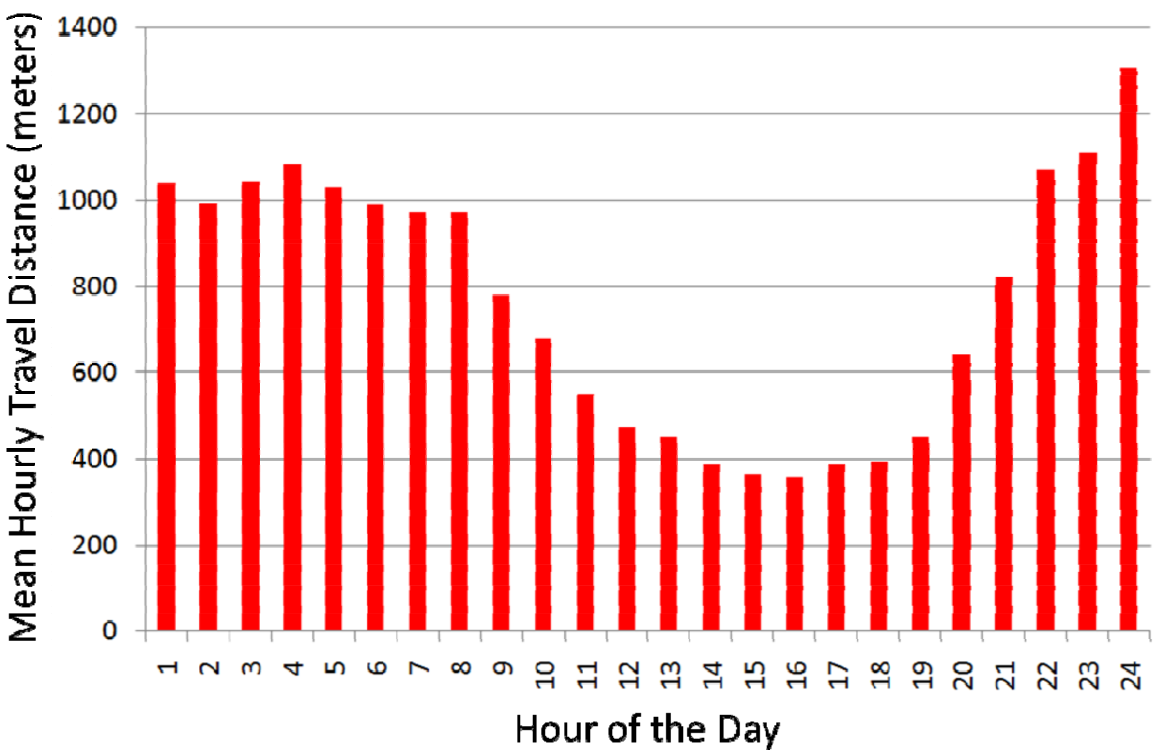

Figure 3. Mean hourly minimum travel distance for GPS-collared wolf B446 between 23 May and 30 November 2009 calculated as the cumulative straight line distance between sequential GPS location pairs recorded during each respective hour of the day.

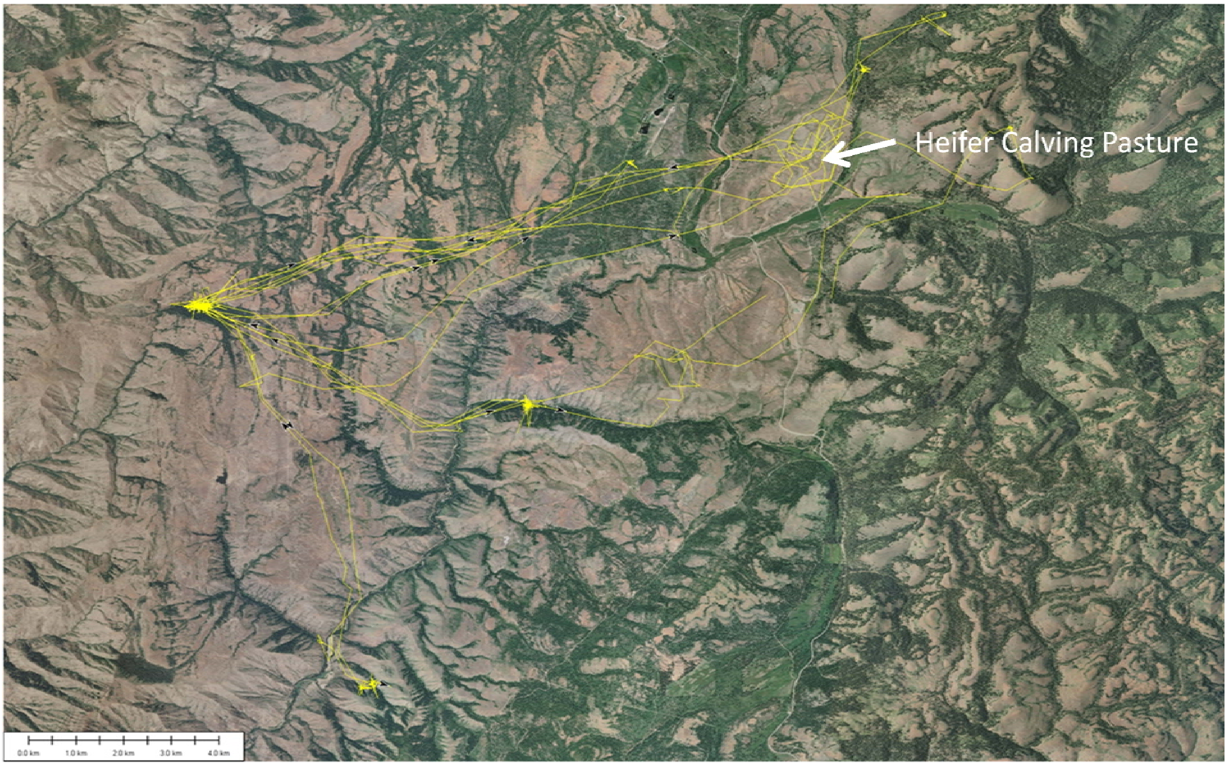

Figure 4. Movement of Wolf B446 between 1 June 2009 and 15 June 2009. Direction of travel is indicated by arrows. The den site is in the left central portion of the image. During this period predation was occurring on a herd of 317 first- and second-calf heifers held on a pasture in the upper center-right of the image.

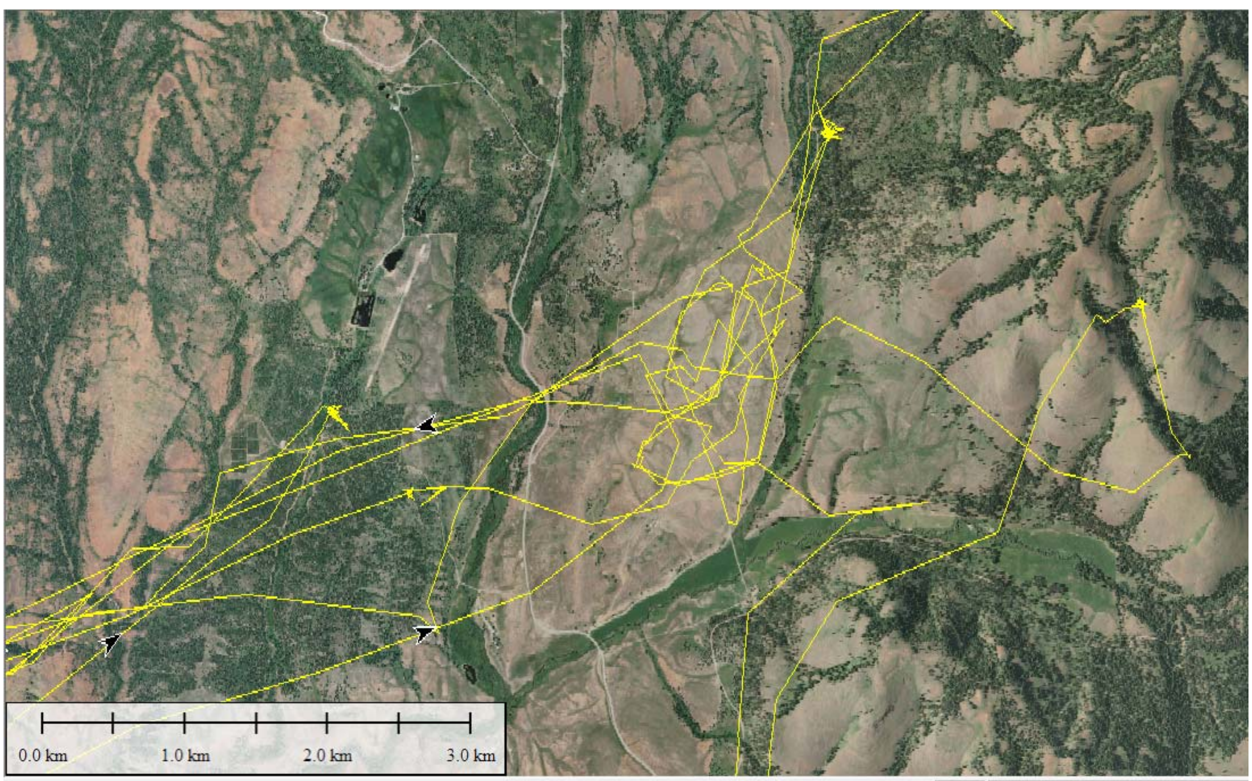

Figure 5. Enlargement of the area in the center of the image shown in Figure 2 illustrating the recorded travel patterns of wolf B446 between1 June and 15 June 2009.

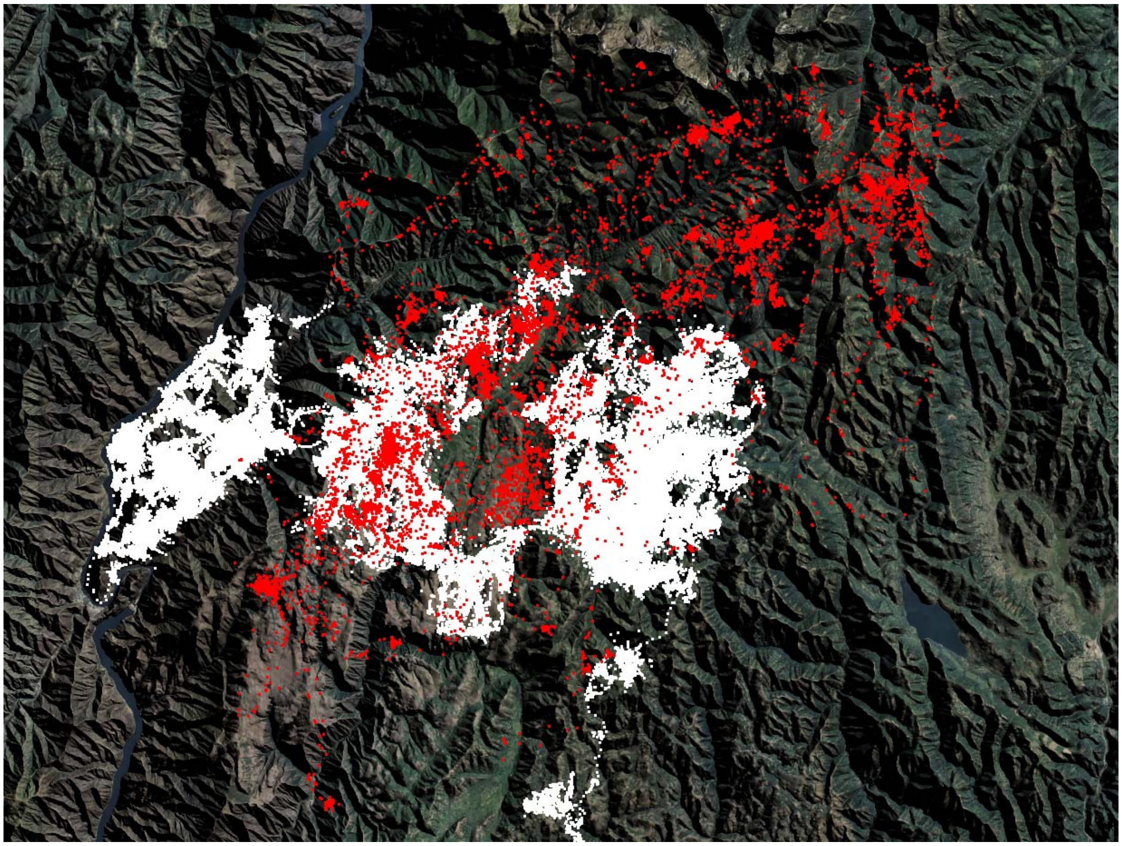

Figure 6. All GPS-collared cow locations recorded during the 2009 grazing season (white) with all GPS-collared wolf B446 positions (red) superimposed on a topographic map of the area. The shield shaped area in the center of the image without collared cow locations is a fenced pasture where a different herd of uncollared, first- and second-calf heifers were grazed.

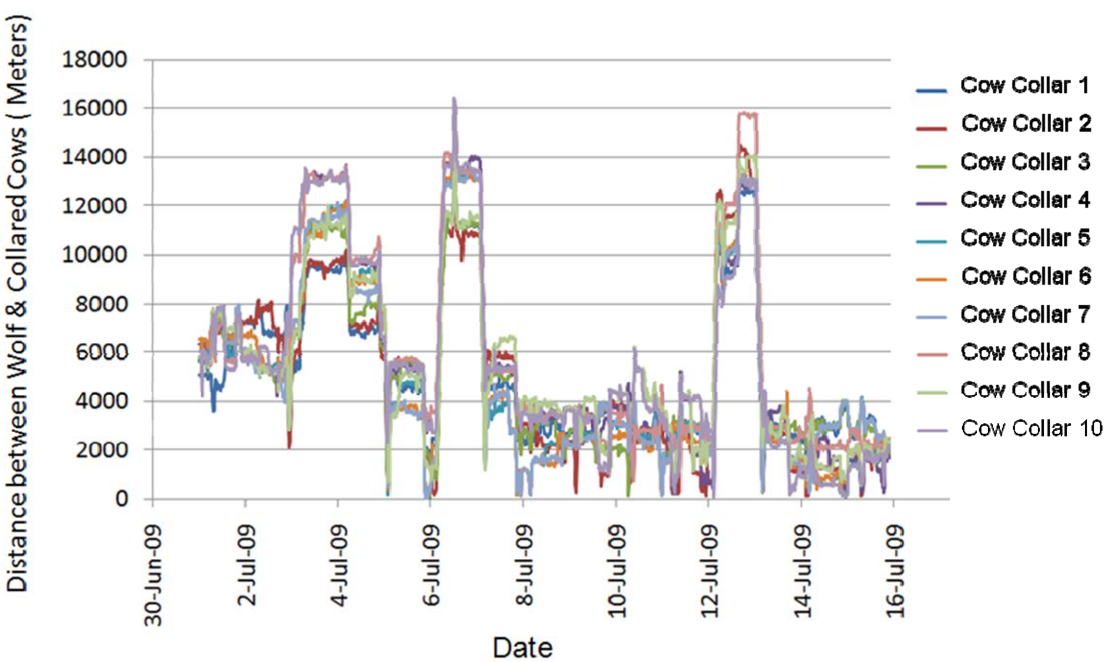

Figure 7. Distance of the GPS-collared cows from GPS-collared wolf B446 during the first 15 days of July 2009.

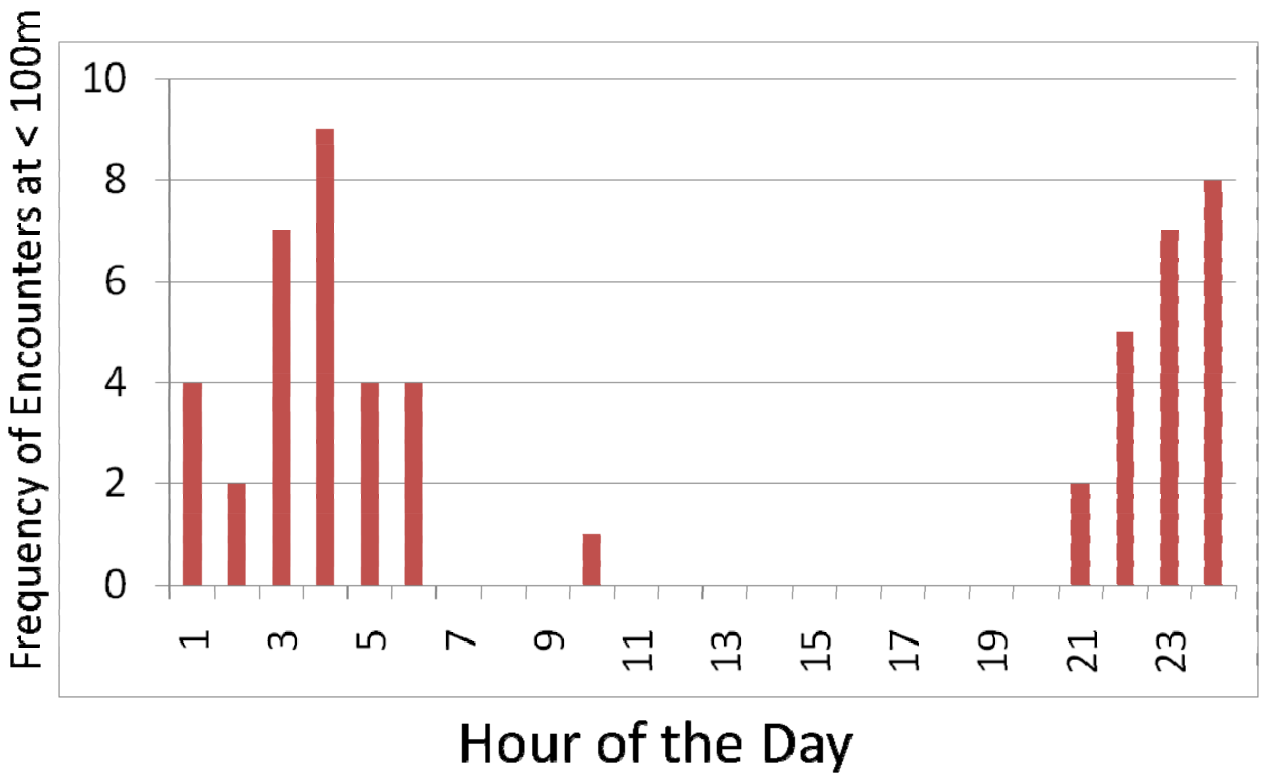

Figure 8. Frequency of GPS-collared wolf (B446) andcattle potential interactions (or encounters) occurring at distances < 100 m (109 yd) relative to the hour of day between 23 May 2009 and 30 Nov 2009 (Duration 191 days).

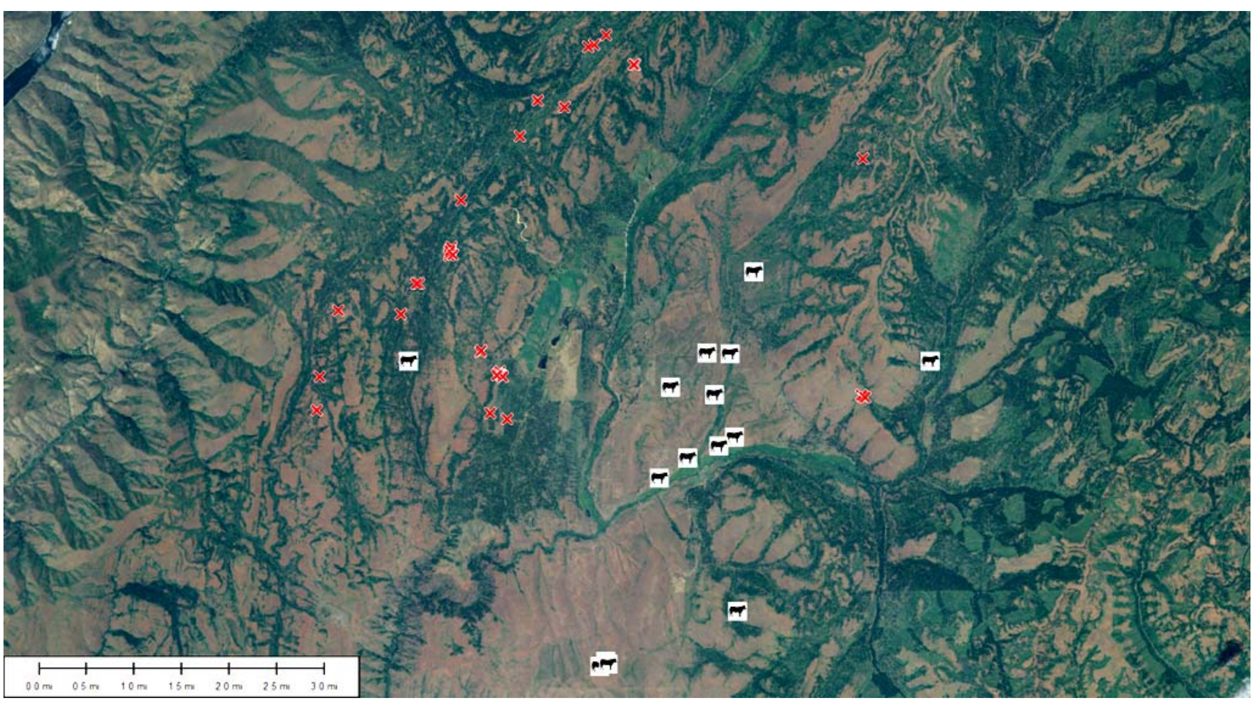

Figure 9. Fifty-three potential interactions (red x) recorded where the distances between nearly concurrent GPS locations for wolf B446 and 10 GPS-collared beef cows were < 100 m (109 yd) between 23 May and 30 November 2009 (Duration 191 days). Also shown are confirmed wolf depredations on both the herd with GPS-collared cows and the separate, nearby herd of un-collared first and second-calf heifers.

Oregon State University

BEEF052

Beef Cattle Sciences

Oregon Beef Council Report

Spatial Behavior and Distribution of Cattle Grazing Riparian Zones in Northeastern Oregon [1]

D. E. Johnson [2], M. Wilson [3], K. D. Wilson [4], L. L. Larson [5], J. Williams [6], S. K. Ndzeidze [7], T. DelCurto [8], and P. E. Clark [9]

Synopsis

The spatial and diurnal behavior of cattle grazing 3 riparian pastures is being investigated in northeastern Oregon. Time spent by cattle in streams, on streambanks, and in buffers at increasing distances from streams is being quantified as well as ecological site use and preference during resting and grazing periods. The 2009 report for this project can be found at: http://beefcattle.ans.oregonstate.edu/html/publications/documents/BEEF009-BeefCouncilReportRiparian.pdf

Summary

The objective of this research is to document and quantify the spatial movement of cattle grazing riparian pastures so that accurate assessment of use and ecological interaction can be made. Track logs with 1 second data collection intervals indicate that cows spent about 63% of their time stationary, 33% moving at <1.0 km/hr, 2% at >1.0 km/hr and ≤2.0 km/hr, and <1% at velocities >2.0 km/hr. Daily travel distance was about 5km/day. Cattle used the area between the right and left wetted edges of the stream 1.06% of the day and the boundary zones 5 m, 10 m, and 20 m out from the wetted edge 2..21%, 3.52%, and 5.29% of the day respectively. The area between wetted edges is 6.02% of the pasture and half the pasture is within 106.5m of the stream. Velocity plots generated from GPS collar data were used to identify periods when animals were stationary and moving slowly or very slowly.

Introduction

Proper management of streambanks and riparian pastures is a goal of all management plans generated for landscapes in northeastern Oregon. Development of rational grazing plans and monitoring protocols that accurately catalog effects of managerial actions is dependent upon knowledge of the dynamics of grazing animal distribution, diet selection, and timing of use. Many studies have attempted to document the effects of riparian grazing, yet questions still persist because quantitative information about cattle use of riparian zones has been difficult and expensive to collect. Our study is using GIS and GPS technologies to examine livestock distribution and movement with great spatial and temporal precision in an effort to

1. This document is part of the Oregon State University – 2010 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://beefcattle.ans.oregonstate.edu.
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understand how cattle graze riparian pastures, where they graze, and what are actual effects of modern grazing systems. This study was also designed to test the capabilities of GPS collars logging at high frequency for monitoring cow positions in a riparian setting and to determine the relative duration of occupancy and preference for ecological sites and plant communities.

Materials and Methods

Study Area

The study area of our project consists of 3 study sites located in northeastern Oregon. One site is on private land and the remaining 2 are on the Hall Ranch (45.130°N, 117.710°W). The Hall Ranch is owned and managed by Oregon State University's Eastern Oregon Agricultural Experiment Station at Union, Oregon. The Hall Ranch sites have a modified continental climate with the majority of the approximately 700mm (27.6 in) of precipitation falling between November and May (Daily et al. 2010). In this report we will discuss only the grazing responses on the Catherine Creek Riparian Pasture on the Hall Ranch.

Study pastures consist of riparian dry and wet meadows, shrublands, and forests along active streams. Common plant communities are: 1) Cheatgrass (*Bromus tectorum* L.), 2) wet meadow (*Poa pratensis* L., *Phleum pratense* L., *Carex* spp.), 3) dry meadow (*Poa pratensis* L.), 4) Douglas hawthorn (*Crataegus douglasii* Lindl.), 5) riparian shrub (*Populus balsamifera* L. ssp. *trichocarpa* (Torr. & A. Gray ex Hook. Brayshaw), *Alnus incana* (L.) Moench, Salex spp.), 6) gravel bar, and 7) pine (*Pinus ponderosa* C. Lawson) with a shrub understory of grasses, snowberry (*Symphoricarpos albus* (L.) S.F. Blake) and Wood's rose (*Rosa woodsii* Lindl.). The river was also digitized and became an eighth class as surface water.

Streams in the larger study vary in width from less than a yard (1 m) to more than 25 ft. (8 m) wide. Pastures vary in size from 139.4 acres (56.4 ha) to 250 acres (101.17 ha). All pastures are grazed during the summer or fall by beef cattle as an integral part of a broader ranching production system. Pastures were delineated using a GPS and photographed from the air on 17 September 2009. The Hall Ranch pastures were photographed again on 4 July 2010 to document any changes during the year. Aerial images were acquired at high resolution (≈ 20cm by 20cm ground pixel size or 1:706 scale) using a Canon EOS Rebel XSi 12.4 megapixel digital conventional color camera mounted in the belly of a Cessna 182 aircraft. Images were corrected for lens curvature and geographically registered to USDA National Agriculture Imagery Program (NAIP) 2009 imagery. Pasture mosaics were made that show vegetative communities and stream position (Figures 1and 2).

The GIS layers for vegetative communities, stream boundaries, off-stream water points, and fences in each pasture were mapped during field visits using our high-resolution, rectified photographs and verified using GPS. All pasture data layers (aerial photographs, vegetation, stream, and boundaries) were entered into a GIS database for use in either ArcGIS 9.3 (ESRI 2009) or Global Mapper 10.0 (Global Mapper Software LLC 2010).

Animals and GPS Collars

In 2009 and 2010, 10 randomly selected cows were collared for each of the 3 riparian pastures designated for the study. In each pasture, 2 sequential trials of 6 days were conducted because GPS data loggers record for approximately 6.25 days on a set of batteries. After the first trial cattle were gathered, collar batteries and SD cards replaced, and cattle were returned to the pasture for another 6 days (Trial 2). Upon completion of the second trial cattle were gathered and collars removed. Thus, each collared cow had the potential for 12 days of track logging per pasture per year.

Collars collect latitude, longitude, elevation, GPS date/time, velocity, bearing, number of satellites used for the positional fix, and fix quality on a 1-second interval. Data points before the cattle entered the pasture were removed from the data set. Only days with complete data sets (99% of the day recorded) were used in this analysis. Data collection for the overall project was completed on 12 October 2010.

Data retrieved from the collars were converted into ASCII text format that could be read into Microsoft® Excel®, Global Mapper®, and ESRI® ArcMap®. Shapefiles were also constructed, which are compatible with most GIS programs. In addition, cow tracklogs were classified by velocity using a custom built software program, Animal Movement Classification Tool (Johnson et al. 2010), so that animal activity could be inferred and actual distances traveled per day or hour calculated. Stationary positions (those with 0 velocity for 10 minutes or longer) were converted to polygons via a minimum convex polygon algorithm and attributed with start date/time, end date/time, duration, and surface area (Figure 2).

Results

Since data collection has just been completed for this study, this interim report covers only results from the Catherine Creek Study Site during 2008 and 2009 and should be considered preliminary. Final analysis will be completed by May 2011. This report will also only cover results from the Catherine Creek Pasture for 2008 and 2009.

Data from Catherine Creek collars were partitioned into complete days for each pasture and trial with the travel for that day and animal considered an observation. During 2009, 19 cows provided information during Trial 1 and 20 cows in Trial 2 for a total of 232 full days of observation (Table 1.) During each year of the experiment about 20 million positions were collected and analyzed for diurnal activities.

Daily activity of cattle was extracted by calculating running mean velocity averaged over 61 seconds so it corresponds with previously collected data collected by human observers. Our computer algorithm separated and classified 61-second periods when no velocity was recorded as stationary. In a similar fashion velocity classes for travel were also extracted (Table 2). Cattle grazing the Catherine Creek Riparian Pasture were stationary 63.2% of the day and moved at a rate less than 1.0 km/hr for another 33.99% (Table 2). Rapid movement for these free-roaming animals was relatively rare and of short duration; <0.02% of the monitored time had a mean 1 minute velocity >4.0 km/hr.

An example of a daily velocity diagram is shown in Figure 3. Velocity diagrams were made for each full day the cows were tracked and periods of travel identified. This information was used to define periods when animals were resting (stationary) and potentially grazing (slow travel). Thus we can quantify pasture use as either resting sites or grazing/moving. This is important because time spent resting may have relatively low impact on riparian vegetation when contrasted with grazing. Velocity diagrams coupled with range site usage and track logs may reveal other attributes of individual cows such as their propensity for travel, dispersal up slopes, or exploratory behavior. We hypothesize that this type of information may be correlated to cow temperament and, when viewed in light of performance data, could be useful for animal selection/culling decisions.

Daily travel distance was calculated for each collared animal in the herd by summing Euclidian displacement between positions with a recorded velocity greater than the GPS detection limit (0.06 m/sec or 0.197 ft/sec). This process removes stationary positions from the calculation and eliminates most of the pseudo-travel that results from summing GPS errors while the animal was actually stationary. Daily travel distance for the 2009 trial on the Catherine Creek Riparian Pasture is provided in Table 3. Mean distance for Trial 1 was 5.17 km/day (3.21 mi/day) and for Trial 2 was 4.66 km/day (2.90 mi/day).

Proximity to the stream was measured from the 151 full day (>99% of potential observation recorded during the day) track logs (Table 4 and Figure 4). Collared cattle spent 1.06% of their time between the wetted edges of Catherine Creek. This area includes stream surface as well as islands and gravel bars within the stream (Figure 1). The surface area between the wetted edges is approximately 6.02% (3.40 ha or 8.4 acre) of the total pasture area of 56.41ha (139.4 acre). Cows were in a buffer that included stream plus the area 5 m (16.4 ft) from the wetted edge 2.21% of the day. Expanding the buffered area to 10m (32.8 ft) and 20m (65.6 ft) corresponded to 3.52% and 5.29% of the cow's day.

Cattle distribution in the pasture was not uniform (Figure 5). Preferred areas tended to be more open with more grass which corresponded to wet and dry meadow areas as would be expected. Cattle when moving seemed to be seeking areas with abundant forage. Cattle interacted frequently with the stream on portions of Catherine Creek that were between favorite grazing areas and near travel routes. The GPS technology allowed us to identify locations where impacts to stream banks might accrue and monitoring should occur.

Conclusions

In conclusion, our research project has quantified cow spatial behavior on 3 riparian pastures of northeastern Oregon. This report focuses on the Catherine Creek pasture of the Hall Ranch where we found that cattle spent 63% of the day stationary and 34% moving at <1.0 km/hr (0.62 mi/hr). Cattle traveled about 5km/day (3.1 mi/day) and spent about 1% of their time between the wetted edges (BWE) of the stream which accounted for 6.02% of the pasture's surface area. When a 5 m (16.4 ft) buffer is added to the area BWE, cows were present 2.21% of the day. Because we have quantified the spatial paths of cows in the riparian pasture, we can evaluate effects of grazing by examining sub-portions of the pastures with higher or lower use. This information should clarify the effects of grazing cattle on riparian pastures and streambanks and lead to better management.

Acknowledgments

This research study was financially supported by the Oregon Beef Council, USDA/Agriculture and Food Research Initiative, USDA/Agricultural Research Service, Cooperating Ranches and Ranch Families, Oregon Agricultural Experiment Station, and Oregon State University. We wish also to thank Ms. Carolyn Dingus and 2 unknown reviewers for editorial suggestions on this manuscript. The mention of product names or corporations is for the convenience of the reader and does not constitute an official endorsement or approval by Oregon Beef Council, US Department of Agriculture, Agricultural Research Service Research Service, Oregon State University, or the Oregon Agricultural Experiment Station of any product or service to the exclusion of others that may be suitable.

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Johnson et al. 2010. Global Geomatic Solutions. Oviedo, FL.

Table 1. Summary of the data collected during 2009 on the 3 study sites, since more collars were available during 2010; we expect to have more cattle successfully tracked and more positions collected. Each trial began with 10 cows that were collared and were tracked at 1-second intervals, thus positions are synonymous with number of seconds of tracking.

	Trial 1 GPS Positions Collected	Number of Collared Cows	Trial 2 GPS Positions Collected	Number of Collared Cows	Total GPS Positions Collected	Observation Duration (days)
Pasture 1	2,424,761	5	2,974,603	6	5,399,364	65
Pasture 2	3,586,838	7	4,096,617	8	7,683,455	93
Pasture 3	3,197,390	7	2,917,353	6	6,114,743	74

Table 2. Data collected on cows grazing the Catherine Creek pasture on the Hall Ranch, Union County, Oregon during the 2009 grazing trial is summarized as the percent of the day spent in travel sorted by velocity classes. Mean velocity was calculated over a 61-second running mean then classes as: 0 km/hr = Stationary, 2) >0.0 to 1.0 km/hr, 3) >1.0 to 2.0 km/hr, 4) >2.0 to 3.0 km/hr, 5) >3.0 to 4.0 km/hr, 6) >4.0 to 5.0 km/hr, and 7) >5.0 km/hr. Percentage of the day was calculated by dividing by the seconds of data collected and multiplying by 100. Only days with more than 99% of the day included in the data set were used in the analysis. Collared cows were stationary most of the day (63.2%) and moved slowly (<2.0 km/hr) for an additional 36% of the day.

Date	Stationary 0.0 km/hr (%)	>0.0 to 1.0 km/hr (%)	>1.0 to 2.0 km/hr (%)	>2.0 to 3.0 km/hr (%)	>3.0 to 4.0 km/hr (%)	>4.0 to 5.0 km/hr (%)	>5.00 km/hr (%)
12-Aug-09	60.7	34.9	2.8	1.1	0.5	0.0	0.0
13-Aug-09	59.2	36.5	3.2	0.9	0.2	0.1	0.0
14-Aug-09	63.3	33.8	2.2	0.5	0.2	0.0	0.0
15-Aug-09	60.4	36.7	2.2	0.6	0.1	0.0	0.0
16-Aug-09	63.0	34.5	1.7	0.6	0.2	0.0	0.0
19-Aug-09	61.4	36.3	1.8	0.4	0.1	0.0	0.0
20-Aug-09	62.4	35.3	1.6	0.5	0.2	0.0	0.0
21-Aug-09	67.4	30.6	1.4	0.4	0.2	0.1	0.0
22-Aug-09	67.8	30.0	1.5	0.4	0.2	0.0	0.0
23-Aug-09	66.4	31.3	1.7	0.4	0.2	0.0	0.0
Mean	63.2	33.99	2.01	0.58	0.21	0.02	0.00

Table 3. Mean travel distance/day for beef cattle grazing the Catherine Creek Pasture during 2009 on the Hall Ranch in Union County, Oregon.

Trial 2	12-Aug-09 (km/day)	13-Aug-09 (km/day)	14-Aug-09 (km/day)	15-Aug-09 (km/day)	16-Aug-09 (km/day)	Mean (km/day)
Cow 1	5.01	4.92	4.59	4.74	4.34	4.72
Cow 2	6.44	10.15	4.3	5.63	4.33	6.17
Cow 3	6.77	5.48	6.12	5.9	6.65	6.18
Cow 4	6.09	4.73	3.86	5.12	4.67	4.89
Cow 5	6.39	3.92	5.47	3.83	4.72	4.87
Cow 6	5.36	4.3	3.56	4.4	3.25	4.17
Cow 7	6.45	5.83	4.39	5.19	4.1	5.19
Mean	6.1	5.6	4.6	5.0	4.6	5.17

Trial 2	19-Aug-09 (km/day)	20-Aug-09 (km/day)	21-Aug-09 (km/day)	22-Aug-09 (km/day)	23-Aug-09 (km/day)	Mean (km/day)
Cow 1	4.35	4.28	4.04	4.17	2.25	3.82
Cow 2	5.69	5.71	4.43	3.96	3.07	4.57
Cow 3	8.63	5.94	4.79	4.11	6.11	5.92
Cow 4	5.18	4.76	3.7	3.59	3.28	4.10
Cow 5	4.27	4.86	3.31	2.98	5.42	4.17
Cow 6	4.42	4.16	3.09	2.82	2.84	3.47
Cow 7	5.87	5.17	4.89	3.62	7.47	5.40
Cow 8	5.58	5.42	5.69	5.34	6.96	5.80
Mean	5.50	5.04	4.24	3.82	4.68	4.66

Table 4. Mean minutes of occupancy for beef cattle grazing the Catherine Creek Pasture on the Hall Ranch in Union County, Oregon. Zones or buffers of 5, 10 and 20 m (16.4 ft, 32.8ft and 65.6 ft) from the thalweg (line defining the main course along the length of the river) were constructed and counts of cow positions made within the buffers. Catherine Creek has a mean width of about 8 m (26.2 ft) or approximately 4 m (13.1 ft) on either side of the center of the stream when it exists as a single channel. The wetted edge calculation includes all surface area of the stream between the left and right water lines which includes islands in the braided portion of the channel. Approximately 6.0% of the pasture is between the wetted edges.

Stream Zone	Approximate% of Pasture	2008 Trial 1 (% of Day)	2008 Trial 2 (% of Day)	2009 Trial 1 (% of Day)	2009 Trial 2 (% of Day)	Overall Mean (% of Day)
Days of Observation		42	32	36	41	151
<5 m center of thalweg	4.4	1.08	0.45	0.50	1.40	0.90
<10 m thalweg	8.8	2.48	1.14	0.92	2.88	1.93
<20 m thalweg	17.1	5.42	3.24	2.32	5.78	4.32
Between Wetted Edges (BWE) (includes water & islands in creek)	6.0	1.21	0.42	0.50	1.90	1.06
<5 m from stream wetted edge + BWE	10.8	2.67	1.14	1.24	3.44	2.21
<10 m from stream wetted edge + BWE	15.6	4.30	2.24	1.98	5.07	3.52
<20 m from stream wetted edge + BWE	24.5	6.97	4.50	2.90	6.29	5.29

Figure 1. A mosaic of aerial photographs taken on 4 July 2010 of the Hall Ranch, Union County, Oregon. Both the Milk Creek and Catherine Creek Pastures were photographed, corrected for lens distortion and geographically registered. Red lines represent 100 m in the Universal Transverse Mercator (UTM) projection using the World Geodetic System Datum of 1984 (WGS84). Ground resolution (pixel size) is 0.506 m and the corrected full mosaic covers 1448 ha (3579 acre). Current streambanks and vegetative communities were digitized on these images.

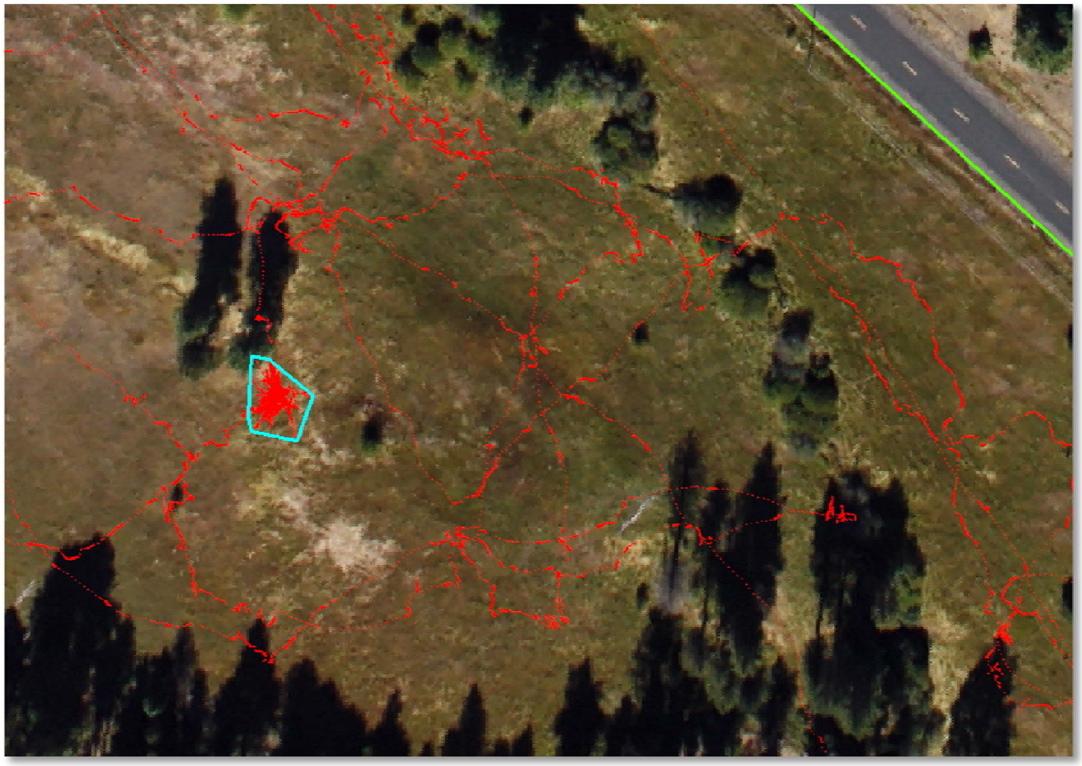

Figure 2. The red points show the positions, taken at 1-second intervals, of a cow grazing the Milk Creek Pasture in 2009. The blue polygon shows where the cow was stationary for more than an hour. This particular polygon shows the cow was stationary from 17 October 2009 5:48 PM to 17 October 2009 11:44 PM (5.933 hr).

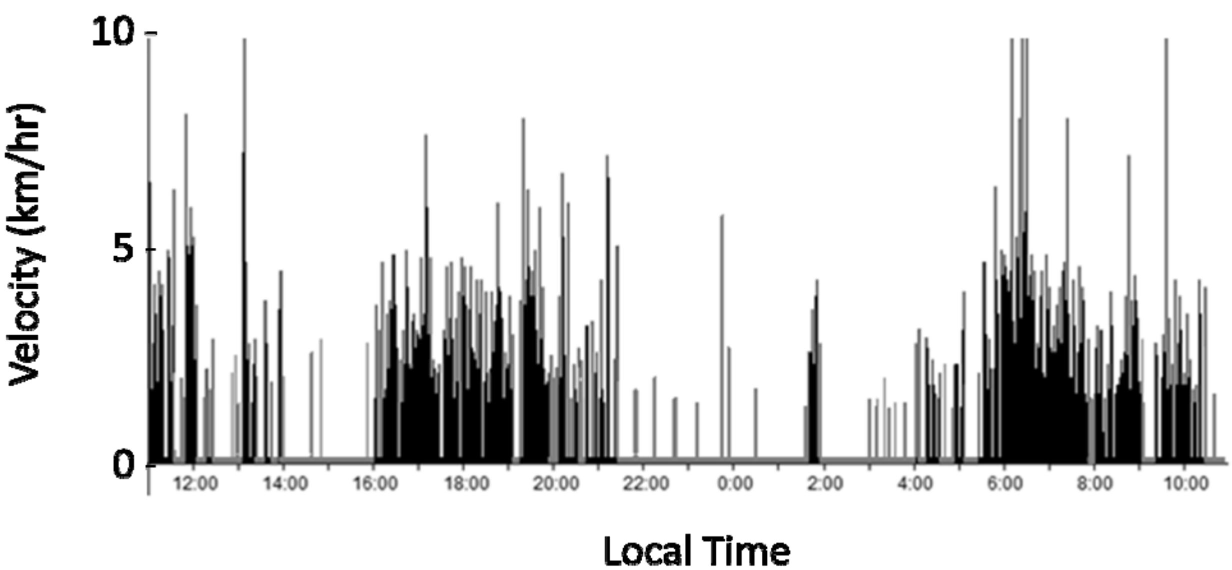

Figure 3. Velocity diagram of a cow (Collar 120) grazing the Catherine Creek Pasture, Hall Ranch, Union County, Oregon from, 12 August 2009 11:00 to 13 August 2009 11:00. Periods of activity and quiescence are visible as are active periods. This cow was moving from 16:00 hrs to 21:30, moving for a brief period between 1:00 hrs and 2:00 hrs, and active again from 5:30 hrs to 11:00 hrs. Almost all travel was at velocities less than 5.0 km/hr (3.1 mi/hr).

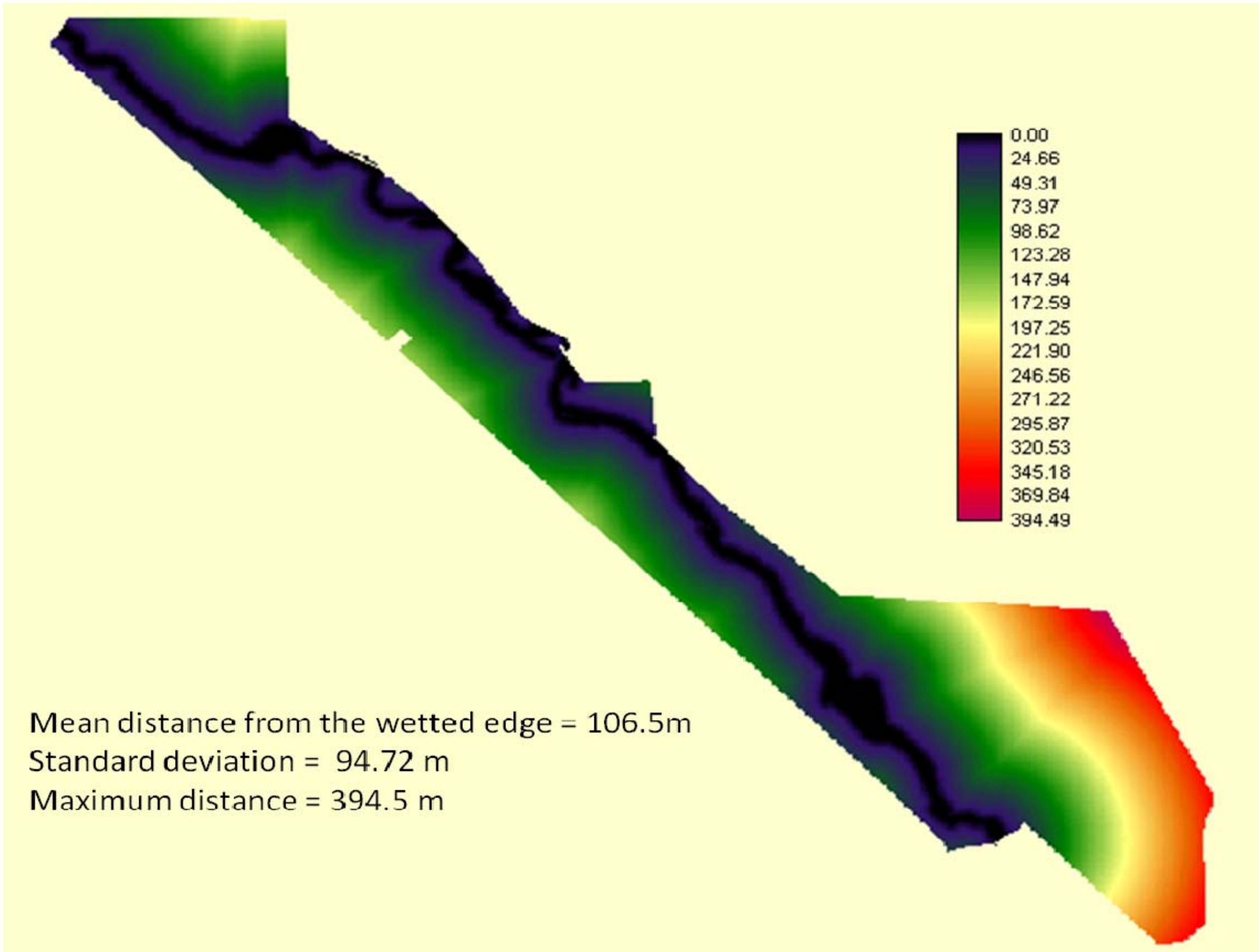

Figure 4. Raster map produced for Catherine Creek Pasture in which each 1m x 1m pixel is attributed with the distance between the pixel center and the nearest wetted edge. Areas of the stream and islands in the stream between the left and right wetted edges were classed as 0.

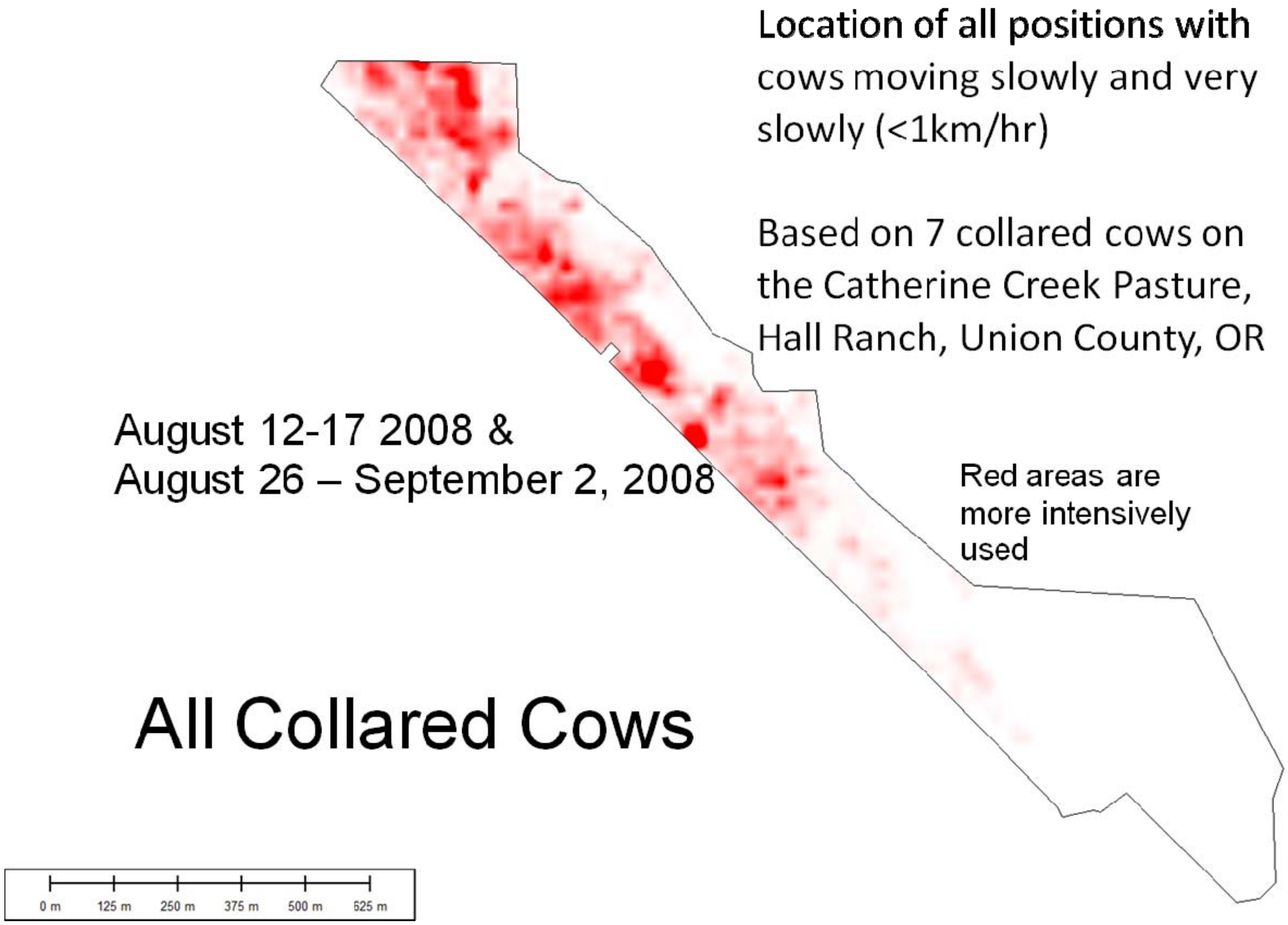

Figure 5. A cow use map for the Catherine Creek Riparian Pasture for the 2008 grazing season in which red areas are locations with the most use, pink are intermediate, and white is no use. Only GPS positions with mean velocities greater than 0 km/hr and <1.0 km/hr (0.62 mi/hr) were used in the determination of use in an attempt to focus solely on grazing.

Oregon Beef Council Report

The potential of DNA analysis for cattle diet determination in sagebrush rangelands [1]

J. A. Perez-Amaro [2], R. Mata-Gonzalez [3], T. DelCurto [4], D. Bohnert [5], O. Riera-Lizarazu [6], C. Boyd [7], and J. Leonard [8]

Synopsis

The first experiments to demonstrate that DNA techniques can be used to detect plant animal interactions in sagebrush rangelands are reported. High-resolution DNA melt curve (HRM) analysis of the intron trnL gene indicates that plant materials existing in fecal samples can be separated and the individual dietary components can be identified in a consistent and repeatable manner.

Summary

We suggest the use of fecal DNA analysis as an attractive alternative to traditional micro-histological methods for rangeland livestock diet determinations. Molecular detection of plant dietary components depends upon the capacity of DNA to resist digestion and of the polymerase chain reaction (PCR) to amplify plant-specific DNA from semi-digested material. We conducted a feeding trial in which steers were fed known proportions of sagebrush mixed with grass hay in order to validate the sensitivity of detection of sagebrush by using high-resolution melting (HRM) analysis of fecal DNA samples. The melting profile of PCR products was done utilizing saturating dyes that fluoresce in the presence of double-stranded DNA. Results returned perfect matches with the corresponding diet treatments that included sagebrush. The method detected sagebrush in diets containing as little as 3% sagebrush in the diet mix, but it can potentially detect even lower proportions. The control treatment diet that included no sagebrush was also correctly identified by the melting profiles. The DNA melting profile makes it possible to quickly and accurately determine whether DNA sequences match, providing an attractive option for studying plant animal interactions in native ecosystems. This is a novel and robust approach for characterizing mixed and highly degraded DNA templates such as those often encountered in ecological studies using fecal samples.

Introduction

Sagebrush plays an important role in rangeland ecosystem processes (Crawford et al., 2004), yet the relevance of sagebrush species in herbivore diets is unknown. Controversy exists on the potential detrimental effect of cattle grazing on sagebrush ecosystems, which are essential for the

1. This document is part of the Oregon State University – 2010 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://beefcattle.ans.oregonstate.edu.
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survival of associated fauna of special concern such as sage-grouse (Crawford et al., 2004). There are anecdotal reports of sagebrush decline in winter pastures grazed by cattle, but it is not clear if this is attributable to sagebrush consumption. Following traditional methods of livestock diet determination it has been concluded that sagebrush is not a substantial component of cattle diets (McInnies and Vavra, 1987). However, traditional diet determination techniques are often inconclusive and expensive (Holechek et al., 1982). Fecal micro-histology is a common technique that relies on microscopically identifying morphological characteristics of plant tissue recovered in excreta based on tissue reference collection of potential forages. This technique has serious disadvantages such as 1) being labor intensive and 2) in many cases being unable to discriminate between morphologically similar forages (Holechek et al., 1982). Identification of sagebrush from fecal samples using morphological differences is particularly complicated due to limited differences between sagebrush species.

Recent advances in biotechnology permit that any type of organism can be identified by examination of short genetic markers uniquely present in the organism's deoxyribonucleic acid (DNA) (Hebert and Gregory, 2005). In this study the use of fecal DNA analysis is explored as a tool to determine with high accuracy the diet components of cattle grazing in sagebrush rangelands. This technique is based on the premise that DNA from consumed organisms is not completely degraded during digestion and therefore could be collected in feces, amplified, and analyzed. Because of the uniqueness of DNA sequences, this technique is highly specific and is becoming more attractive as the costs of DNA laboratory technology are decreasing. This method has been successfully used to obtain diet composition and proportion in fecal samples of carnivores (Deagle and Tollit, 2007). Matching DNA from fecal samples and rangeland forages may become a key source of knowledge for grazing management and for protecting plants and animals in environmentally sensitive areas.

Materials and Methods

A series of experiments have been conducted with the general goal of detecting the potential presence of sagebrush in cattle diets in pastures of central Oregon. In this report we present information on a controlled experiment aimed at qualitatively distinguishing species in fecal samples. For this experiment we used the high resolution melting (HRM) analysis, a laboratory technique that permits to differentiate plant species present in a complex mix (fecal samples) by obtaining a characteristic temperature melting profile of DNA strands (Reischl, 2006). To demonstrate the usefulness of this method, a controlled feeding trial was conducted, followed by laboratory determinations.

Feeding trial

Five crossbred steers (average weight 717 kg) fitted with a permanent 10.2-cm i.d. ruminal cannula were used in a 5 x 5 latin square experimental design with observation periods of 21 days. Dietary treatments consisted of the following grass hay:sagebrush ratios (percentage, DM basis): 100:0, 99.5:0.5, 99:1, 97:3, and 91:9. This was done to ensure that steers had only two different plant-family components in the diet. Sagebrush leaves were hand harvested from a private property in eastern Oregon during the summer of 2009. All leaf material was oven-dried and ground to facilitate the preparation of the diet mixtures. Steers were housed in partially covered individual pens with concrete floors and had continuous access to hay, water and sulfur salt blocks. Ground sagebrush leaves, mineral and vitamin supplements were mixed with the rumen content and fed immediately before all animals received hay. Treatment of the experimental steers was in accordance with regulations of the Oregon State University Animal Care and Use Committee (Figure 1).

DNA isolation

Fecal DNA was extracted using 1 g of freeze-dried feces weighed into a 15 mL centrifuge tube. Before DNA extraction, feces were vortexed, washed using 5 mL ethanol, and centrifuged (4000 × g, 2 min) to pellet the fecal particles. The supernatant was discarded. The washing step was repeated once using 5 mL TE (10 mM Tris, 1 mM EDTA, pH 8). DNA was extracted from the remaining plant material using DNeasy Tissue Kit following the manufacturer’s instructions (Qiagen GmbH, Hilden, Germany). Mock extractions without samples were systematically performed to monitor possible contaminations. Nucleic acid from each sample was finally obtained in 50 µL elution buffer.

Figure 1. Five steers were involved in the feeding trial.

Barcode amplification and cloning

A short fragment (trnL intron) of the chloroplast genome was amplified using a polymerase chain reaction (PCR) from feces with a primer set consisting of two universal primers (g and h) (Taberlet et al., 1991). The nucleotide sequence of the selected 5' primer was GGGCAATCCTGAGCCAA and that of the 3' primer was CCATTGAGTCTCTGCACCTATC. PCR reactions were performed in 10 µL with 0.25 U Qiagen Hot Start Taq (Qiagen GmbH, Hilden, Germany) and 50 ng DNA. The reaction mix consisted of 1 × PCR buffer (Qiagen GmbH, Hilden, Germany), 1 pmol forward primer, 0.2 mM each dNTP, 1.5 mM MgCl2, and 1.0 pmol forward and reverse primer. PCR was performed in a Thermoblock using the following characteristics: activation step at 95°C for 5 min; 35 cycles of denaturation at 95°C for 1 min, annealing at 55°C for 1 min and extension at 72°C for 1 min; and a final extension at 72°C for 10 min. Amplified DNA was subjected to gel electrophoresis to corroborate the desired product size by ethidium bromide staining. PCR products were purified using the Quiagen PCR purification kit (with qiaquick spin columns). Prescreening of extracts for DNA quantity and quality was performed for sorting of samples for likely success and reliability by using the NanoDrop ND-1000 UV-Vis Spectrophotometer. The products of PCR multiplication (amplicons) were ligated into a pDrive Cloning vector using the Qiagen PCR cloning kit following company recommendations. This procedure allows physical separation of different amplicons of plants from fecal samples. 100 colonies with insert were randomly selected for the diet treatments with 0%, 3% and 9% of sagebrush for further HRM analysis (Figure 2).

Figure 2. Cells containing PCR inserts were grown on kanamycin selective plates coated with 5-bromo-4-chloro-3-indolyl-β-d- galactopyranoside (X-gal) and picked via blue/white screening.

High-Resolution Melting Analysis

High-resolution melting (HRM) analysis is based on the premise that the number, type, and succession of the component base pairs of any DNA sequence determine the melting temperature at which its strands are separated (Reischl, 2006). Therefore, a signature-melting curve can be obtained for each sequence that differs in as little as one base pair (Graham et al., 2005). In our study, melting profiles of sequences recovered in fecal samples were compared with melting profiles of DNA sequences corresponding to the plants that composed the feeding trail diets. A positive matching would mean that it is possible to detect and differentiate in fecal samples those species contained in the diets.

Shorter, multiple copy sequences from the chloroplast genome efficiently cloned into the pDrive Cloning Vector were subjected to a nested PCR. For the firststep, PCR amplification of the trnL intron from all colonies, a primer set (M13) was used. The nucleotide sequence of the selected 5' primer was GTAAAACGACGGCCAGT and that of the 3' primer was AACAGCTATGACCATG. For the second step (nested) PCR, a primer set (SP6/T7) was used. The nucleotide sequence of the 5' nested primer was GTAATACGACTCACTATAG and that of the 3' nested primer was CATTTAGGTGACACTATAG. Post-PCR melt profiling was performed in the 96-well formatted LightScanner instrument. In each treatment, a DNA reference amplicon from sagebrush was used as standard to determine matching or non-matching for each of the selected colonies. Data was normalized, temperature shifted and converted to dF/dT plots. Melt profiles were generated with LightScanner and analyzed with a software from Idaho Technology (Salt Lake City, UT).

Results

With the comprehensive trnL chloroplast DNA assay, 125 fecal specimens were assessed and 2400 clones with unique variants were analyzed by HRM techniques. In all cases, it was possible to distinguish directly the two main plant components, hay and sagebrush, present in the experimental diets. HRM differentiates between DNA molecules based on their sequence-dependent thermostability (Figure 3, panel A). HRM tracks melting of PCR amplicons using an intercalating fluorescent dye, and a melt curve is generated by slowly denaturing (melting) the DNA sample through a range of temperatures. Amplicons with different sequences displayed different melting profiles, allowing identification of sequence variants (Figure 3, panel A). To better visualize the melting profiles (Tm), the negative first derivatives were plotted, making the Tms of the products appear as peaks, as seen in Figure 3B.

The melting curves clustered into two different groups, one corresponding to the hay materials and the other corresponding to sagebrush in those treatments where sagebrush was present (3% and 9%) (Figure 3, panel A). Melting curves corresponding to dietary sagebrush closely resembled that of the sagebrush reference sample. In contrast, the melting curves of the control treatment with 0% sagebrush showed only one clearly defined cluster of curves corresponding to the hay materials.

HRM analysis can be successfully used for cattle diet determinations when coupled with cloning and DNA sequencing. HRM analysis detected as positive 100% of the sagebrush containing samples even at low levels of sagebrush in the diet (3%). Here it was demonstrated that a positive PCR test for sagebrush should therefore be interpreted as a significant presence of sagebrush in cattle diets. Our study showed that species consumed in small numbers were detected as reliably as other species eaten in greater numbers. These findings are in agreement with other studies (Deagle et al., 2005).

The sensitivity of the trnL gene was high. Each sample of known positive presence of sagebrush was positively detected by our technique. A gradual decline in the rate of PCR positive results was observed as the known concentrations of sagebrush in the diet declined.

The ability of melt profiling to identify the presence of sagebrush variants at and over 3% of sagebrush inclusion provides advantages over micro-histology. In particular, when a deviant melt profile identifies the presence of a variant, these low-abundance variants are more likely to be recognized via sequencing. Additionally, only representative melt profiles from each cluster where sequence variation is not present can be separated prior to sequencing, thus reducing the cost of sequencing and the time required for its interpretation.

Conclusions

DNA based methods like sequencing in concert with HRM analysis represent a promising and accurate technique for identification of plants present in cattle diets. Botanical determinations from feces using this approach can be resolved with high taxonomic clarity and do not require identification of macroscopic characters in fecal matter. Furthermore, molecular techniques may be able to detect dietary components at very low proportions, which likely would be undetected by traditional methods. The methods reported here represent significant advances in diet determinations. The use of artificial cattle diets can help in testing different methods for diet determinations, but moving from a model system to a field system will require more experimental research before we can use the approach with confidence. Future research efforts will include DNA sequencing, which will allow us to calculate how many different plant DNA sequences in a fecal sample exist. Determinations of nucleotide sequences of the botanical elements will identify potential matches or exclusions of plant species in fecal samples.

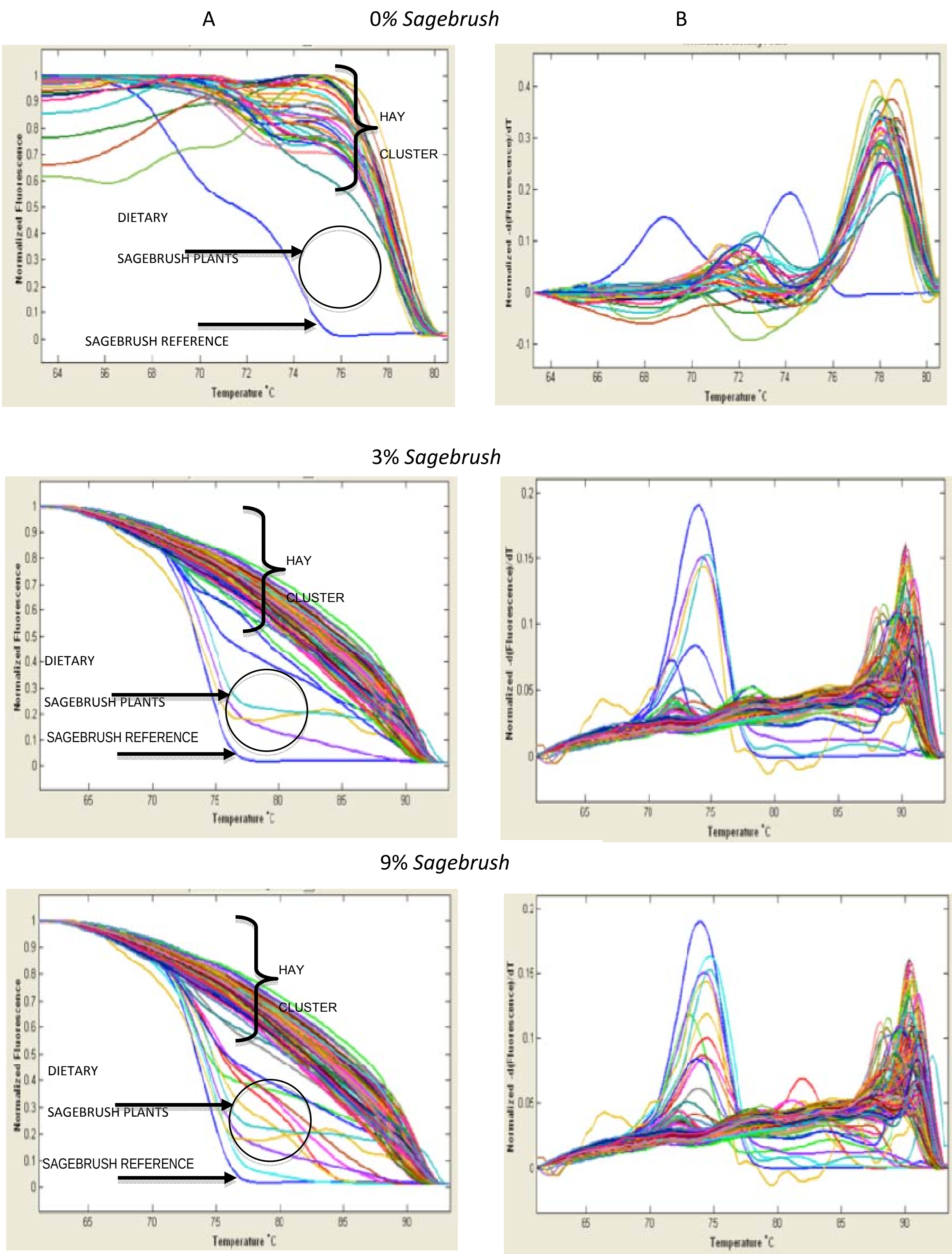

Figure 3. High-resolution melting analysis. A) Highresolution melt and B) Derivative of fluorescence with respect to temperature (dF/dT) curves for 0%, 3% and 9% of sagebrush present in feces. A randomized trnL amplicon from Sagebrush (pointed with arrow) was used as reference curve. Curve colors represent different plant dietary components. The normalized and dF/dT melt curves confirm that the trnL genotypes from Sagebrush are distinguishable from other plants present in fecal samples.

Project Publications

The following publications are available from their respective publishers:

- Perez-Amaro JA, R. Mata-Gonzalez, O. Riera-Lizarazu (Submitted and accepted for publication in 2009). DNA fecal analysis as a tool for cattle diet determination in rangelands. Abstract paper, 62rd Annual Meeting, Soc. for Range Management, Albuquerque, New Mexico, USA.
- Perez-Amaro JA, Mata-Gonzalez R, Ureña AEG, DelCurto T, Bohnert DW, Joaquín-Torres BM (Submitted and accepted for publication in 2010). Productive response of steers fed low-quality grass hay: Effect of a terpene rich supplement. Abstract paper, XLVI Annual Research Meeting of the National Research Institute for Agriculture, Forestry and Livestock (INIFAP-Mexico), San Francisco de Campeche, Mexico.
- Perez-Amaro JA, R. Mata-Gonzalez, T. DelCurto, D. Bohnert, O. Riera-Lizarazu, C. Boyd, J. Leonard (Submitted and accepted for publication in 2011). Preliminary results for the rapid and unequivocal determination of sagebrush using DNA recovered from cattle feces. Abstract paper, 64rd Annual Meeting, Soc. for Range Management, Billings, Montana, USA.

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Oregon Beef Council Report

Progress Reports – Rangeland Ecology and Management

Conflict stressors, spatial behavior and grazing budgets of cattle

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Project Objectives: The objective of this study is to develop equipment and software that can monitor stress in beef cattle as reflected in heart rate, body core temperature, and movement patterns and to evaluate the relative effect of common stressors such as noise and activity during gathering and handling.

Project Start Date*:* January 2011
Expected Project Completion Date: January 2012

Project Status: Stress is a disruptive or upsetting condition that occurs in response to adverse external or internal stimuli that has the potential to affect an animal's physical health. Acute stress is usually indexed by changes in heart rate, a rise in blood pressure, muscular tension, irritability, and depression. Our project is developing equipment and software that can monitor stress in beef cattle and examine the effects of common stressors on free-roaming animals. Although the project was approved by the Oregon Beef Council in summer 2010, funding has not been received as of 28 October 2010. Because electronic components need to be acquired and assembled prior to field work and we have missed this year's field season, we have postponed the beginning of the project until January 1, 2011. In spite of this delay, some work has been done in preparation for the project. Nineteen GPS collars that record at 1-second intervals were constructed for the OBC Riparian Project which has now finished its data collection phase. These collars are being repaired and refurbished so that they are available for the Conflict Stressors Project. Remote scent release devices have been constructed for use on the project, and ground work has been laid for heart rate and body core temperature monitoring devices. There have been new and exciting developments in the area of electronic monitoring of free-roaming livestock that should yield insight into the cause of stress and measures that can be taken to control it. We look forward to conducting this research.

Development and evaluation of rangeland vegetation and sediment monitoring: phases I and II

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Project Objectives: The overall objective of this study is to develop and test methodologies for monitoring forage utilization on grazing allotments and detecting change in streambed sediments associated with cattle use in riparian areas. This effort addresses two major areas of concern: 1) The development of quantitative data bases for allotment management and 2) The development of sampling methodology to facilitate the refinement of stubble height standards for riparian and upland grazing. Training would be provided to landowners/permittees and agency personnel.

Project Start Date*:* Phase I – June 2007; Phase II – June 2008
Expected Project Completion Date: September 2011

Project Status: Meetings are being held with national, regional, state, forest and district range staff from both the Forest Service and Bureau of Land Management. Inventory issues associated with scale, statistical rigor and data accuracy have been discussed in detail. A pilot project on forested allotments in northeastern Oregon has been successfully completed. Similar inventory techniques were extended to the Snake River Province Sagebrush Steppe (BLM). In both cases (BLM and USFS), the adoption of the methodology occurred on a case by case basis.

Allotment inventory needs to provide data that can address allotment questions while at the same time provide compatible information for the vegetation classification units associated with larger landscape management. The ecological site classification utilized by the Bureau of Land Management and the Plant Community/Association classification utilized by the Forest Service represents a scale of vegetation classification that is used in allotment management that is also suitable for integration into most landscape inventories. The BLM and USFS are currently working to adopt a common system of ecological site classification. The foundation for that effort is the Ecological Site Inventory which was developed and is maintained by the Natural Resources Conservation Service. To expand the acceptance of the monitoring methodology developed in this project a document needs to be developed that supports the Ecological Site Inventory system, providing guidance on the measurement of forage utilization and stream sedimentation.

Forest community types used in the project include Ponderosa Pine-Douglas Fir-Elk Sedge, Ponderosa Pine-Fescue, Ponderosa Pine-Wheatgrass, Mixed Conifer-Pinegrass, Juniper-Big Sagebrush, Big Sagebrush-Bunchgrass, Low Sagebrush-Bunchgrass, Bunchgrass on Shallow Soil, Dry Phase Moist Meadow, Moist Meadow and Wet Meadow. Ecological sites used in the sagebrush steppe include sites having soil depth >20’’, slopes <12% , no aspect and elevations either less than or greater than 3800 ft (<3800 Clayey 9-12; <3800 Mtn Clayey 9-12; >3800 Mtn Clayey 12-16; <3800 Loamy 9-12; <3800 Mtn Loamy 9-12; >3800 Mtn Loamy 12-16) and sites with soil depths >20’’, slopes >12%, north or south aspect and variable elevation (<4500 Clayey South 9-12; >4500 Mtn South 12-16; >3000 Mtn North 9-12; >3000 Mtn North 12-16).

A final study has been initiated to demonstrate how the vertical and horizontal structure of a grass plant impacts utilization estimates. Specifically, this study evaluates how the ratio of vegetative and flowering tillers in a grass plant will impact the ability of land managers to estimate landscape appearance and height weight relationships.

The application of the inventory techniques and the testing of project products will continue as part of agency and land manager training. We are compiling project products to develop a document or documents that support their application to the description of ecological sites. No additional funding is needed to complete the project.

Grazing behavioral responses of beef cattle to medusahead invasion in sagebrush steppe rangeland

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Project Objectives: A two-year study is being conducted to determine 1) seasonal forage quality of medusahead-invaded rangeland relative to adjacent rangeland supporting desirable vegetation; 2) relative grazing preference of beef cattle for medusahead-invaded rangeland and adjacent rangeland supporting desirable vegetation; 3) seasonal cattle behavioral responses to medusahead invasion.

Project Start Date*:* April 2010
Expected Project Completion Date: December 2011

Project Status: Rangeland pastures (1,000 to 3,500 acres) in southeast Oregon containing both areas of substantial, near monotypic infestations of medusahead and areas of remnant, intact desirable vegetation (seed or native range grasses) were selected for study. All areas (patches) principally comprised of medusahead and areas of desirable rangeland vegetation will be identified and subsequently mapped in each study field during the summer of 2011. Other map layers including slope, aspect, topographic position and other mapping information potentially important for modeling cattle grazing behavior will also be secured or generated. Resulting map data files will be incorporated into a geographic information system (GIS) for analysis. The study will employ global positioning system (GPS) collars to measure seasonal behavioral responses of beef cattle to medusahead invasion. Cattle will graze the study fields continuously, season long (~April through July) to allow determination of seasonal variation in grazing behavior. In addition to providing GPS information, collars contain motion sensors that yield data that can be used to classify and estimate durations of animal activities like grazing, resting, and traveling (Ungar et al. 2005). To relate cattle activities with data acquired by the collar's motion sensors, each instrumented cow will be continuously observed for 8 daylight hours. This exercise will allow us to associate cattle behaviors with specific geographic locations, vegetation types, topographic positions, etc. within study fields. Seasonal cattle forage preference will be characterized by overlaying vegetation mapping data with measured cattle grazing locations. Concurrent with collection of cattle behavioral information, composite forage quality samples will be gathered on a biweekly schedule during the trial from five randomly selected medusahead patches and five paired areas of intact desirable rangeland vegetation within each study field. Forage samples will be analyzed for crude protein content, acid detergent fiber, and neutral detergent fiber to determine relative seasonal variation in forage quality of medusahead and desirable rangeland vegetation to aid in the interpretation of cattle grazing behavior. Data from 2011 will be published in the next edition of the Beef Research Report and presented at extension and scientific meetings. The same grazing behavioral and forage quality research protocol will be conducted in 2012, and data from both years will be compiled, analyzed, and published as extension and peer-reviewed scientific articles.

Quantitative diet analysis in cattle using fecal DNA markers

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Project Objectives: The potential of fecal DNA markers as qualitative indicators of cattle diet composition has been investigated. The objective of this study is to expand our research and use DNA markers to find not only the identity of the plant species in the diet but also their proportions in the total diet, which should help to better understand cattle nutrition and rangeland forage use in central Oregon.

Project Start Date*:* October 2010
Expected Project Completion Date: October 2011

Project Status: Fecal DNA analysis is a promising technique for diet determinations that has been little explored in herbivores. In a previous phase of this research we have been able to qualitatively identify DNA profiles that permit to identify the presence of plant species in cattle diets. The present project aims at advancing this research by quantifying the proportion of key species in the diet. We have collected fresh cattle feces from native rangelands on the Brothers, OR, area. To determine the relative proportions of target plants present in the feces, the previously determined DNA sequences will be amplified using the relatively new technique known as RT PCR (real time polymerase chain reaction). RT PCR is a variant of the classical PCR which allows to replicate and to amplify portions of a plant genome. If a target DNA sequence is present in the feces we can potentially isolate it and replicate it using PCR. RT PCR permits to precisely estimate the number of copies of DNA strands present in a sample by real time monitoring and quantification of DNA during DNA replication. To provide evidence that amplifications from fecal DNA represent the actual target species, the target species will be purposefully included at known rates in the diet of experimentally controlled cattle.

Using weeds to control weeds-use of western juniper leaf extract to suppress cheatgrass and medusahead germination and establishment on western rangelands

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Project Objectives: The overall goal of this project is to develop an inexpensive, easy-to-make, easy-to-use bioherbicide from the leaves of western juniper (*Juniperus occidentali*s Hook.) trees in an effort to control annual weedy species such as cheatgrass (*Bromus tectorum* L.) and medusahead (*Taeniatherum caput-medusae* (L) Nevski) on grazing lands in central and eastern Oregon.

Project Start Date*:* October 2010
Expected Project Completion Date: October 2011

Project Status: We have demonstrated that water soluble photochemical compounds from western juniper leaves can be simply extracted with water (even in the field) and effectively used to inhibit germination and seed production of cheatgrass and medusahead in the laboratory, greenhouse, and in the field. A 10% w/v (weight/volume) is the minimum concentration needed to be effective and 15% w/v appears to be a good upper limit. In the initial field test in 2008/09, a 15% liquid juniper extract had greater suppression of cheatgrass and Plateau® was more effective on medusahead, but the optimum juniper extract has yet to be developed. We have shown that juniper leaves taken from branches cut and left on the ground for 3 months in the summer heat appear to have more phytotoxicity than fresh leaves. This finding, leads us to speculate that under more droughty conditions (such as might be produced under global warming), breakdown products in the leaves may be the more toxic elements. This project will concentrate on determining three important things: (1) optimization of the juniper extract and best practices of application; (2) through the use of HPLC (High Performance Liquid Chromatography), continue to characterize exactly which phytochemicals are in the aqueous extract along with their concentrations and toxic effectiveness; and (3) develop a survey to gauge the opinion of stakeholders with and without western juniper trees on their land as to whether they would use such a bioherbicide in place of traditional commercially available herbicides. This project is important because it uses actual field applications of such a bio-product. The product as well as the development process could translate into other applications off the range where weedy species cause problems such as along roadsides and in urban areas.

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Beef Cattle Sciences

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