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Oregon State University

Beef Cattle Sciences

Beef Research Report

2010 Edition

Oregon State University | Extension Service

Beef Research Report

Beef Cattle Sciences

Alternative Beef Marketing Resources [1]

Lauren Gwin [2]

Introduction

This list of resources, both Oregon-specific and nationally relevant, offers beef producers more information about alternative marketing options.

Frequently asked questions about using custom-exempt slaughter and processing facilities in Oregon for beef, pork, lamb, and goat

By Lauren Gwin, OSU/NMPAN & Jim Postlewait, ODA Food Safety Division

smallfarms.oregonstate.edu/sites/default/files/publications/techreports/TRFAQsmeat.pdf

This brochure explains, to farmers and customers, the federal and state rules relevant to live, "on the hoof" sales of livestock (by wholes, halves, quarters) that can be processed at a custom-exempt, state-licensed facility.

Marketing Beef for Small-Scale Producers

By Arion Thiboumery, Iowa State University Extension & Mike Lorentz, Lorentz Meats

www.extension.org/mediawiki/files/0/00/Marketing_Beef_for_Small-Scale_Producers.pdf

If you are a small-scale producer, marketing less than 100 beef a year, one of the best ways to market your beef for the least amount of time and money is to direct market in halves, quarters, and bundles. This document explains how to resolve common problems with selling this way and is also relevant to marketing pork, lamb, or other meats directly.

Beef Marketing Alternatives

By the National Center for Appropriate Technology/ATTRA

attra.ncat.org/attra-pub/beefmark.html

This article discusses multiple ways for producers to add value to their beef both within the conventional marketing system, including retained ownership and cooperative marketing, and through alternative marketing strategies. NCAT/ATTRA has an excellent series of detailed publications on many aspects of alternative marketing options for livestock products, at attra.ncat.org.

Niche Meat Processor Assistance Network

www.nichemeatprocessing.org

NMPAN is a national network of people and organizations creating and supporting appropriate-scale meat processing infrastructure for niche meat markets. NMPAN coordinates, distributes, and develops info & resources on regulations, business development & marketing, plant design, mobile processing options, and more; find webinars, case studies, videos, and other tools on the website.

How to Direct Market Your Beef

By Jan Holder

www.sare.org/publications/beef/beef.pdf

This guidebook describes how an Arizona ranch family built a profitable, grass-based beef operation focused on direct marketing. It is organized to provide valuable instruction and tips on topics from slaughter to sales.

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1. This document is part of the Oregon State University – 2010 Beef Research Report. Please visit the Beef Cattle Sciences website at http://beefcattle.ans.oregonstate.edu.
2. Oregon State University/Niche Meat Processor Assistance Network, Corvallis 97731. Email: lauren.gwin@oregonstate.edu

Meat and Poultry Buying at Farmers' Markets: A Survey of Shoppers at Four Markets in Oregon

By Lauren Gwin, OSU/NMPAN & Larry Lev, OSU

smallfarms.oregonstate.edu/sites/default/files/publications/techreports/TRMeatPoultryBuying.pdf

Farmers' markets remain a challenge for meat and poultry; vendors report fairly low sales and minimal profit. To understand why, we surveyed consumers at four Oregon markets. Nearly half had never purchased meat or poultry at a farmers' market. The main reasons consumers who eat meat and poultry do not buy more at markets are price, inconvenience, and food safety concerns. We recommend consumer education strategies.

Niche Markets: Assessment and Strategy Development for Agriculture

ag.arizona.edu/arec/wemc/nichemarkets.html

This series of articles, while not specific to meat & poultry products, offers valuable information and instruction on developing niche markets for agricultural products.

Label Claims and Certifications

- Labeling basics: www.extension.org/pages/Meat_Labels_and_Label_Claims
- Certified Organic: www.ams.usda.gov/AMSv1.0/NOP
- Grass-fed
  - USDA Voluntary label claim: tinyurl.com/USDA-grassfed-claim
  - American Grassfed Association: www.americangrassfed.org/our-standards-and-certification/
  - Food Alliance: foodalliance.org/grassfed
- Humane
  - Animal Welfare Approved: www.animalwelfareapproved.org
  - Certified Humane Raised and Handled: www.certifiedhumane.org
  - American Humane: www.americanhumane.org

National/multi-state databases focused on sustainable foods

A great way to promote your products and see how others are direct marketing theirs:

- **FoodHub:** food-hub.org
  - Food producers and buyers of all scales (OR, WA, CA, AK, ID, MT)
- **Local Harvest:** http://www.localharvest.org
  - Farmers' markets, family farms, & other sources of sustainably grown food
- **Eatwild:** eatwild.com
  - Grassfed products: beef, lamb, goats, bison, poultry, pork, dairy, and other wild edibles.

For more information about the topics described in this publication, please contact Lauren Gwin - Oregon State University (541-737-1569, or lauren.gwin@oregonstate.edu).

Oregon State University

BEEF024

Beef Research Report

Beef Cattle Sciences

Adaptation of *Brassica* spp. and Fodder Radishes as Late Season Forages in the High Desert Region of Oregon [1]

Chanda L. Engel [2], Brian A. Charlton [3], Richard J. Roseberg [4], and Rachel A. Bentley [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. 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 kg nitrogen and 22.4 kg sulfur/ha after plants reached the 2-leaf stage 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 RAD varieties ($P \leq 0.05$), but by PD 3 all BRS varieties yielded more than RAD varieties ($P \leq 0.05$), with turnip varieties tending to have higher yields among the BRS group. 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 interaction occurred ($P \geq 0.16$). Both BRS and RAD produced good late season yields, and seem well-suited to extend the grazing season. For earlier PD, differences between varieties were as large as differences between species, but by PD3 the BRAS varieties produced greater yields than other species.

Introduction

Forage brassicas (BRS; *Brassica)* spp. and fodder radish (RAD; *Raphanus sativus*) are cold-tolerant, fast- growing crops that have been used

1. This document is part of the Oregon State University – 2010 Beef Research Report. Please visit the Beef Cattle Sciences website at http://beefcattle.ans.oregonstate.edu.
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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; 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 significantly 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 60.0 lb nitrogen and 20.0 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 (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	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 ($P < 0.05$).

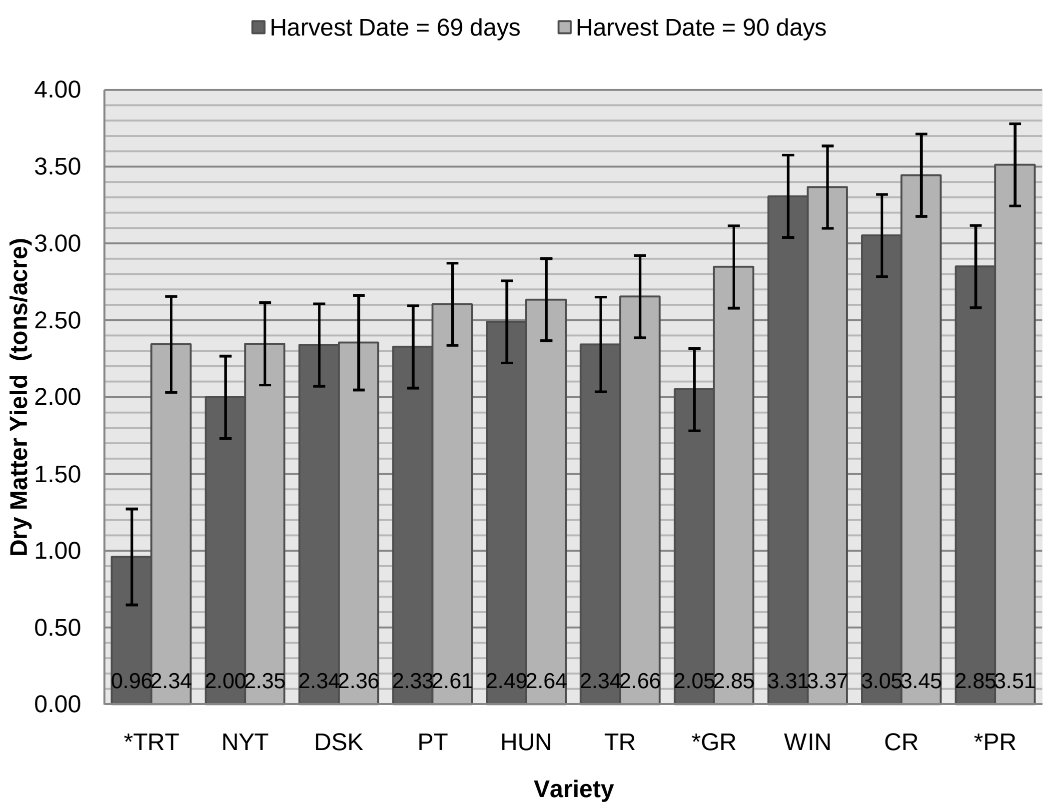

Figure 1. The effect of the interaction of variety by harvest date for BRAS, RAD, and TRT varieties on dry matter yield at 69 and 90 d following planting for the first planting date. An overall variety by harvest date interaction was not observed ($P = 0.26$). Within a variety, if denoted with an *, a difference was detected between the 69 and 90 d harvest date following planting ($P < 0.05$).

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).

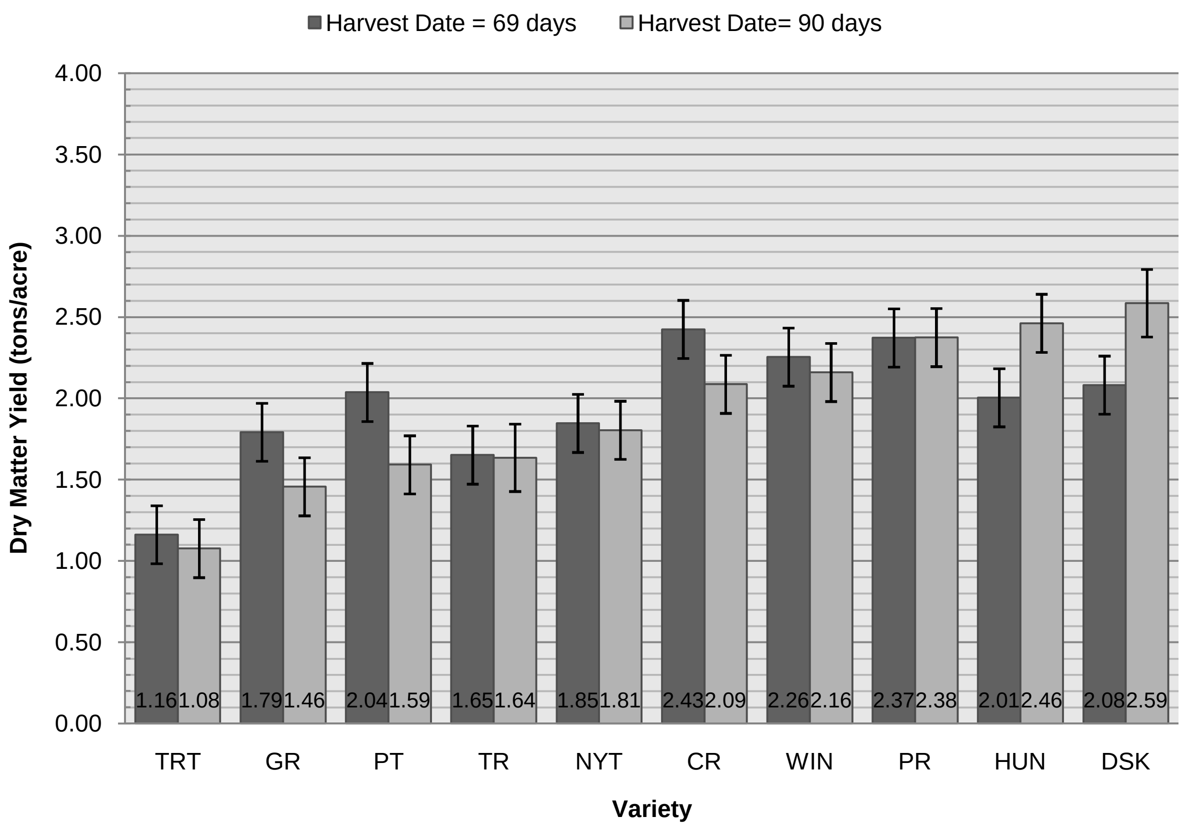

Figure 2. The effect of the interaction of variety by harvest date for BRAS, RAD, and TRT varieties on dry matter yield at 69 and 90 d following planting for the second planting date. An overall variety by harvest date interaction was not observed (*P* = 0.16). Within a variety, if denoted with an *, a difference was detected between the 69 and 90 d harvest date following planting (*P* < 0.05).

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 (Ton/acre)	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 ($P < 0.05$).

Conclusions

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 RAD (with the exception of CR) and 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 with CR and TR 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.

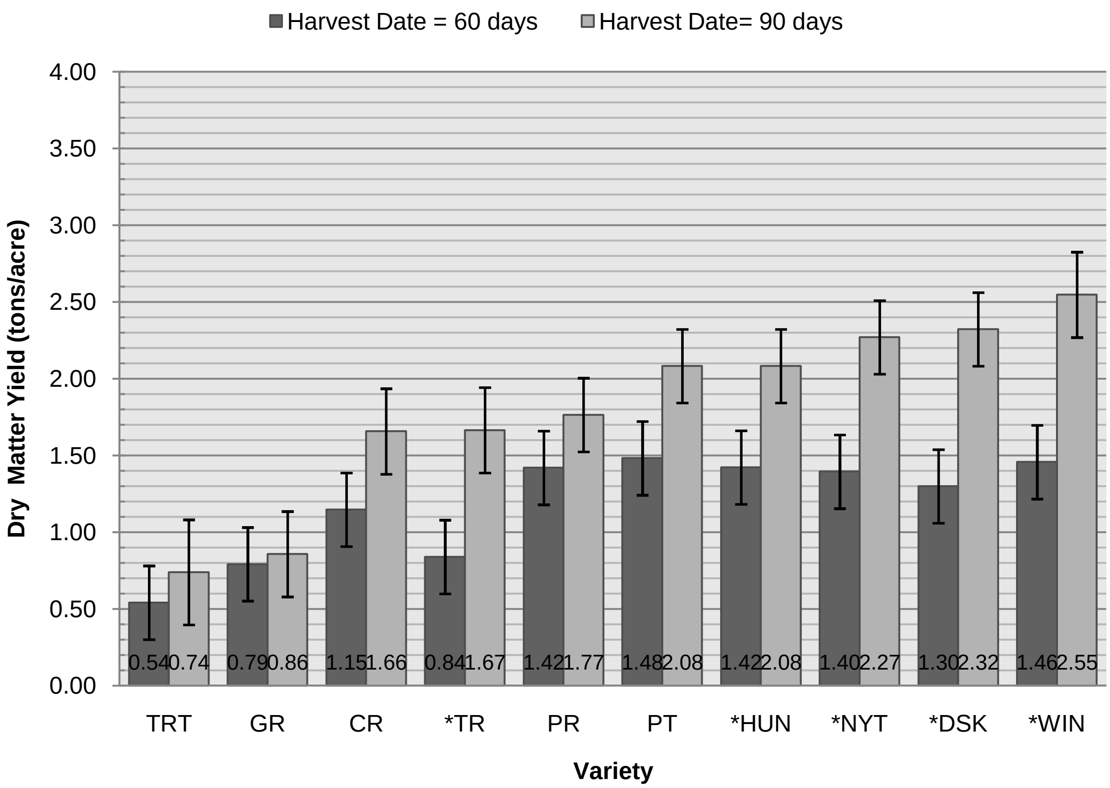

Figure 3. The effect of the interaction of variety by harvest date for BRAS, RAD, and TRT varieties on dry matter yield at 69 and 90 d following planting for the third planting date. An overall variety by harvest date interaction was not observed ($P = 0.47$). Within a variety, if denoted with an *, a difference was detected between the 69 and 90 d harvest date following planting ($P < 0.05$).

An additional year of study is necessary to confirm the results of this experiment. Additionally an economic analysis is necessary to determine economic feasibility.

Acknowledgements

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Oregon State University

BEEF026

Beef Research Report

Beef Cattle Sciences

Forage Value of Pasture Weeds in Southwestern Oregon [1]

Amy Peters [2], Shelby Filley [3], and Andrew Hulting [4]

Synopsis

Forage quality of common pasture weeds was determined through laboratory testing to compare feed value of weeds to desirable forage species and nutrient requirements for grazing livestock.

Summary

This study quantified forage quality of fourteen pasture weed species common to southwestern Oregon. Over three consecutive years, weed species were collected from varying sites in southwestern Oregon during the spring, summer, and fall. Collection sites were randomly sampled. The following weed species were analyzed: bog rush, bull thistle, Canada thistle, diffuse knapweed, French broom, gorse, Italian thistle, Scotch broom, spotted knapweed, yellow starthistle, Himalaya blackberry, sedge, Portuguese broom, and meadow knapweed. Collections were made at different times of the year to quantify forage quality for the following plant developmental stages: rosette/vegetative, bolt, and early bloom/boot. Each species was analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN), net energy, and mineral content at each developmental stage. Results indicate that some weed species have nutrient profiles similar to more desirable forage species such as orchardgrass and ryegrass. Weed species forage values are low at some plant developmental stages, however, suggesting supplemental feeding would be required by livestock producers. Mineral profiles varied for each species, indicating possible livestock health problems might occur, such as nutrient imbalances, if certain weeds were the only available feed. Several weed species, including the thistles and knapweeds, had very high levels of potassium, calcium, and magnesium at all stages of plant development. We compared nutritional values of weeds to the nutritional requirements throughout the production cycle of beef cattle, sheep, and goats. Livestock producers can use this information to more accurately meet livestock nutritional needs while livestock are grazing weed species or when livestock grazing is utilized for weed suppression as part of an integrated weed management system. Further research of weed species used as forage will quantify anti-quality factors and palatability.

Introduction

Weeds continuously invade pastures and annual or perennial crops grown for livestock feed. Weeds in forages may reduce the quantity and quality of harvested hay or grazed forage, be toxic or poisonous to livestock (Cash et al., 2010; Hulting and Neff, 2010), or cause injury to the mouths of grazing animals (Colquhoun, 2003). Some weed species, including the thistles with their spiny leaves,

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may not be eaten by livestock, whether in pasture or hay. Many grass weed species are readily eaten and provide quality nutrition to grazing livestock. Intensive grazing of weed species can be an important biological control strategy as part of an integrated weed management plan for some invasive plants. When livestock producers consider using livestock grazing for weed management, the perception of weeds must be converted from one of pests to that of a feed source (Jones, et al, 2001). Quantifying the forage quality of individual weed species is essential for making weed management decisions that include planned livestock grazing. A more targeted grazing approach to control these weeds can provide feed for livestock, reduce weed infestations, and provide more light, water, and space for desirable forage species.

Forage testing laboratories often report that many weeds they have analyzed have adequate nutritional profiles but are usually coupled with bizarre mineral profiles, or high nitrate levels and other anti-quality components, which make these species undesirable as livestock feeds (Sirous, 2004). In some cases, nutrient analysis of a weed may be similar to forage but chemicals in the weed may cause livestock to avoid the plant. Marten et al. (1975) reported that ratios of minerals may be a factor in desirability of weeds as feed. Ratios of K/(Ca + Mg) (on a meq basis) of 2.2 or greater may indicate that a forage will predispose ruminants to grass tetany or hypomagnesemia (Grunes, 1973 in Marten, et. al. 1975), a serious, often fatal metabolic disease involving low Mg levels in the blood. Bosworth et al. (1986) found that high magnesium levels can also indicate problems in grazing livestock.

In order for grazing to be effectively used for weed control, the weeds need to be acceptable, i.e. palatable, to the livestock (Targeted Grazing, 2009). Some weeds, either part of the time or continuously, are unpalatable to the grazer for a variety of reasons (e.g. foul tasting, sharp points, or cause digestive upset). Previous experience may also influence whether not an animal chooses to eat a particular weed species. Choice of grazing animal type (browsers versus grazers) and timing of grazing to a period when plants are acceptable is important to successful use of grazing to control weeds.

In this paper we present results of a study which determined the approximate nutrient value of selected weeds found in southwestern Oregon sampled at various growth stages. Weed forage values were compared to nutrient requirements of livestock throughout the production cycle of the animal. Our objective was to provide information to be used by livestock producers, including those selling product on the "organic" market and those interested in pay-to-graze operations, to enable them to make informed livestock management and weed management decisions.

Materials and Methods

Over three consecutive years from 2004-2007, 14 weed species in southwestern Oregon were analyzed including bog rush (*Juncus effuses),* sedge *(Juncus spp),* spotted kanpweed (*Centaurea maculosa Lam*.), diffuse knapweed (*Centaurea diffusa),* Scotch broom (*Cytisus scoparius L.),* French broom (*Cytisus monspessulanus),* bull thistle (*Cirsium vulgare),* Canada thistle (*Cirsium arvense),* yellow starthistle (*Centaurea solstitialis L.),* meadow knapweed ***(****Centaurea pratensis),* gorse *(Ulex europaeus L.),* Himalaya blackberry (*Rubus armeniacus*), Portuguese broom (*Cytisus striatus*), and Italian thistle (*Carduus pycnocephalus L.*). Weed samples were collected in spring, summer, and fall, corresponding to physiological stages of plant development including the rosette/vegetative, bolt, and early bloom/boot. Plant parts most likely to be eaten by livestock, including new shoots and leaves, were sampled by clipping. Lower stems and leaves were excluded from the sample because we speculated that there would be little or no consumption of these plant parts by grazing livestock. Samples were randomly collected from five or more plants and a composite sample from various sites at each sample date was made. These samples were immediately placed in a cooler with ice, later frozen, and then shipped to a laboratory for analysis (Dairy One Forage Lab, Ithaca, NY).

Laboratory tests for nutritive value during each of 3 years included dry matter (DM), crude protein (CP: Kjeldahl N x 6.25), acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN), net energy, and mineral content including the macrominerals Ca, P, K, Na, and Mg and the microminerals Fe, Zn, Cu, Mn, and Mo.

Results

Nutrient content of weed species fluctuated over the sampling period. Quality was generally high, often meeting livestock nutritional needs (Table 1). For many of the weed species analyzed, CP content was highest in the spring, decreased in summer, and increased in fall. This pattern of nutrient content fluctuation is similar to that of improved grass and legume forages. The TDN content appeared to fluctuate less than that of CP, however, it decreased in some weed species for the summer sampling. Macro- and micro-mineral content of the various weeds are listed in Tables 2 and 3, respectively. In general, the mineral content of weeds analyzed would meet the nutrient requirements of grazing livestock during part of the reproductive cycle. However, there are some instances with either deficient or toxic levels of minerals present compared to minimum requirements or maximum tolerable amounts for the animals.

Table 1. Average crude protein (CP) and total digestible nutrients (TDN) for common pasture weeds sampled for 3 years and compared to standard values for common forages and livestock nutrient requirements.

	%CP			%TDN		
Forage						
Alfalfa hay	22			51		
SW OR grass hay	8			57		
Orchardgrass pasture, veg.	18			65		
Weed	*Spring*	*Summer*	*Fall*	*Spring*	*Summer*	*Fall*
Bog rush	10	11	6	54	54	54
Sedge	11	13	10	55	57	56
Spotted knapweed	20	13	8	63	61	59
Diffuse knapweed	18	12	7	62	62	59
Scotch broom	21	20	17	61	58	57
French broom	20	15	14	62	60	59
Bull thistle	18	19	9	60	59	60
Canada thistle	21	18	12	58	58	61
Yellow starthistle	13	10	10	60	61	59
Meadow knapweed	21	17	8	63	63	58
Gorse	18	17	11	60	58	56
Himalaya blackberry	15	15	16	64	64	62
Portuguese broom	19	20	7	58	58	53
Italian thistle	15	14	7	61	59	58
Cow[1]	12.3	7.4	7	67	54	48.8
Ewe[2]	15	13.4	9.2	65	55	59
Doe[3]	8.6	8	-	58.2	54.9	-

[1] Nutrient requirements based on a 1,000 lb, spring calving cow. Spring represents early lactation, superior milking ability (20 lb/day); summer late lactation, early gestation; and fall mid gestation. Winter CP and TDN for late gestation would be 7.9 and 53.6%, respectively (NRC 1984).
[2] Nutrient requirements based on a 154 lb, spring lambing ewe. Spring represents last 4 to 6 weeks lactation, suckling twins; summer maintenance, dry ewe; and fall flushing and early gestation. Winter CP and TDN for last 4 weeks of gestation would be 11.3 and 65.0%, respectively (NRC 1985).
[3] Nutrient requirements based on a 110 lb, spring kidding meat goat doe. Spring represents early lactation; summer dry doe at maintenance and medium activity; and fall breeding. Winter CP and TDN for late gestation would be 9.1 and 55.0, respectively (NRC 1981).

Table 2. Average macromineral content in percentages for common pasture weeds sampled for 3 years in spring (Sp), summer (Su), and fall (F).

	% Ca			% P			% K			% Na			% Mg		
Item	Sp	Su	F	Sp	Su	F	Sp	Su	F	Sp	Su	F	Sp	Su	F
Bog rush	0.21	0.2	0.26	0.13	0.19	0.09	1.52	2.08	1.82	0.1	0.05	0.5	0.13	0.15	0.1
Sedge	0.22	0.41	0.5	0.15	0.17	0.15	1.2	22.6	2.17	0.05	0.03	0.04	0.09	-	0.13
Spotted knapweed	1	0.87	1.1	0.32	0.25	0.21	2.85	2.14	1.84	0.03	0.01	0.02	0.28	0.3	0.21
Diffuse knapweed	1.06	1.02	1.05	0.28	0.26	0.22	3.13	2.69	1.81	0.013	0.06	0.01	0.26	0.26	0.22
Scotch broom	0.51	0.42	0.3	0.2	0.16	0.13	1.05	1.2	0.94	0.031	0.02	0.08	0.15	0.16	0.18
French broom	0.6	0.57	0.57	0.22	0.12	0.12	1.45	1.08	0.92	0.03	0.01	0.01	0.18	0.16	0.2
Bull thistle	2.06	1.42	1.52	0.23	0.4	0.2	3.97	4.38	2.38	0.03	0.02	0.01	0.3	0.31	0.25
Canada thistle	1.22	1.27	1.53	0.26	0.29	0.16	2.82	3.29	3.44	0.02	0.01	0.02	0.48	0.2	0.23
Yellow starthistle	0.95	0.54	0.98	0.28	0.26	0.29	2.47	2.02	1.57	0.032	0.01	0.05	0.53	0.43	0.5
Meadow knapweed	0.7	0.6	1.4	0.35	0.31	0.24	4.6	3.5	2.1	0.08	0.03	0.08	0.35	0.43	0.33
Gorse	0.45	0.36	0.3	0.2	0.17	0.1	1.18	1.21	0.71	0.36	0.37	0.39	0.27	0.29	0.21
Himalaya blackberry	0.5	0.54	0.67	0.26	0.29	0.18	1.53	1.7	1.39	0.02	3	0.009	0.14	0.36	0.36
Portugues e broom	0.45	0.33	0.27	0.21	0.21	0.13	1.34	1.28	0.99	0.171	0.02	0.02	0.14	0.13	0.09
Italian thistle	1.92	1.11	0.78	0.31	0.24	0.12	4.69	1.83	2.12	0.17	0.22	0.04	0.31	0.31	0.24

Eleven of the fourteen weeds studied met CP and TDN requirements of a 1000 lb. cow for the first 5 months of gestation (summer, for spring calving herds). The brooms did not meet cow energy (TDN) requirements during summer. Most weed species analyzed in this study did not meet TDN and CP requirements of cows in the last 4 months of gestation. Requirements for the cow at lactation were met by the knapweeds, French broom, Italian thistle, and Himalaya blackberry.

Sheep and goats are selective eaters, preferring shrubs, forbs and other broadleaf plants to grasses. Nutrient requirements throughout the year for spring lambing and kidding sheep and goats are presented in (Table 1). Sheep requirements for a 154 lb ewe bred in the fall to lamb in spring were compared to weed nutrient contents throughout the year (NRC, 1985). A ewe at maintenance (August- September) could meet its nutrient requirements for CP and TDN by grazing spotted knapweed. However, spotted knapweed in summer is low in zinc as is Spanish broom in spring and summer.

Zinc would, therefore, need to be made available to the animal from other sources such as forages, supplemental feed, or a mineral mix. For the first 15 weeks of gestation (October-January), the CP and TDN requirements of a ewe could be met by grazing yellow starthistle. However, yellow starthistle is low in zinc, copper, and manganese; therefore, ewes would need to be supplemented with minerals.

For 110 lb meat goats kidding in spring, CP and TDN requirements for maintenance can be met by consuming fall growth of Himalaya blackberry, yellow starthistle, and meadow knapweed. Requirements at gestation, fall through spring, can be met with several species analyzed including: Himalaya blackberry, yellow starthistle, and

Table 3. Average micromineral content in parts per million for common pasture weeds sampled for 3 years in spring, summer, and fall.

	Iron (ppm)			Zinc (ppm)			Copper (ppm)			Manganese (ppm)			Molybdenum (ppm)		
Item	Sp	Su	F	Sp	Su	F	Sp	Su	F	Sp	Su	F	Sp	Su	F
Bog rush	98	102	72	36	45	39	6	6	4.5	549	695	717	<1	0.45	0.58
Sedge	570	162	148	20	25	20	5	8	5	462	549	452	<1	0.35	0.83
Spotted knapweed	2545	575	1395	27	27	21	15	10	9	94	33	64	<1	1	0.68
Diffuse knapweed	259	208	196	21	19	18	9	8	7	43	34	61	<1	1.3	1.7
Scotch broom	152	123	234	41	26	28	13	12	7	426	499	257	<1	0.65	0.53
French broom	210	130	332	48	48	53	5	5	6	304	221	236	2	1.05	1.2
Bull thistle	687	115	234	70	35	29	18	21	12	117	80	79	<1	0.7	<.1
Canada thistle	4922	120	156	63	86	66	26	15	8	57	89	67	0.87	0.7	<.1
Yellow starthistle	1327	141	164	63	38	50	19	10	11	57	14	16	0.87	0.7	0.7
Meadow knapweed	305	140	183	24	27	23	7	18	8	36	42	50	0.67	<1	0.53
Gorse	152	123	202	49	33	28	6	5	4	142	81	81	<1	<1	1.03
Himalaya blackberry	243	79	206	43	31	27	12	11	9	227	198	221	0.27	0.3	0.25
Portuguese broom	190	91	107	44	33	52	11	8	8	536	164	233	1.6	0.25	0.35
Italian thistle	3386	1	1934	35	31	29	18	17	11	202	39	101	0.77	0.57	0.4

meadow knapweed in fall and Himalaya blackberry, diffuse knapweed, Scotch broom, bull thistle, Portuguese broom, and meadow knapweed in early spring. Since goats browse, preferring shrubs to grasses, they may be the most effective at weed control for many of the species analyzed in this study.

Macro-minerals include calcium (Ca), phosphorous (P), potassium (K), sodium (Na), and magnesium (Mg). The macro-mineral content of the weeds studied were present in amounts that ranged from deficient to sufficient for grazing livestock. They would pose no problems for toxicity or deficiency if a well-formulated mineral mix were consumed by the grazing animal. However, ratios of potassium to calcium plus magnesium were high in some weed species analyzed, indicating possible grass tetany problems for ruminants consuming them. Bull thistle, Canada thistle and Italian thistle had ratios greater than 2.2 in all seasons, and the knapweeds had high ratios in summer and fall.

Micro-minerals include iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), and molybdenum (Mo). They showed mixed results. The Fe content of the majority of the weeds in this study was sufficient to meet or exceed the nutrient requirements of livestock. Some weed species contained excessive, even toxic, levels of Fe. We speculated that high levels of Fe in some samples were due to contamination of the sample by soil. Therefore, when encountering weeds with high Fe, take precautionary steps. Most weeds examined had Zn and Mn concentrations sufficient to meet, but not exceed, maximum tolerable levels for grazing animals.

Copper levels in some weed species were often too high for sheep. Since Cu is known to accumulate in the sheep liver, grazing strictly on these weeds may cause toxicity. The spring sample of Canada thistle, for example, contained 26 ppm Cu, exceeding the sheep maximum tolerable level. However, the cow and doe would need additional Cu if they were to consume the majority of their diet as Canada thistle. Molybdenum levels in some weeds were much lower than animal requirements and supplementation would be needed. None of the weed species exceeded maximum levels for Mo. Several weed species had mineral levels that could negatively affect ruminants. Some minerals are known to interact with others, causing possible mineral imbalances in livestock. Mineral interactions can be complicated and are beyond the scope of this paper. Animal managers need to carefully compare mineral requirements of livestock with weed mineral content (Tables 2 and 3). Sampling of pastures containing mostly weeds is recommended prior to turning livestock out, especially if the weeds will make up a majority of the grazing animal's diet. Mineral requirements of grazing livestock can be found in reference books or by contacting local county Extension Service offices.

Conclusions

Results from this experiment indicate that nutrient requirements of grazing animals can be met with some weed species. It will depend on animal species, its production cycle, weed species present, and growth stage of the weed. Management of grazing is important and will impact the success or failure of using livestock as a biological weed management tool. Producers will want to encourage livestock to graze the weed when it is most palatable and susceptible to defoliation. A sound weed management program that includes livestock grazing will require information such as nutrient value of weeds combined with a high degree of management, flexibility, and dedication by livestock producers.

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Oregon State University

BEEF032

Beef Research Report

Beef Cattle Sciences

Long-Term Moderate Livestock Grazing Reduces the Risk, Size, and Severity of Wildfires [1]

Kirk W. Davies [2], Jon D. Bates [2], Tony J. Svejcar [2], Chad S. Boyd [2]

Synopsis

Long-term moderate livestock grazing reduces the accumulation and continuity of fine fuels in sagebrush rangelands. This reduces the risk, size, and severity of wildfires in these plant communities.

Summary

Livestock grazing has the potential to have a substantial influence on fuel characteristics in rangelands around the globe. However, information quantifying the impacts of grazing on rangeland fuel characteristics is limited. The effects of grazing on fuels are important because fuels characteristics are one of the primary factors determining the risk, severity, continuity, and size of wildfires. We investigated the effects of long-term (70+ yrs) livestock grazing exclusion (non-grazed) and moderate levels of livestock grazing (grazed) on fuel accumulations, continuity, gaps, and heights in shrub-grassland rangelands. Livestock used the grazed treatment though 2008 and sampling occurred in mid- to late summer in 2009. Non-grazed rangelands had >2-fold more herbaceous standing crop than grazed rangelands ($P < 0.01$). Fuel accumulations on perennial bunchgrasses were approximately 3-fold greater in non-grazed than grazed treatments. The continuity of fuels in non-grazed compared to grazed treatments were also greater ($P < 0.05$). The heights of perennial grass current year's and previous years' growth were 1.3- and 2.2-fold taller in non-grazed compared to grazed treatments ($P < 0.01$). The results of this study suggest that moderate livestock grazing decreases the risk of wildfires. These results also suggest that when wildfires do occur in grazed rangelands, that the severity, continuity, and size of the burn will be less than in non-grazed rangelands. Thus, moderate livestock grazing is helping to protect sagebrush obligate wildlife habitat.

Introduction

Because livestock grazing and fire occur across most rangelands around the world, grazing induced modifications to fuel characteristics are probably having a substantial impact on many plant communities (Davies et al. 2009). Understanding the impact of grazing on fuels in rangelands is important because fuel characteristics influence wildfire risk, severity, continuity, and size, and the effectiveness of fire suppression efforts. However, the impact of moderate levels of grazing on fuel amounts and continuity remains largely unexplored in rangelands. To determine the impact of grazing on fuel characteristics in rangelands, we investigated

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the effects of long-term (70+ yrs) livestock exclusion compared to long-term moderate livestock grazing in sagebrush steppe plant communities in the northern Great Basin. We hypothesized that livestock grazing would: 1) reduce fine fuel accumulations, and 2) decrease fuel continuity (consistency of fuels across space).

Materials and Methods

The study was conducted at the 16,000 acre Northern Great Basin Experimental Range (NGBER) in southeastern Oregon (lat 43º29'N, long 119º43'W) about 56 km west of Burns, Oregon, USA. To determine the effect of grazing on fuel characteristics, we used a randomized block design with two treatments (grazed and non-grazed). Treatments were applied at eight different sites with differing vegetation, soils, and topography. Non-grazed treatments were 4.9 acre livestock grazing exclosures established in 1936. Native herbivores had access to vegetation inside the exclosures. The grazed treatment plots were located adjacent to the exclosures and within the same soil, topography, and vegetation association as the exclosures. Density data collected in 1937 revealed no differences in Sandberg bluegrass, large perennial bunchgrass grasses, annual grasses, perennial forbs, and annual forbs between inside and outside the exclosures ($P > 0.05$). The grazed treatments adjacent to the exclosures were grazed by cattle through 2008. Grazed treatments were moderate, 30-50% use of the available forage. From 1938 to 1949 livestock use was rotation grazing with stocking rates determined from range surveys conducted in 1938 and 1944. From 1949 to 2008, the grazing program was a deferred-rotational system with an occasional year of complete rest. No grazing occurred prior to sampling in 2009. Analysis of variance (ANOVA) was used to determine the influence of grazing on fuel characteristics by comparing the moderately grazed treatment to the long-term non-grazed treatment (S-Plus v.8, Insightful Corp., Seattle, WA). The eight sites were treated as blocks in the analyses.

Results

Long-term moderate levels of livestock grazing generally decreased the amount (Fig. 1) and continuity (Fig. 2) of fuel cover in rangelands. Gaps in the fuel covered more area in grazed than non-grazed treatments ($P = 0.04$). Fuel gap cover was 1.2-fold greater in the grazed compared to non-grazed treatments. In contrast to the other cover values, shrub and ground litter cover values were not different between treatments ($P = 0.91$ and 0.25, respectively).

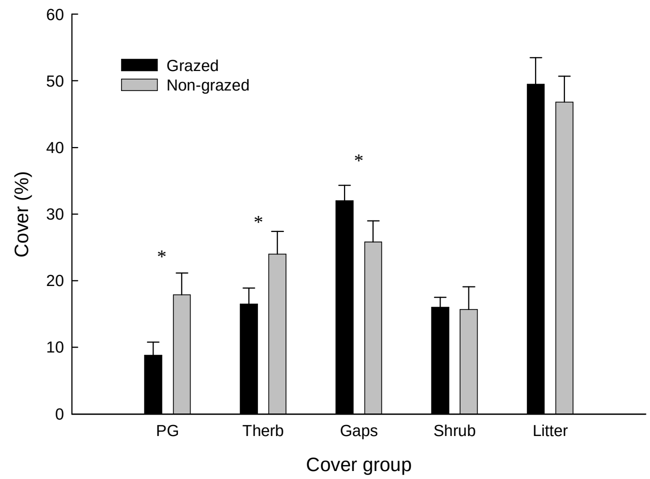

Figure 1. Percent cover (mean + SE) by group in moderately grazed and non-grazed sagebrush rangelands. Vegetation cover measurements included live and dead standing cover. PG = Perennial bunchgrass, Therb = total herbaceous vegetation, Gaps = fuel gaps, and Litter = ground litter. Asterisks (*) indicates significant difference between treatments ($P < 0.05$).

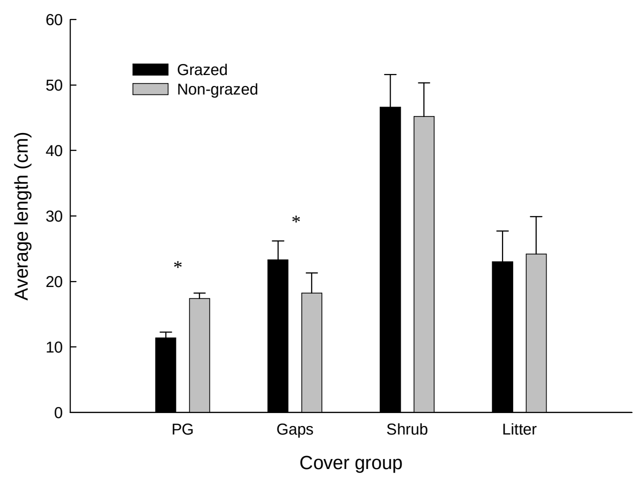

Figure 2. Continuous cover length (mean + SE) by group in moderately grazed and non-grazed sagebrush rangelands. Vegetation cover measurements included live and dead standing cover. PG = Perennial bunchgrass, Gaps = fuel gaps, and Litter = ground litter. Asterisks (*) indicates significant difference between treatments ($P < 0.05$).

The non-grazed treatment had larger continuous perennial bunchgrass cover and smaller fuel gaps ($P < 0.01$ and $= 0.03$, respectively). Assuming a square area shape to fuel gaps and continuous perennial grass cover, fuel gaps were

1.6-fold larger in grazed compared to ungrazed treatments and continuous perennial grasses were 2.3-fold large in area in ungrazed than grazed treatments. Shrub and ground litter cover continuity did not differ by treatment (*P* = 0.73 and 0.55, respectively).

Livestock grazing influenced some of the fuel load characteristics in rangeland plant communities (Fig. 3). Herbaceous vegetation standing crop biomass was more than 2-fold greater in non-grazed than grazed treatments ($P < 0.01$). Total fine fuel accumulations varied by treatment ($P < 0.01$). Total fine fuel accumulations were 2-fold higher in non-grazed compared to grazed treatments. However, ground litter did not differ between treatments ($P = 0.48$). A difference in herbaceous vegetation annual biomass production between treatments was not detected ($P = 0.21$).

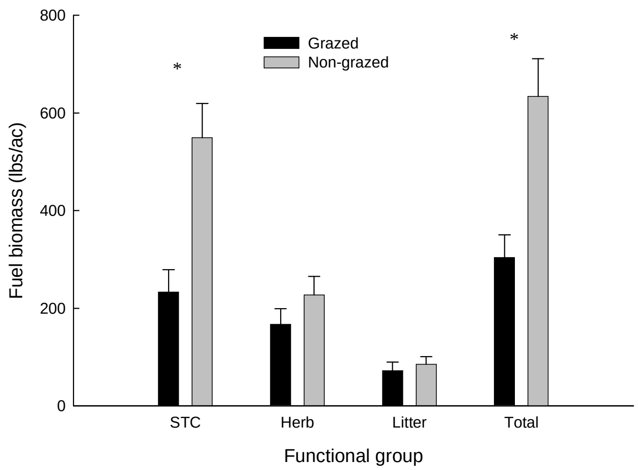

Figure 3. Fuel accumulations (mean + SE) by functional group in moderately grazed and non-grazed sagebrush rangelands. STC = herbaceous vegetation standing crop (current and past years' growth still erect), Herb = current year's herbaceous vegetation growth, Litter = ground litter, and Total = herbaceous vegetation standing crop and litter. Asterisks (*) indicates significant difference between treatments ($P < 0.05$).

Moderate livestock grazing on sagebrush rangelands influences fuel accumulations and continuity, which in turn probably influences burn characteristics and wildfire risk. Our data suggests that moderate levels of livestock grazing decreases fine fuel loading and continuity. These alterations have the potential to decreasing the probability, continuity, size, and severity of wildfires in sagebrush rangelands. Livestock grazing impacts several fuel characteristics simultaneously. This greatly increases its potential influence on wildfires. The influence of grazing on fuels, by affecting fire severity, may also affect post-fire plant community response and assembly in sagebrush plant communities and potentially other semi-arid and arid rangelands.

The probability of burning and burn continuity may be decreased in moderately grazed sagebrush rangelands because of a reduction in fine fuels, larger gaps between fuels, and less continuous fuels. Long-term non-grazed compared to moderately grazed sagebrush rangelands would be more likely to burn, burn with less patches of unburned within the burn perimeter, and produce fires that would be more difficult to suppress. Moderate levels of cattle grazing, by reducing the risk of catastrophic wildfires and post-fire exotic plant invasions, may protect sagebrush rangeland plant communities and the wildlife dependent upon them.

Conclusions

Moderate levels of long-term cattle grazing have significant impacts on fuel characteristics and subsequently may alter the risk, size, severity, and continuity of wildfires on sagebrush rangelands. Our results suggest that moderate livestock grazing reduces the risk of wildfires on sagebrush rangelands by decreasing the amount of fine fuel available for ignition and limiting potential fire spread by reducing fine fuel continuity and accumulation. The reduction in potential spread of fire in long-term moderately grazed sagebrush plant communities can also increase the efficiency of suppression efforts. Thus, moderate livestock grazing is protecting sage-grouse and other sagebrush obligate habitat from being lost in large, severe wildfires.

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Moderate Livestock Grazing Protects Sagebrush Plant Communities From Post-Fire Cheatgrass Invasion [1]

Kirk W. Davies [2], Jon Bates [3], and Tony Svejcar [4]

Synopsis

Moderate livestock grazing compared to not grazing prevented cheatgrass from invading sagebrush plant communities after burning. The ungrazed areas had a buildup of fuels that probably increased the mortality of perennial bunchgrass, thus opening the plant community up to cheatgrass invasion.

Summary

Grazing and fire in sagebrush plant communities are both controversial issue. However, information is lacking detailing their interactions. We evaluated the impacts of fire on sagebrush rangeland, which had either been moderately grazed up until just prior to burning (1993), or which had been excluded from grazing since 1936. Vegetation characteristics were measured in the 12th through 14th years after burning. Burning caused a huge increase in cheatgrass, an exotic annual grass, in the ungrazed areas, but not in the moderately grazed areas. The ungrazed treatment also had less desirable perennial vegetation. The increase in cheatgrass coincided with mortality of the native perennial bunchgrasses. We suspect that accumulation of plant litter in the ungrazed treatment resulted in greater bunchgrass fire induced mortality. This information suggests that moderately grazing sagebrush rangelands may be needed to indirectly prevent cheatgrass invasion and thus, protect critical wildlife habitat and other beneficial land uses. This study highlights the importance of understanding the interactions between disturbances.

Introduction

The impacts of livestock grazing prior to fire on native plant communities are relatively unknown. Because domestic livestock grazing is not part of the historical disturbance regime for Wyoming big sagebrush plant communities in the Intermountain West (Mack and Thompson 1982), some have suggested that its impacts would be negative (Fleischner 1994, Noss 1994). Historical disturbances (e.g. fire) are often considered a requirement to maintain native plant communities and this has resulted in the reconstruction of historical disturbance regimes to direct ecosystem management. However, some ecosystems have experienced irrevocable changes in environmental conditions and biotic potentials that could potentially alter the response of plant communities to historical disturbances. For example, climate change or invasive plants may result in different responses from plant communities to disturbances than would be expected under historical conditions.

The objective of this study was to determine the impacts of grazing and no grazing prior to fire in

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Wyoming big sagebrush plant communities. Understanding the impacts of grazing prior to fire in Wyoming big sagebrush plant communities is important because most of these plant communities are grazed by domestic livestock, are at risk of burning, and provide valuable habitat for wildlife. With the introduction of exotic annual grasses such as cheatgrass, the impact of grazing prior to fire in Wyoming big sagebrush plant communities is unknown.

Materials and Methods

The study was conducted on the Northern Great Basin Experimental Range (NGBER) in southeastern Oregon about 56 km west of Burns, Oregon. Treatments were: 1) ungrazed unburned, 2) ungrazed burned, 3) grazed unburned, and 4) grazed burned. Ungrazed treatments were implemented with the erection of 4.9-acre domestic livestock grazing exclosures in 1936. Native herbivores had access to the exclosures. The grazed treatments were areas adjacent to the exclosures and had moderate livestock grazing (30-40 percent of available forage used) until 1990. In the fall of 1993, prescribed burns were applied to both the grazed and ungrazed treatments. Average fine fuel loads were about 100 lbs/acre greater in the ungrazed than grazed treatments prior to burning. Vegetation characteristics were sampled in 2005, 2006, and 2007 (12, 13, and 14 years post-burning). Repeated measures analysis of variances (ANOVA) using Proc Mix in SAS v.9.1 (SAS Institute Inc., Cary, NC) were used to determine the influence of grazing and fire on vegetation characteristics. Fixed variables were grazed and burned treatments and their interaction. Random variables were sites and site by treatment interactions.

Results

Large perennial bunchgrass and cheatgrass densities were influenced by the interaction of burning and grazing ($P < 0.01$; Fig. 1). Large perennial bunchgrass density was lowest in the ungrazed burned treatment and highest in the grazed burned treatment with a 1.9-fold difference between the two treatments. Burning decreased perennial bunchgrass density in the ungrazed treatment but did not influence bunchgrass density in the grazed treatment. Cheatgrass density was 15-fold greater in the ungrazed burned treatment than the other treatments. Perennial forb density was decreased by burning ($P < 0.01$), but was not influenced by grazing ($P = 0.36$). Large perennial bunchgrass production generally increased with burning ($P < 0.01$; Fig. 2). Bunchgrass production increased more with burning in the grazed compared to the ungrazed treatment.

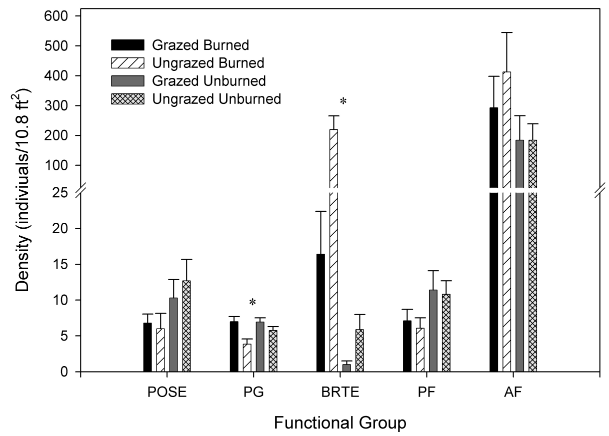

Figure 1. Plant functional group density (mean + S.E.) of the treatments averaged over 2005, 2006, and 2007 at the Northern Great Basin Experimental Range. POSE = Sandberg bluegrass PG = tall perennial bunchgrass, BRTE = cheatgrass, PF = perennial forb, and AF = annual forb. Ungrazed = livestock excluded since 1936, Grazed = moderately grazed by livestock until 1990, Burned = prescribed fall burned in 1993, and Unburned = no prescribed burning. Asterisk (*) indicates significant interaction between grazing and burning treatments for that functional group ($P < 0.05$).

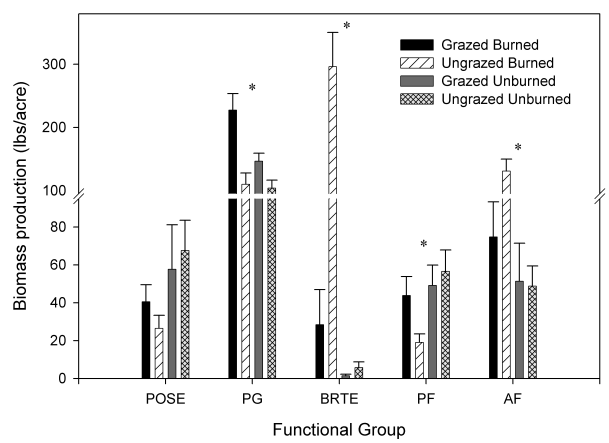

Figure 2. Plant functional group biomass production (mean + S.E.) of the treatments averaged over 2005, 2006, and 2007 at the Northern Great Basin Experimental Range. POSE = Sandberg bluegrass PG = tall perennial bunchgrass, BRTE = cheatgrass, PF = perennial forb, and AF = annual forb. Ungrazed = livestock excluded since 1936, Grazed = moderately grazed by livestock until 1990, Burned = prescribed fall burned in 1993, and Unburned = no prescribed burning. Asterisk (*) indicates significant interaction between grazing and burning treatments for that functional group ($P < 0.05$).

Burning the grazed treatment increased perennial bunchgrass production 1.6-fold. Cheatgrass biomass production was 49-fold more in the ungrazed burned treatment than in the other three treatments ($P < 0.01$; Fig. 2). Perennial forb biomass production decreased 3-fold when the ungrazed treatment was burned ($P < 0.01$). Biomass production of annual forbs, consisting mostly of exotics, increased with burning ($P < 0.01$). However, annual forb production was lowest in the ungrazed unburned treatment and highest in the ungrazed burned treatment. In the ungrazed burned treatment, cheatgrass produced more biomass than all the perennial herbaceous vegetation combined.

Grazing history influenced the response of Wyoming big sagebrush plant communities to fire. Moderately grazing sagebrush plant communities with livestock increased the fire tolerance of the native herbaceous plant community and thus, prevented cheatgrass invasion. The cheatgrass invasion of the ungrazed treatment post-fire has probably changed the future disturbance regime of those communities. Cheatgrass invasion often increases fire frequency due to an increase in the amount and continuity of fine fuels (Whisenant 1990). The invasion of cheatgrass and, subsequently, the altered future disturbance regime will negatively impact sage-grouse, pygmy rabbits, and other sagebrush-obligate wildlife species as well as reduce production of perennial bunchgrasses.

Moderate grazing probably mediated the effects of fire because it reduced the amount of fine fuel. Less fuel, especially on the perennial bunchgrasses, probably increased the survival of native herbaceous perennial vegetation. The accumulation of fuels on perennial grasses has been demonstrated to increase mortality from burning (Odion and Davis 2000). Mortality of perennial bunchgrasses would potentially open the plant community to cheatgrass invasion, because perennial bunchgrasses are the most critical plant functional group for preventing exotic annual grass invasion of sagebrush-bunchgrass plant communities (Davies 2008).

Although domestic livestock grazing was not part of the historical disturbance regime of these plant communities, it may now be needed because of new pressures from invasive plants and climate change. However, individual circumstances will dictate the value of emulating historical disturbance regimes for maintaining native plant communities. In our specific example, the historical disturbance regime of Wyoming big sagebrush plant communities is estimated to have consisted of 50- to greater than 100+ year fire-return intervals (Wright and Bailey 1982, Mensing et al. 2006) and lacked large herbivore grazing pressure (Mack and Thompson 1982). Emulating this disturbance regime for Wyoming big sagebrush plant communities did not produce the expected effect of shifting the dominance from shrubs to native forbs and perennial grasses. Long-term protection from livestock grazing followed by fire resulted in substantial cheatgrass invasion and a large increase in non-native forbs

Conclusions

Preventing grazing in Wyoming big sagebrush plant communities weakened the ability of the perennial herbaceous vegetation to tolerate fire. Moderate livestock grazing appears to be beneficial to the long-term sustainability of Wyoming big sagebrush plant communities. Preventing grazing to protect sagebrush plant communities may actually facilitate their demise and accelerate the decline of sagebrush obligate-wildlife species. However, these results should not be misinterpreted to suggest that all grazing is beneficial. Heavy and/or improper grazing (over-grazing) would be detrimental to these plant communities; thus, the level and timing of grazing is critical.

Acknowledgements

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Oregon State University

BEEF036

Beef Research Report

Beef Cattle Sciences

Effects of Polyunsaturated Fatty Acid (PUFA) Supplementation on Performance and Acute-Phase Response of Transported Beef Steers [1]

Reinaldo Cooke [2], Alexandre Scarpa [3], Frederico Nery [3], Flavia Cooke [4], Philipe Moriel [5], Bret Hess [6], Randy Mills [7], and David Bohnert [8]

Synopsis

Supplementation with PUFA during preconditioning modulated health processes and enhanced growing lot performance of feeder calves.

Summary

The objective was to compare growth, feed intake, and acute-phase response of steers supplemented or not with PUFA for 30 d prior to shipping to the feedyard. Seventy-two Angus steers weaned at 7 mo of age (d -55) were randomly allocated to 18 drylot pens (4 steers/pen). Pens were assigned to receive a grain-based supplement (avg. 1.5 kg/steer/d) without (CO) or with 0.15 kg/steer/d of a PUFA source (PF) or a saturated fatty acid source (SF). Treatment intakes were formulated to be iso-caloric, iso-nitrogenous, and offered daily from d -30 to d 0. Mixed alfalfa-grass hay was offered free-choice during the same period. On d 0, steers were loaded onto a livestock trailer and transported for approximately 350 miles over a 6 h period. However, steers remained in the truck for a total of 24 h before unloaded into a commercial growing lot (d 1), where steers were maintained in a single pen, managed similarly, and received a diet not containing PF or SF. Forage intake was evaluated daily from d -30 to d -1. Shrunk body weight was collected on d -33, 1, and 144 for growth evaluation. Blood samples were collected on d 0, 1, and 3, and analyzed for plasma concentrations of interleukin 1 and 6, tumor necrosis factor (TNF)-α, haptoglobin, ceruloplasmin, cortisol, and fatty acids. No treatment effects were detected for preconditioning growth rates or feed efficiency, but feed intake was often reduced for PF steers compared with CO and SF ($P < 0.01$). Plasma concentrations of PUFA were greater in PF steers compared to CO and SF prior to and after transportation ($P < 0.01$). Following transportation, concentration of TNF-α increased for CO, did not change for SF, but decreased for PF steers ($P < 0.01$). During the growing lot, PF steers tended to have greater growth rates compared to CO steers ($P = 0.06$). In conclusion, PUFA supplementation during preconditioning had detrimental effects on feed intake, but reduced plasma concentrations of TNF-α following transportation, and improved growing lot ADG.

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Introduction

Three of the most stressful events encountered by a feeder calf are weaning, transportation, and feedlot entry. These events, which may occur together or in a short period of time, lead to physiological, nutritional, and immunological changes that highly affect subsequent calf health and feedlot performance. One example is the acute-phase response, an important component of the innate immune system that can be detrimental to growth rates in cattle. Consequently, management strategies that prevent and/or alleviate the acute-phase response have been shown to benefit cattle productivity and overall efficiency of beef operations.

Supplementation of rumen-protected PUFA to feeder heifers prior to and after transportation decreased concentrations of acute-phase proteins during the 7 d following feedyard entry (Araujo et al., 2009). These results indicated that PUFA supplementation might be an alternative to alleviate the acute-phase response stimulated by transportation and feedlot entry. However, heifers and steers supplemented with PUFA experienced, during the feedyard phase only, reduced ADG and feed intake (Araujo et al., 2008; Araujo et al., 2009) compared to cohorts offered iso-caloric and iso-nitrogenous control diets.

Therefore, one alternative to conciliate the beneficial effects of PUFA supplementation on the acute-phase response without reducing feedlot performance would be supplementing PUFA prior to shipping/feedlot entry only. We hypothesized that feeder steers supplemented with PUFA prior to shipping would experience alleviated acute-phase response following feedlot entry, resulting in enhanced feedyard performance. The objectives of this study were to evaluate plasma concentrations of acute-phase proteins, cytokines, and cortisol, in addition to health and growth rates of feeder steers supplemented or not with a PUFA source for 4 wk prior to shipping to the feedlot.

Materials and Methods

The experiment was conducted in accordance with an approved Oregon State University Animal Care and Use Protocol, and was divided into a preconditioning (d -30 to 0) and a growing phase (d 1 to 144). The preconditioning phase was conducted at the Eastern Oregon Agricultural Research Center, Burns. The growing phase was conducted at a commercial growing lot (Top Cut; Echo, OR).

Seventy-two Angus steers weaned at 7 mo of age (d -55) were stratified by body weight on d -30 of the study, and randomly allocated to 18 drylot pens (4 steers/pen). Pens were assigned to 1 of 3 treatments (6 pens/treatment): 1) corn and soybean meal-based supplement containing 0.33 lbs/steer of a PUFA source (PF; Megalac-R®; Church and Dwight, Princeton, NJ), 2) corn and soybean meal-based supplement containing 0.33 lbs/steer of a saturated fatty acid source (SF; Megalac®; Church and Dwight), and 3) corn and soybean meal-based supplement containing no fat source (CO). Supplements were offered daily, at a rate of approximately 3.3 lbs/steer, throughout the preconditioning phase (d -30 to 0). Supplement intakes were formulated to be iso-caloric and iso-nitrogenous, whereas mixed alfalfa-grass hay was offered in amounts to ensure free-choice access during the same period. On the morning of d 0, steers were combined into 1 group, loaded into a commercial livestock trailer, and transported to the growing lot (Top Cut). The travel time was approximately 10 h, but steers were maintained in the truck for a total of 24 h before being unloaded (d 1) in order to simulate the stress challenge of a long-haul. During the growing phase (d 1 to 144), all steers were maintained in a single pen, managed similarly and received the same diet, which did not contain any of the preconditioning treatments.

Blood samples were collected on d 0 (prior to loading), 1 (immediately upon arrival), and 3, via jugular venipuncture into commercial blood collection tubes (Vacutainer, 10 mL; Becton Dickinson, Franklin Lakes, NJ) containing sodium heparin. Steer rectal temperature was assessed with a digital thermometer (GLA M750 digital thermometer; GLA Agricultural Electronics, San Luis Obispo, CA) concurrently with each blood collection. All blood samples were harvested for plasma and stored at −80°C until assayed for concentrations of cortisol (DPC Diagnostic Products Inc., Los Angeles, CA), ceruloplasmin and haptoglobin (according to Arthington et al. 2008), fatty acid composition (according to Kramer et al., 1997), and proinflammatory cytokines interleukin (IL)-1, IL-6, and tumor necrosis factor (TNF)-α (SearchLight; Aushon Biosystems, Inc., Billerica, MA).

Performance and physiological data were analyzed using the PROC MIXED procedure of SAS (SAS Inst., Inc., Cary, NC) and Satterthwaite approximation to determine the denominator df for the tests of fixed effects. The model statement used for plasma measurements and DMI contained the effects of treatment, day, and the interaction. Data were analyzed using pen(treatment) as the random variable. The specified term for the repeated statement was day and the covariance structure utilized was autoregressive, which provided the best fit for these analyses according to the Akaike information criterion. Concentrations of plasma cytokines were transformed to log to achieve normal distribution (Shapiro-Wilk test; $W > 0.90$). The model statement used for ADG and G:F analysis contained only the effects of treatment, whereas the random variable was pen(treatment). Significance was set at $P \leq 0.05$, and tendencies were determined if $P > 0.05$ and ≤ 0.10.

Results

During the preconditioning phase, a treatment × day interaction was detected ($P < 0.01$) for feed intake (Figure 1) because PF steers often had reduced intake compared to the other treatments. However, no treatment effects were detected on preconditioning growth rates and feed efficiency (Table 1). These results support previous efforts indicating that PUFA supplementation reduced DMI in cattle (Araujo et al., 2008), but did not affect ADG or feed efficiency (Araujo et al., 2009).

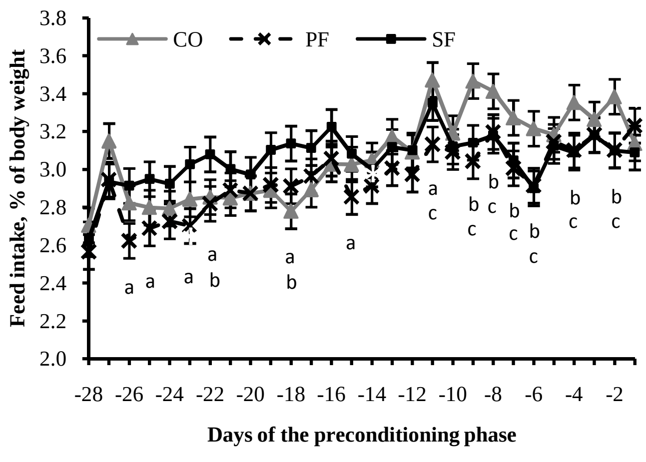

Figure 1. Daily feed intake, as a percentage of body weight, of steers offered diets without (CO) or with the inclusion of a rumen-protected saturated (SF) or PUFA (PF) source during the preconditioning phase. Days with letter designation indicates the following treatment differences ($P < 0.05$): a = SF vs. PF, b = SF vs. CO, and c = CO vs. PF.

No treatment effects were detected for rectal temperatures and plasma concentrations of haptoglobin, ceruloplasmin, and cortisol (Table 1). These results indicate that PUFA supplementation did not decrease plasma concentrations of acute-phase proteins. Further, similar cortisol concentrations suggest that steers from all treatments experienced a similar stress challenge due to transport and feedyard entry.

Table 1. Preconditioning growth, feed efficiency, rectal temperatures, plasma concentrations of acute-phase proteins, cytokines, and cortisol of steers offered diets without (CO) or with the inclusion of a rumen-protected saturated (SF) or PUFA (PF) source during a 30-d preconditioning phase.

	Treatments			
Item[1,2]	CO	SF	PF	P =
Growth rate, lbs/d	1.83	1.91	1.72	0.54
Feed efficiency, lbs/lbs	0.141	0.147	0.137	0.70
Rectal temperature. °C	103.3	103.4	103.5	0.49
Haptoglobin, 450 nm	3.99	4.43	5.41	0.58
Ceruloplasmin, mg/dL	26.2	26.2	27.1	0.68
Cortisol, ng/mL	36.7	36.7	28.7	0.29
IL-6, pg/mL (log)	0.88	0.56	0.79	0.67
IL1, pg/mL (log)	1.51	1.12	1.46	0.16

A treatment × day interaction was detected ($P < 0.01$) for plasma TNF-α. Following transportation, concentration of TNF-α increased for CO, did not change for SF, but decreased for PF steers (Table 2). When plasma concentrations of all cytokines analyzed jointly, given that their proinflammatory activities are redundant and synergistic (Whiteside, 2007), a treatment × day interaction was detected ($P = 0.05$), given that following transportation, cytokine concentrations increased for CO, did not change for SF, but decreased for PF steers (Table 2).

A treatment × day interaction was also detected ($P = 0.04$) for plasma PUFA concentrations. On d 0, PF steers tended ($P = 0.10$) and had greater ($P < 0.01$) plasma PUFA concentrations compared to SF and CO steers, respectively. On d 1 and 3, plasma PUFA concentrations were greater in PF steers ($P < 0.01$) compared to both treatments.

During the growing lot phase, PF steers tended ($P = 0.06$) to have greater growth rates compared to CO steers (2.70 vs. 2.57 lbs/d; SEM = 0.04), but similar ($P = 0.43$) to SF steers (2.64 kg/d). No differences were detected for growing lot ADG between PF and SF steers ($P = 0.28$).

Table 2. Plasma concentrations of TNF-α and combined proinflammatory cytokines of steers offered diets without (CO) or with the inclusion of a rumen-protected saturated (SF) or PUFA (PF) source during a 30-d preconditioning.

	Day of collection			
Item[1]	0	1	3	SEM
Plasma TNF-α, pg/mL (log)				
CO	1.74 [a]	1.88 [a]	2.23 [b]	0.21
SF	1.91 [a]	2.10 [a]	1.95 [a]	0.21
PF	1.90 [ab]	2.00 [a]	1.55 [b]	0.21
Combined cytokines, ng/mL (log)				
CO	1.99 [a]	2.10 [a]	2.45 [b]	0.18
SF	2.00 [a]	2.18 [a]	2.08 [a]	0.18
PF	2.15 [ab]	2.27 [a]	1.95 [b]	0.18

[1] Within rows, different letters differ (P < 0.05).

This increase in growing lot daily gains between CO and PF steers can be attributed, at least in part, to the beneficial effects of PUFA supplementation on the acute-phase response following transportation and feedlot entry. The acute-phase response can be detrimental to performance of feeder calves, particularly during the receiving period of the feedlot (Arthington et al., 2008), whereas PUFA are believed to modulate the immune system by altering inflammatory reactions (Miles and Calder, 1998). Within the immunomodulatory effects of PUFA, linolenic acid promotes an inflammatory response. Conversely, linoleic acid favors the synthesis of proinflammatory cytokines (IL-1, IL-6, and TNF-α) that trigger hepatic synthesis of acute-phase proteins (Carroll and Forsberg, 2007). According to the manufacturer, the PUFA source offered to steers in the present study contained linoleic and linolenic acids (28.5 and 3.0 %, respectively). Although a greater amount of linoleic acid was present in the PUFA source offered herein, animal requirements for linoleic and linolenic acids are still unknow. Therefore, linolenic acid might be required in reduced amounts to trigger an anti-inflammatory response and overcome the proinflammatory effects of linoleic acid, what would explain the results reported in herein. However, further research is required to address this matter.

Conclusions

Inclusion of a rumen-protected PUFA source into preconditioning diets reduced the some aspects of the acute-phase response triggered by transport and feedyard entry, and improved growing lot performance of feeder calves. Therefore, PUFA supplementation might be an alternative to enhance health parameters and feedlot performance of growing cattle.

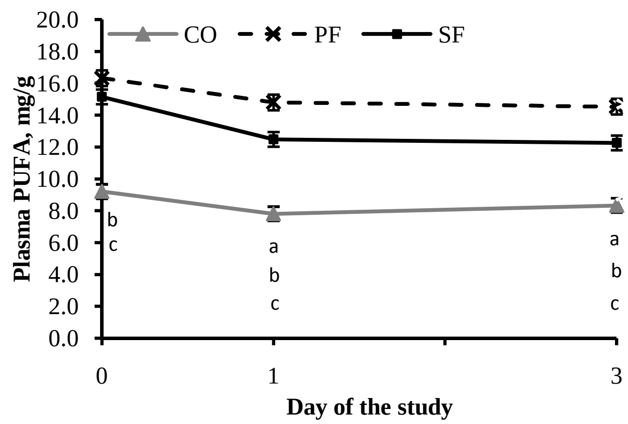

Figure 2. Plasma concentrations of PUFA (mg/g) of steers offered diets without (CO) or with the inclusion of a rumen-protected saturated (SF) or PUFA (PF) source during the preconditioning phase (d -30 to d 0). On d 0, steers were transported to a feedyard, where preconditioning treatments were not offered. Days with letter designation indicates the following treatment differences (P < 0.01): a = SF vs. PF, b = SF vs. CO, and c = CO vs. PF.

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Oregon State University

BEEF034

Beef Research Report

Beef Cattle Sciences

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

Chad J. Mueller [2], Tim DelCurto [3], Randy R. Mills [4], Cassandra P. Sullivan [5] and Garrett 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.

	Grandsire		Gender		P values [a]		
Item	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 to 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

BEEF035

Beef Research Report

Beef Cattle Sciences

Preliminary Report on Prevalence of Bovine Viral Diarrhea Virus, Persistently Infected (BVD PI) Cattle in the Oregon Beef Cattle Population [1]

Barbi A. Riggs [2], Randy Mills [3], Charles T. Estill [4], Chad Mueller [5]

Synopsis

Oregon State University initiated a control program for Bovine Viral Diarrhea virus, Persistently Infected (BVD PI) beef cattle. This study began to document and estimates the prevalence of BVD PI animals on Oregon ranches.

Summary

The objective of this experiment was to evaluate the prevalence of BVD PI in beef cattle in Oregon. To date 9,822 hd of cattle have been enrolled in the OSU Biosecurity/BVD program and completed BVD PI screening, representing 43 ranches located in 16 counties. Preliminary results indicate the prevalence of BVD PI in Oregon is 0.07%. However, 11% of ranches that have competed BVD PI screening had at least one animal testing positive for BVD PI. Data suggests that the prevalence of BVD PI among all cattle is lower than the reported national prevalence (0.13-2.0%). However, data indicates that there are more ranches (11%) in Oregon that have at least one animal test positive for BVD PI than the national rate (4%). The preliminary data does not adequately represent the geographical distribution of the cattle population or ranches in Oregon and therefore further BVD PI screening needs to be conducted.

Introduction

Bovine Viral Diarrhea virus (BVD) has received significant attention from the private sector and academia as a disease that causes insurmountable economic loss to the cattle industry throughout the U.S. The economic impact has driven the industry to begin adopting premium payments for cattle sold as BVD persistently infected (PI) free. The increased public awareness and added market value creates the opportunity to educate ranchers on biosecurity practices, using BVD as a model, with additional opportunity to increase revenue of Oregon cattle sold as BVD PI free. The long term impact of this project on the Oregon cattle industry includes improved herd health, resulting in improved performance, marketability, profitability and improved consumer confidence of Oregon raised cattle. It is our intent that this project will help not only control the prevalence of BVD in the state but will also impact prevalence of other diseases of concern such as trichomoniasis and paratuberculosis. Biosecurity education will prepare the Oregon cattle industry to

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contain other potential catastrophic diseases such as foot and mouth disease (FMD).

Bovine Viral Diarrhea virus (BVD) is a complex disease that causes beef cattle to have a range of symptoms from sub-clinical to death. The virus often leads to suppression of the immune system and results in secondary infections such as acute respiratory and digestive tract disease. Fetal infections are the most important manifestation of BVD, particularly when susceptible pregnant heifers/cows develop a viremia after the initial acute infection. There are several possible outcomes of fetal infection, depending on gestational stage when the fetus is exposed: abortions, congenital abnormalities, and newborn calves born immunotolerant to the BVD and are persistently infected (PI) throughout their lifetime (Fulton, 2002). The PI animal has a very high persistent viremia and BVD is shed throughout the animal's life. The persistent shedding of virus makes the PI animal the primary transmission source of BVD to susceptible cattle.

It is difficult to establish the economic impact BVD PI animals have on the cattle industry due to performance loss, reproductive efficiency loss, morbidity and mortality of secondary diseases. Studies indicate that in herds with at least one PI animal present, the cost of BVD was reported to be $14.85-$24.84 per cow/year (Larson et al, 2002). The feedlot segment reports the cost of BVD per head is around $30-$47.00 (Hessman, 2006). The economic impact of BVD has driven the interest for control programs around the country.

Vaccination programs alone cannot control or eliminate BVD. A successful control program must include not only proper vaccination, but removal of PI animals and implementation of proper biosecurity measures to minimize or eliminate risk of re-exposure to BVD (Dubovi, 2001; Fulton, 2002). Implementation of a biosecurity plan will reduce risk of exposure to many other economically important infectious diseases and prepare producers for biological risk management in the event of a disease outbreak, local or national.

The prevalence of BVD in the state of Oregon is undocumented. Studies show that prevalence of BVD in the U.S. beef cattle population is between 0.13%-2.0%. The prevalence of herds that have at least one PI is around 4% (O'Connor et al., 2007; Wittum et al., 2001). While most herds are BVD PI free; of the herds that have BVD PI animals, it is likely that there will be more than one PI animal in the herd.

Materials and Methods

Beef cattle producers were exposed to the OSU Biosecurity/BVD PI control program via oral presentations or written articles at local and state Oregon Cattlemen's Association meetings, OSU Extension programs and state and local media. Each of these oral presentations or written articles was designed to educate ranches on the disease of BVD and about the importance of biosecurity.

Ranches were recruited to participate in the OSU program and test for BVD PI through media and at each educational event. All ranches in Oregon were eligible to participate. A website (www.ans.oregonstate.edu/bvd) for the OSU Biosecurity/BVD PI program was launched October, 2008. This site hosts the information and requirements for ranch participation and enrollment. Whole herd testing (all calves, replacement heifers, bulls, and open cows) was recommended, but not required. Ranches enrolled in the program submitted an application and questionnaire to the OSU Biosecurity/BVD team and in return received testing supplies to collect and submit ear notch samples to Animal Profiling International, Inc. for BVD PI screening. The questionnaire posed 45 questions related to ranch demographics, performance, herd health, marketing and biosecurity practices. Data was collected for later analysis to evaluate the relationship of these factors to the prevalence of BVD PI on ranches in Oregon.

Cattle herds were screened through reverse transcriptase polymerase chain reaction (PCR) technology using pooled animal tissue samples of 28 samples or less. A reverse transcriptase-PCR assay on pooled fresh tissue is a sensitive and specific method of screening cattle for BVD PI.

A PCR test positive for BVD PI (PI (+)) required a 2nd test 3 weeks after the initial sample to differentiate transient from persistent infection. If the PI (+) animals are confirmed to be persistently infected upon the 2nd test result, the animal was quarantined from any and all non-PI animals until euthanization or harvest could occur. The dams of a calf that is PI (+), as determined by the above method, was also tested for BVD PI by using PCR and protocol as outlined above.

If we assume that the true prevalence is roughly in the middle of this range (1.05%) then we would like to know if Oregon has a higher or lower prevalence than the average national prevalence estimate. Using Win Episcope 2.0 to estimate Sample Size for Threshold Levels with Expected proportion in the population of 1.06% and Threshold Proportion in Group of 1.7% with 99% confidence and 95% Power of Test we needed to sample 5376 animals. Prevalence of BVD PI was calculated for the population ((number of animals PI (+) / total number of animals tested) x 100) and for herds ((number of ranches with at least one PI (+) / total number of ranches tested) x 100).

Results

To date 9,948 animals have completed the testing. This represents 43 ranches (Table 1.). The OSU program was initiated in October, 2008 and will continue until October, 2010. Preliminary data in this study showed a 0.07% prevalence of BVD PI, or roughly one animal per 1500 head of cattle tested. This is below other US studies reporting prevalence rates of 0.13%-2.0% (O'Connor et al., 2007; Wittum et al., 2001). However, the preliminary OSU data showed 11% of herds (7 of 43) tested had at least one PI positive (+) animal, which is well above the estimated national number of 4% of herds tested had at least one PI (+) animal (O'Connor et al., 2007; Wittum et al., 2001). This study agrees with other research that although the prevalence among individual cattle is low, if a ranch has one PI (+) animal it is likely to have more than 1 PI, hence the greater prevalence among herds. This study reported a much greater herd prevalence than O'Connor et al. (2007), which may be explained by the difference in herd dynamics. O'Conner et al. (2007) tested herds with different mean and median animals per herd (131, 100 respectively) than this study mean and median (27, 223 respectively). This study screened a few very large ranches (>800 hd) and found PI on those large operations. This may skew the prevalence among herds. Loneragan et al . (2005) reported prevalence of 0.3% among 2,000 hd of auction barn purchased calves arriving at a single feedyard which is typically a population of animals that have a greater risk of BVD PI exposure than the cattle screened in this study (all calves originated and tested prior to leaving ranch of origin).

Animal Profiling International, the contracted laboratory conducting the reverse transcriptase-PCR assay for BVD PI, has documented prevalence of the disease in Oregon over the past four years (Table 1). In 2006 and 2007 the prevalence of animals having BVD was close to the national figures (0.21%), however, over the past 2 years the prevalence was lower than the national average (0.06%). The decrease in prevalence may be explained by the fact that initial motivation for BVD screening of the cattle population was most commonly a result of existing herd health concerns where BVD was suspected. Most recently, motivation for screening has shifted from diagnostic to surveillance and increased marketing potential for PI free calves compared to the national figures estimated by other researchers.

This study was designed to determine if the beef cattle population (1,390,000 head) in Oregon had a greater or lesser prevalence of Bovine Viral Diarrhea Virus persistently infected animals than what is found in the US cattle population. Nationwide, the prevalence of BVD-PI has been estimated to be between 0.13 and 2.0%. Although we estimated a sample size of 5376 animals was needed to determine if Oregon has a higher or lower prevalence than the average national prevalence estimate, the current study has sampled 9,948 animals. However, this represents only 16 counties in Oregon, of which 6 of the counties had only one ranch enrolled in the OSU BVD/Biosecurity program. This data set is not adequate to evaluate if geographical regions within Oregon have similar prevalence rates. Furthermore, some of the counties with the largest cattle populations are under-represented (Malheur, Union, Wallowa, Klamath and Lake). Likewise, Harney County, with the largest cattle population in the state, has not enrolled nor tested any cattle to date. Prevalence of BVD PI cattle reported in this study are preliminary numbers only, a more complete data set representing a greater number of counties and a greater proportion of cattle needs to be collect in order to have a more clear idea of the true prevalence of BVD PI in the state of Oregon.

Conclusions

In conclusion, preliminary results from this study suggest the prevalence of BVD PI among all cattle in Oregon (0.07%) may be lower than the national prevalence rate (0.13%-2.0%). However, the number of ranches in Oregon with at least one BVD PI animal (11.63%) appears to be larger than the national figure (4%). However, the data collected to date does not adequately represent the differences in geographical populations of cattle or ranches. Further BVD PI diagnosis needs to be conducted to provide a more accurate prevalence number.

Table 1. Oregon cattle and ranches tested for BVD PI through OSU Biosecurity/BVD program and Animal Profiling International.

	Cattle Tested	Ranches Tested	Cattle PI (+)	Ranches with at least one PI (+)	Prevalence of BVD PI in Cattle	Percent of Ranches that have at least one BVD PI (+)
OSU Biosecurity/BVD Program						
Oct. 2008-Feb 2010	9,995	43	7	5	.07 %	11.63%
Animal Profiling International						
2006	6,230		13		0.21%	
2007	7,258		15		0.21%	
2008	8,913	93	7	3	0.06%	3.23%
2009 (Jan-July)	11,422	111	7	4	0.06%	7.92%
Total API	33,823		56		0.17%	

Acknowledgements

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Oregon State University

BEEF037

Beef Cattle Sciences

Beef Research Report

Effects of Polyunsaturated Fatty Acid (PUFA) Supplementation on Forage Intake and Digestibility in Beef Cows [1]

Reinaldo F. Cooke [2], Alexandre Scarpa [3], Frederico Nery [3], Flavia Cooke [4], and David W. Bohnert [5]

Synopsis

Supplementation with PUFA reduced forage and total feed intake, but did not alter forage digestibility parameters in beef cows.

Summary

The objective was to compare intake and in situ forage digestibility in beef cows supplemented or not with a rumen-protected PUFA source. Three Angus x Hereford cows fitted with ruminal cannulas were allocated to a 3 x 3 Latin Square design containing 3 periods of 21 d each. Treatments consisted of grain-based supplements without (CO) or with the inclusion (10%; as-fed basis) of a PUFA source (PF) or a saturated fatty acids source (SF). Treatment intakes were formulated to be iso-caloric and iso-nitrogenous, and offered daily at a rate of 0.7 % of body weight/cow/d. Within each experimental period, mixed alfalfa-grass hay was offered in amounts to ensure ad libitum access from d 1 to 13, and hay intake was recorded daily. Data collected from d 8 to 13 were used to determine treatment effects on hay and total feed intake. From d 14 to d 21, cows were restricted to receive 90 % of their voluntary hay intake. Immediately before treatment feeding on d 16, polyester bags containing 4 g of hay were suspended within the rumen of each cow, and incubated in triplicates for 0, 4, 8, 12, 24, 36, 48, 72, and 96 h. After removal, bags were washed, dried for 96 h at 50°C in forced-air ovens and weighed. Triplicates were combined and analyzed for neutral-detergent fiber (NDF) content. Hay and total feed intake were reduced ($P < 0.05$) in PF cows compared to SF and CO cows (2.19, 2.30, and 2.31 % of BW for forage DMI; and 2.86, 2.98, and 3.05 % of BW for total DMI). However, no treatment effects were detected ($P > 0.48$) for ruminal degradation rate of hay dry matter (6.81, 7.48, and 6.86 %/h for CO, PF, and SF) and hay NDF (6.05, 6.43, and 6.17 %/h for CO, PF, and SF). Similarly, no treatment effects were detected ($P > 0.63$) for effective ruminal degradability of hay dry matter (64.53, 64.93, and 64.94 % for CO, PF, and SF) and hay NDF (71.24, 71.76, and 71.57 % for CO, PF, and SF). In conclusion, PUFA supplementation did not impact forage digestibility, but decreased forage and total feed intake in beef cows.

Introduction

Supplementation of rumen-protected PUFA to feeder cattle might be an alternative to alleviate the bovine acute-phase response stimulated by transportation and feedlot entry (Araujo et al., 2009). However, feeder calves supplemented with a rumen-

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protected PUFA source during preconditioning or feedlot receiving period experienced reduced ADG, feed intake (Araujo et al., 2008), and feed efficiency (Araujo et al., 2009) compared to cohorts offered iso-caloric and iso-nitrogenous control diets. It can be hypothesized that these outcomes were due to reduced dietary digestibility and consequent feed intake in PUFA-supplemented calves (Schauff and Clark, 1989). In these studies, however, total fat content of diets were less than 6% of the DM, the limit in which fat can be present in cattle diets without detrimental effects on ruminal digestibility (Hess et al., 2008).

Therefore, the objectives of the present study were to compare DMI and in situ forage digestibility in beef cows offered diets containing less that 6% of fat (DM basis), and enriched or not with a rumen-protected PUFA source.

Materials and Methods

This experiment was conducted at the Eastern Oregon Agricultural Research Center - Burns, in accordance with an approved Oregon State University Animal Care and Use Protocol.

Three Angus x Hereford cows (724 ± 39 kg of BW), housed in individual drylot pens and fitted with ruminal cannulas were allocated to a 3 x 3 Latin Square design containing 3 periods of 21 d each. Treatments consisted of corn and soybean meal-based supplement without (CO) or with the inclusion (10%; as-fed basis) of a PUFA source (PF; Megalac-R®, Church and Dwight, Princeton, NJ) or a SFA source (SF; Megalac®, Church and Dwight). Treatment intakes were formulated to be iso-caloric and iso-nitrogenous, and offered daily at a rate of 0.7 % of BW/cow/d (Table 1).

Within each experimental period, mixed alfalfa-grass hay was offered in amounts to ensure ad libitum access from d 1 to 13, and hay DMI was recorded daily by measuring refusals. Samples of the offered hay and treatment ingredients were collected weekly to determine nutrient composition (Dairy One Forage Laboratory, Ithaca, NY) and DM, whereas samples of refusals were collected daily to determine DM content only. Hay samples were dried for 96 h at 50□C in forced-air ovens. Data collected from d 8 to 13 were used to determine treatment effects on hay and total DMI. From d 14 to d 21, cows were restricted to receive 90 % of their voluntary hay DMI.

Immediately before treatment feeding on d 16, polyester bags (pore size 50-60 µm) containing 4 g (DM basis) of mixed alfalfa-grass hay were suspended within the rumen of each cow, and incubated in triplicates for 0, 4, 8, 12, 24, 36, 48, 72, and 96 h. Prior to incubation, all bags were soaked in warm water (37 oC) for 15 min. The 0-h bags were not incubated in the rumen but were subjected to the same rinsing procedure used for the ruminally incubated bags. After removal, bags were washed repeatedly until the rinse water was colorless, dried for 96 h at 50°C in forced-air ovens, and weighed. Triplicates were combined and analyzed for NDF (Robertson and Van Soest, 1981) using procedures modified for use in an Ankom 200 Fiber Analyzer (Ankom Co., Fairport, NY).

Table 1. Nutrient profile of treatments.

Item	Treatments CO [1]	SF [2]	PF [3]
NE_g, Mcal/kg [4]	0.75	0.80	0.81
NE_m, Mcal/kg [4]	1.41	1.48	1.49
TDN, %	59.0	60.0	61.0
CP, %	16.5	16.7	16.7
NDF, %	52.5	52.9	52.4
Ether extract, %	2.2	4.0	4.1
Ca, %	0.4	0.6	0.7
P, %	0.3	0.3	0.3

[1] CO = Corn and soybean meal-based supplement (90:10 ratio, respectively; as-fed basis), fed at 0.75% of BW, without supplemental fat.
[2] SF = Corn and soybean meal-based supplement with the addition of rumen-protected saturated fatty acid (Megalac®; Church & Dwight, Princeton, NJ) source (75:15:10 ratio, respectively, as-fed basis) fed at 0.67% of BW.
[3] PF = Corn and soybean meal-based supplement with the addition of rumen-protected PUFA (Megalac-R®; Church & Dwight) source (75:15:10 ratio, respectively, as-fed basis) fed at 0.67% of BW.

Voluntary forage and total DMI were analyzed using the PROC MIXED procedure of SAS (SAS Inst., Inc., Cary, NC) and Satterthwaite approximation to determine the denominator df for the tests of fixed effects. The model statement contained the effects of treatment, day, and the interaction, in addition to period as independent variable. Data were analyzed using cow as the random variable. Kinetic parameters of hay DM and NDF disappearance were estimated using nonlinear regression procedures of SAS, as described by Vendramini et al. (2008). Treatment effects on ruminal degradation rate and effective ruminal degradability (Coblentz and Hoffman, 2009) were analyzed using the PROC MIXED procedure of SAS and Satterthwaite approximation to determine the denominator df for the tests of fixed effects. The model statement contained the effects of treatment and period as independent variables. Data were analyzed using cow as the random variable. Results are reported as least square means and were separated using PDIFF. Significance was set at $P \leq 0.05$, and tendencies were determined if $P > 0.05$ and ≤ 0.10. Results are reported according to treatment effects if no interactions were significant.

Results

Cows receiving PF had decreased ($P < 0.05$) forage and total DMI compared to SF and CO cows, whereas no differences were detected between SF and CO cows (Figure 1). These results support previous efforts indicating that rumen-protected PUFA supplementation, more specifically as calcium soaps of fatty acids, reduced DMI in cattle (Araujo et al., 2008, Araujo et al., 2009). One could speculate that reduced feed intake in PF-fed calves was due to reduced dietary digestibility (Schauff and Clark, 1989).

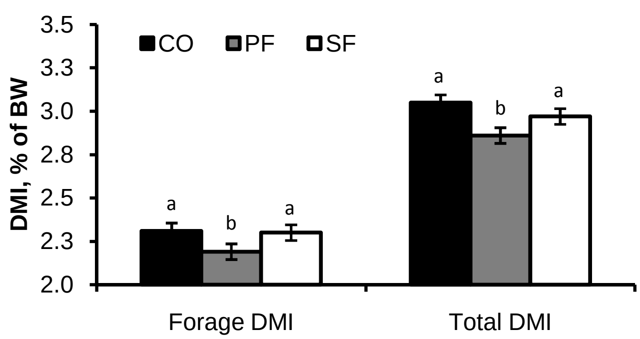

Figure 1. Forage and total DMI, as percentage of BW, of cows offered diets without (CO) or with the inclusion of a rumen-protected SFA or PUFA (PF) source. Within variables, values bearing a different letter differ ($P < 0.05$).

However, in present study, total fat content of PF and SF was approximately 4% (DM basis; Table 1) based on feed intake and nutritional analysis. According to Hess et al. (2008), ruminal digestibility is not impaired if diets contain less than 6% (DM basis) of fat. Supporting this rationale, no treatment effects were detected ($P > 0.48$) on ruminal degradation rate (Kd) of hay DM and NDF (Table 2). Similarly, no treatment effects were detected ($P > 0.63$) for effective ruminal degradability of hay DM and NDF (Table 2).

These results indicate that PUFA supplementation did not impact forage digestibility, but decreased forage and total DMI in beef cows. These negative outcomes cannot be attributed to the chemical composition of the PUFA source, given that the SFA source used in the present experimental was also based on calcium soaps of fatty acids. Therefore, additional research is needed to understand the mechanisms by which PUFA reduces feed intake in cattle, so strategies to alleviate this effect can be developed, which will allow the inclusion of PUFA sources into preconditioning and receiving diets without major pitfalls.

Table 2. In situ disappearance kinetics of dry matter (DM) and neutral-detergent fiber (NDF) of mixed alfalfa-grass hay incubated in cows offered diets without (CO) or with the inclusion of a rumen-protected SFA or PUFA (PF) source.

Treatment	K_d, /h	Effective degradability,[1] %
DM analysis		
CO	0.069	64.53
SF	0.068	64.94
PF	0.075	64.93
SEM	0.004	0.38
P-value	0.48	0.71
NDF analysis		
CO	0.061	71.24
SF	0.062	71.57
PF	0.064	71.76
SEM	0.003	0.36
P-value	0.69	0.63

[1] Calculated as $A + B \times [(K_d + K_p)/K_d]$, where K_p was the ruminal passage rate, which was arbitrarily set at 0.025/h (Coblentz and Hoffman, 2009).

Conclusions

Inclusion of a rumen-protected PUFA source into cattle diets reduced forage and total feed intake; however, forage digestibility parameters were not affected. Therefore, additional research is required to understand the negative effects of supplemental PUFA on feed intake in beef cattle.

Acknowledgements

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Oregon State University

BEEF025

Beef Research Report

Beef Cattle Sciences

Effects of Supplemental Vitamin E with Different Oil Sources on Growth, Health, and Carcass Parameters of Preconditioned Beef Calves [1]

Chad J. Mueller [2], Clint Sexson [3], and Randy R. Mills [4]

Synopsis

Little to no impact on gain performance, carcass characteristics or immune response was detected when feeding high levels of supplemental vitamin E (with or without a supplemental oil source) to beef calves during the preconditioning period.

Summary

This trial was designed to evaluate the impact of supplemental vitamin E with or without different oil sources during a 35-d preconditioning period. Sixty-four Angus-cross calves were stratified by weight and sex then randomly allotted to one of four preconditioning dietary treatments: CON (corn-soybean meal (base) diet with no added vitamin E or oil), SE (base diet plus 68 IU supplemental vitamin E per lb diet), ELA (SE diet plus 1.5% safflower oil) and ELNA (SE diet plus 1.5% linseed oil). Following preconditioning, calves were shipped to a feedlot where they were vaccinated for Infectious Bovine Rhinotracheitis (IBR) and Parainfluenze-3 (PI3) to stimulate immune activity. No differences *($P > 0.10$)* were detected for ADG during the preconditioning and finishing periods or for carcass measurements across treatments. Morbidity rates were less than 1% and consistent across treatments. Calves receiving the CON diet had greater amounts of IBR titer at d35 and d36 *($P < 0.05$)* versus calves receiving supplemental vitamin E. No differences *($P > 0.10$)* were detected for PI3 titers for any treatment contrasts during either feeding phase. Other than one collection period (d42) no differences *($P > 0.10$)* were detected for glucose levels among the treatment contrasts across feeding phases. Supplementation of preconditioning diets with vitamin E with or without supplemental oil showed limited impact on gain or carcass measurements, and on immune response indicators in beef calves.

Introduction

Both metabolic and respiratory illnesses in feedlot calves results in reduced gains, poorer feed conversions and negatively impacts carcass quality (Gardner et al., 1999; Wittum et al., 1996). As a result producers have been encouraged to precondition weaned calves for 30 to 45 days prior to feedlot arrival. Typically preconditioning programs focus on vaccination strategies, dehorning, and castration. These programs emphasize feeding “balanced” diets to improve nutrient intake while acclimating calves to feed bunks, but little research has been conducted on augmentation of

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

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preconditioning diets and their impact on subsequent feedlot health and gain performance. Vitamin E is intimately involved with the immune system, especially regarding oxidative stress and reducing free radicals that can damage cell membranes (Combs, 1998). This study was designed to evaluate the impact of feeding elevated levels of vitamin E with or without essential fatty acid sources, on the gain and health performance during both the preconditioning and feedlot periods and subsequent carcass quality.

Materials and Methods

All procedures involving animals were approved by the Oregon State University Institute of Animal Care and Use Committee. Sixty-four Angus-cross calves (n = 36 steers, 28 heifers; 495 ± 74 lb) were stratified by weight and sex then randomly allotted to one of four 35-d preconditioning treatment groups (Table 1).

Table 1. Dietary treatments fed to newly weaned beef calves during the 35d preconditioning period.

Item	Dietary treatments (DM basis) [a]			
	CON	SE	ELA [b]	ELNA [c]
Cracked corn, %	57.8	57.5	56.7	56.7
Soybean meal, %	38.0	37.8	37.2	37.2
Molasses, %	1.3	1.3	1.2	1.2
Limestone, %	2.2	2.2	2.2	2.2
TM salt [d], %	0.75	0.75	0.74	0.74
Premix [e], %	0.0	0.48	0.47	0.47
Oil source, %	0.0	0.0	1.5	1.5
Nutrient analysis [f]				
Crude protein, %	27.9	30.0	25.9	26.0
Vitamin E, IU/lb	3.8	129.1	248.6	179.6

[a] Treatments were fed at 5.50 lb/day, with *ad libitum* bluegrass hay (6.75% CP).
[b] Oil source was safflower oil.
[c] Oil source was linseed oil.
[d] Trace mineralized salt.
[e] Cracked corn carrier with predetermined levels of supplemental vitamin E.
[f] Based on laboratory analysis.

Preconditioning dietary treatments were CON (base-diet with no supplemental vitamin E or oil), SE (base-diet plus 68 IU of supplemental vitamin E per lb diet DM), ELA (SE diet supplemented with 1.5% safflower oil (linoleic acid source)), and ELNA (SE diet supplemented with 1.5% linseed oil (linolenic acid source)). Concentrate mixes were limit-fed to 5.5 lb (AF basis) offered once daily in the afternoon. Eight pastures of similar size were used to house the calves during the pre-conditioning period of the trial (2 pastures per treatment). Each pasture contained a designated feeding area for the concentrate supplement and for free-choice grass hay (bluegrass hay), along with an open-access watering area. At the conclusion of the pre-conditioning period, all calves were transported (275 mi) to a commercial feedlot for finishing. All calves received an intranasal application of IBR-PI3 vaccine (TSV-2™, Pfizer Animal Health) 48-h post-arrival (d38) and again at 20d post-arrival (d56). This particular vaccine (and route of administration) was used in an attempt to stimulate an acute immune response to determine whether the preconditioning treatments altered the immune activity of the calves during the first 30d post-arrival. Calves were fed in a common pen and sent to slaughter when visual assessment indicated 0.4 inches of backfat cover, as determined by management. Carcass data was collected on all animals at time of harvest.

Blood samples were collected on a subsample of the population (n = 31) during the following times: trial commencement (d0), conclusion of the preconditioning period (d35), post-transit to the feedlot (d36), post-initial respiratory vaccination (d42), and post-secondary respiratory vaccination (d63 and d70). Blood samples were analyzed for glucose concentration (Stanbio Glucose Liqui-UV, Pro. 1060), Infectious Bovine Rhinotracheitis (IBR) antibody titer, and

Table 2. Summary of preconditioning and feedlot gain performance, and carcass characteristics of preconditioned beef calves with or without supplemental vitamin E.

	Preconditioning treatments[a]					Pre-planned Contrasts[b]		
Item	CON	SE	ELA	ELNA	SEM	CON vs. Vit. E	SE vs. OIL	ELA vs. ELNA
Preconditioning and Feedlot Performance								
In weight, lb	495.8	492.9	490.4	495.4	19.1	NS	NS	NS
Preconditioning ADG, lb/d	1.32	1.14	1.48	1.18	0.17	NS	NS	NS
Shrink, %[c]	5.18	5.09	5.81	5.44	0.43	NS	NS	NS
Receiving ADG, lb/d[d]	1.88	2.12	1.93	1.84	0.11	NS	0.09	NS
Finish ADG, lb/d[e]	2.61	2.62	2.59	2.46	0.08	NS	NS	NS
Feedlot ADG, lb/d[f]	2.50	2.55	2.49	2.36	0.08	NS	NS	NS
Final BW, lb[g]	1072.7	1046.0	1052.3	1035.1	24.5	NS	NS	NS
Carcass characteristics								
Carcass weight, lb	665.2	648.8	652.4	641.9	15.2	NS	NS	NS
Backfat, in.	0.43	0.49	0.41	0.43	0.03	NS	0.10	NS
Ribeye area, in^2	12.2	11.5	12.1	11.5	0.30	NS	NS	NS
KPH, %	2.12	2.19	2.06	2.32	0.12	NS	NS	NS
Marbling score[h]	476.3	488.5	461.7	506.0	24.1	NS	NS	NS
Yield grade[i]	2.62	2.93	2.54	2.79	0.11	NS	NS	NS
Retail Yield, %[j]	50.7	50.0	50.9	50.3	0.3	NS	NS	NS

[a] CON = base diet with no supplemental vitamin E or oil, SE = base diet supplemented with 68 IU of vitamin E/lb, ELA = SE diet supplemented with 1.5% safflower oil, ELNA = SE diet supplemented with 1.5% linseed oil.
[b] NS = P > 0.10.
[c] Calculated from individual weights collected after transport to feedlot (275 mi).
[d] Based on initial 35 d in the feedlot.
[e] Calculated for the period following feedlot receiving until harvest.
[f] Calculated for the entire feedlot period (receiving and finishing phases).
[g] Calculated using carcass weights divided by dressing percentage (steers = 63%, heifers = 61%).
[h] 300 = slight (Se), 400 = small (Ch^-), 500 = modest (Ch^0), 600 = moderate (Ch^+).
[i] Calculated as: yield grade = 2.5 + (2.5*backfat) + (0.0038*carcass weight) + (0.2*KPH) – (0.32*ribeye area).
[j] Calculated as % retail yield = 51.34 – (5.78*backfat) – (0.0093*carcass weight) – (0.462*KPH) + (0.740*REA).

Parainfluenza-3 (PI3) antibody titer. The IBR titers were determined via serum virus neutralization using a standard viral challenge, whereas PI3 titers were determined via hemagglutination-inhibition using a standard viral challenge.

All data were analyzed using the General Linear Model procedures of SAS (SAS Inst. Inc., Cary, NC) for a randomized complete block design with sex as block using the following preplanned contrasts: CON versus vitamin E (mean of SE, ELA, and ELNA), SE versus OIL (mean of ELA and ELNA), and ELA versus ELNA.

Results

Table 2 summarizes the performance and carcass data for all treatments. Two calves were treated for sickness during the preconditioning period, but both were not common to a single dietary treatment group. No other animals were diagnosed as sick or treated during the remainder of the study.

No differences *($P > 0.10$)* were detected in daily gain (ADG) during either the preconditioning or finishing periods for any treatment contrasts. The only ADG differences *($P = 0.09$)* tended to be between SE and OIL treatments during the receiving period. There were no differences *($P > 0.10$)* in carcass characteristics for any treatment contrasts. Backfat accumulation tended *($P = 0.10$)* to be greater in SE calves versus the OIL treatment calves. The performance and carcass data indicate that supplemental vitamin E with or without added safflower or linseed oil sources have minimal or no impact on animal gain performance or carcass merit.

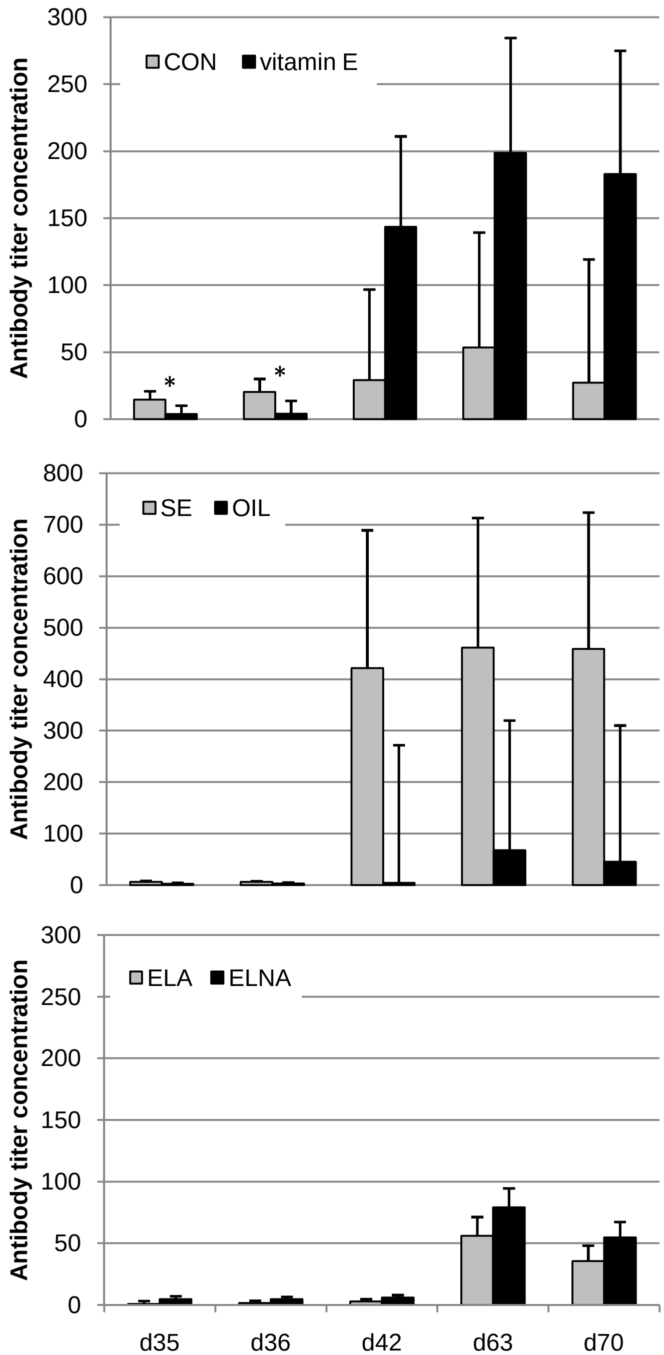

Figure 1. Infectious Bovine Rhinotracheitis (IBR) antibody titer concentrations in preconditioned beef calves. CON = base diet with no supplemental vitamin E or oil, SE = base diet supplemented with 68 IU of vitamin E, ELA = SE diet supplemented with 1.5% safflower oil, ELNA = SE diet supplemented with 1.5% linseed oil. *$P < 0.05$.*

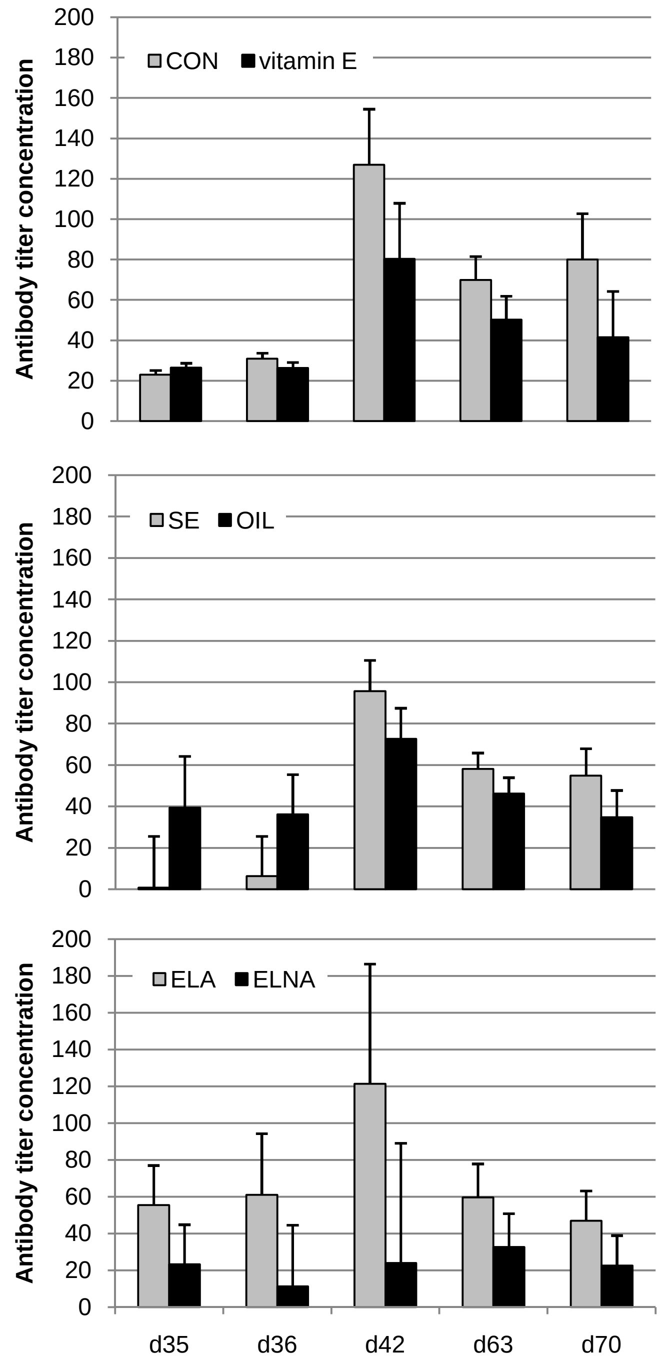

Figure 2. Parainfluenza-3 (PI_3) antibody titer concentrations in preconditioned beef calves. CON = base diet with no supplemental vitamin E or oil, SE = base diet supplemented with 68 IU of vitamin E, ELA = SE diet supplemented with 1.5% safflower oil, ELNA = SE diet supplemented with 1.5% linseed oil. *$P < 0.05$.*

Infectious Bovine Rhinotracheitis (IBR) antibody titers

Figure 1 illustrates the IBR antibody titer concentrations measured on d35, 36, 42, 63, and 70 of the study for each contrast. The only differences *(P < 0.05)* detected in antibody titer levels were at d35 and 36 with CON calves having greater levels versus calves receiving supplemental vitamin E. Upon initial evaluation of the IBR titer data one could state that titer levels responded to supplemental vitamin E (CON vs. vitamin E) and supplemental vitamin E without added oil sources (SE vs. OIL) during the receiving period in the feedlot. After detailed examination of the data and associated residual errors we concluded that the subset of calves sampled were too small and individual variation masked potential differences. The visual trends indicate that supplemental vitamin E (with or without oil) seemed to positively impact immune responses to IBR, but due to individual variation and the small number of calves sampled, those conclusions are not supported.

Parainfluenza-3 (PI3) antibody titers

Figure 2 illustrates the PI3 antibody titer concentration measured on d35, 36, 42, 63, and 70 of the study for each contrast. No differences (*P > 0.10)* were detected at any time period for any contrasting treatments. Similar to the IBR antibody titer data, PI3 antibody titers were lowest at time of transport and increased after vaccinations. Also similar to the IBR antibody titer data, the large amount of individual animal variation and the small number of calves sampled probably masked any potential treatment differences in the current study.

Plasma glucose

Figure 3 illustrates the plasma glucose levels measured on d35, 36, 42, 63, and 70 of the study for each contrast. Regardless of preconditioning treatment plasma glucose levels were similar and responded in a similar manner during the feedlot receiving period across treatments. The increasing glucose levels after feedlot arrival would correspond with increased dry matter and starch intake. Since minimal numbers of calves became ill during the study and performance was similar (indicating similar DM intake, gain efficiency, or both) we would not expect significant differences in metabolic glucose pools.

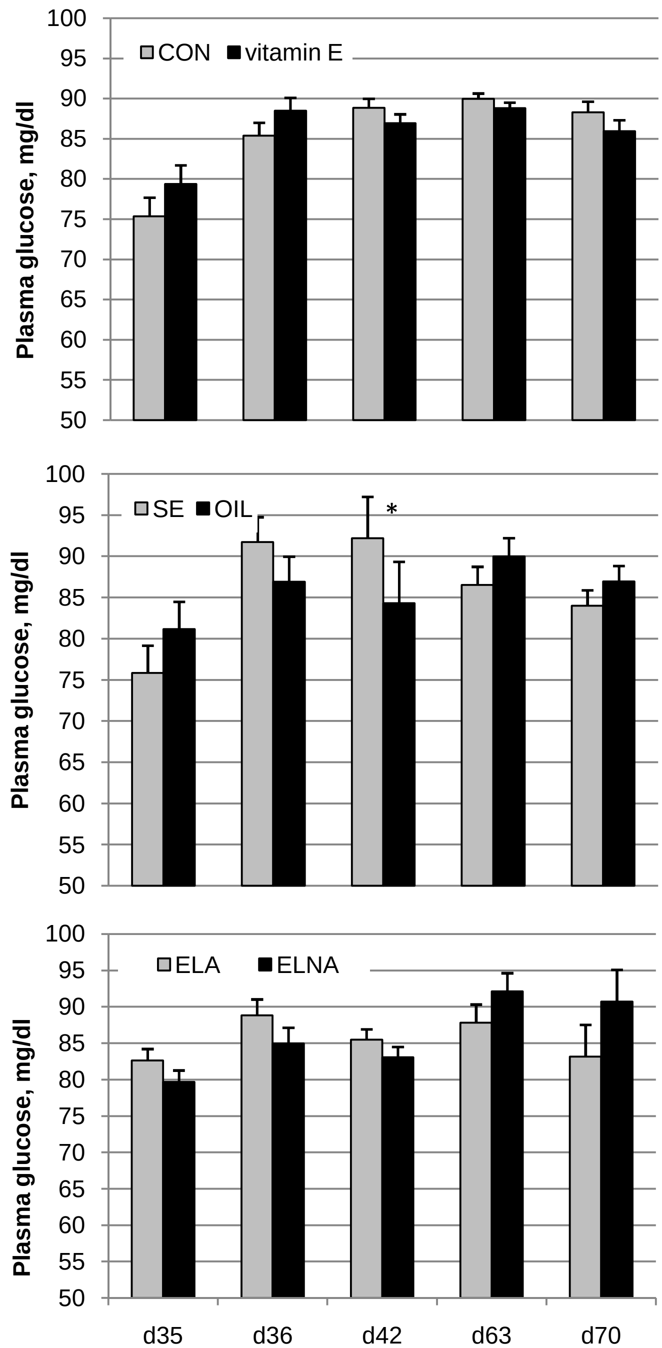

Figure 3. Plasma glucose concentrations in preconditioned beef calves. CON = base diet with no supplemental vitamin E or oil, SE = base diet supplemented with 68 IU of vitamin E, ELA = SE diet supplemented with 1.5% safflower oil, ELNA = SE diet supplemented with 1.5% linseed oil. **P < 0.05.*

Conclusions

Potentially due to the small number of sampled calves in this study (and thus higher levels of associated error), the findings do not support the use of elevated levels of vitamin E in preconditioning diets for beef calves. The use of different oil sources to improve vitamin E uptake by the calves were also not shown to be effective. Antibody titer levels would suggest that there are effects of vitamin E, but replication of the study would be necessary to clarify the results.

Acknowledgements

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Oregon State University

BEEF0027

Beef Research Report

Beef Cattle Sciences

Influence of Cow BCS and Late Gestation Supplementation: Effects on Cow and Calf Performance [1]

David W. Bohnert [2], Randy Mills [4], L. Aaron Stalker [5], Arthur Nyman [2], and Stephanie J. Falck [3]

Synopsis

Our data demonstrates the potential consequences of not maintaining cows in good BCS (≈ 6) at calving; greater calf losses, less weaned calves, decreased calf performance, lower subsequent pregnancy rate, and decreased economic return.

Summary

We conducted a 2-yr study to evaluate the influence of cow BCS and CP supplementation during late gestation on cow and calf productivity. The experimental design was a 2 × 2 factorial; two BCS (4 or 6) and supplemented or not supplemented. Calf birth weight was greater with BCS 6 cows compared with BCS 4 ($P = 0.002$) and for supplemented compared with unsupplemented cows ($P = 0.05$). In addition, weaning weight was greater for BCS 6 compared with BCS 4 ($P = 0.05$) and calf ADG to weaning was greater for the offspring of supplemented compared with unsupplemented cows ($P = 0.02$). We noted no differences in post-weaning calf performance or carcass characteristics ($P > 0.10$). However, BCS 6 cows had approximately 10% more live calves at birth ($P < 0.001$) and at weaning ($P < 0.001$) compared with BCS 4 cows. Also, pregnancy rate was 91% for BCS 6 compared with 79% for BCS 4 cows ($P = 0.005$). Supplementation during late gestation resulted in an estimated net return of \$7/cow, with calves sold at weaning, compared with not supplementing. More importantly, because of additional weaned calves, the estimated net return for BCS 6 cows at weaning was \$71/head more than BCS 4. Likewise, with retained ownership, BCS 6 cows yielded a net return of \$130/head more than BCS 4 cows. This research demonstrates the potential consequences of not maintaining cows in good BCS (≈ 6) at calving; greater calf losses, less weaned calves, decreased pregnancy rate, and lower economic return.

Introduction

Protein supplementation of late-gestation beef cows consuming low-quality forages (< 6% CP) has been shown to increase cow body weight and BCS at calving (Sanson et al., 1990; Bohnert et al., 2002). Also, cows with a BCS less than 4 may breed late or not at all in a controlled breeding season. As a result, it is recommended to have cows in good body condition prior to calving to maximize reproductive performance. Recent research from the University of Nebraska has suggested that providing supplemental protein to mature cows during the last

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90 d of gestation improves calf survivability and yields greater economic return with retained ownership of steers (Stalker et al., 2006) and improved weaning weight and fertility in heifers (Martin et al., 2007). This is novel work that demonstrates protein supplementation of the cow during the last third of gestation can affect the productivity of the offspring which was in utero during protein supplementation. The aforementioned cows in the Nebraska research began protein supplementation with an average BCS of 5 or greater. Based on this information, we hypothesize that cows in poor body condition (BCS ≈ 4) will respond more favorably to CP supplementation than cows in good condition (BCS ≈ 6).

The objectives of the current study were to determine the influence of cow BCS and CP supplementation during the last third of gestation on cow reproductive performance, calf growth and performance through the feedlot, and steer calf carcass characteristics. Also, if CP supplementation is to be profitable it must improve net returns; therefore, we estimated the economic impact of treatments.

Materials and Methods

A two-year project was conducted to evaluate the effects of BCS and late-gestation CP supplementation of cows consuming low-quality forage. Each year, 120 cows were used in a 2 × 2 factorial design. The factors were cow BCS (4 or 6) and CP supplementation (with or without supplementation). Each year during a pre-study period (approximately 60 d prior to study initiation), 120 cows that had been palpated pregnant were stratified by BCS, blocked by age and weight, and randomly allocated to one of four treatments: BCS 4 with no CP supplementation (BCS4 NCP), BCS 4 with CP supplementation (BCS4 CP); BCS 6 with no CP supplementation (BCS6 NCP); BCS 6 with CP supplementation (BCS6 CP). The cows were then managed as two separate groups based on BCS treatment (BCS 4 or BCS 6). The two BCS groups were placed in separate pastures and nutritionally managed to reach their respective target BCS by the study start date (approximately January 1). During the pre-trial period all cows received meadow hay (approximately 6% CP) and the BCS 6 cows were supplemented with alfalfa (approximately 20% CP) as needed to help reach the target BCS by study start date.

In early January each year, all 120 cows were placed into a 65 acre flood meadow pasture that had been harvested for hay the previous summer. All cows received approximately 28 lb/hd/d of low-quality (6.4% CP) meadow hay through calving. Supplemented cows received dried distillers grains (DDGS) every Monday (4 lb/hd), Wednesday (4 lb/hd), and Friday (6 lb/hd) so that the total amount of DDGS provided over the week averaged 2 lb/hd/d. The amount of supplement provided was adjusted as cows calved.

Upon calving, cows were weighed and body condition scored. Calves were weighed and a sample of blood collected for determination of serum IgG level (a measure of immune status) within 24 to 48 h of birth. After being weighed, all cow/calf pairs were be placed into an adjacent 65 acre pasture and provided approximately 30 lb/hd/d of meadow hay until all cows had calved. At that time, all of the cow-calf pairs were transported to the Northern Great Basin Experimental Range (NGBER) and managed a single herd until weaning when calves averaged approximately 140 d of age. Angus and Hereford bulls were used during a 60-d breeding season. All cows and bulls were managed in a single pasture of approximately 2,000 acres during the breeding season. The cow to bull ratio was 20:1 and the breeding season began June 1 each year.

At weaning, all cows were weighed and body condition scored and all calves were weighed. All weaned calves were transported from the NGBER and placed on a flood meadow pasture that had been rake-bunched (Turner and DelCurto, 1991) the previous summer. In addition, DDGS were provided to the weaned calves on Monday (2 lb/hd), Wednesday (2 lb/hd), and Friday (3 lb/hd). After approximately 45 d, the weaned steer calves were placed in a commercial growing lot for approximately 60 d and then finished in a commercial feedlot in Northeast Oregon. In addition, cows were rectally palpated in mid-October each year for determination of pregnancy.

Cow and calf performance data were analyzed as a Randomized Complete Block using the PROC MIXED option in SAS (SAS Inst., Inc., Cary NC). The model included treatment, block, year, treatment × block, treatment × year, and block × year. Data were analyzed using pen (treatment × year) as random variable. Treatment differences were evaluated using the flowing contrasts: BCS 4

Table 1. Losses of cows and calves.

	BCS 4		BCS 6	
Item	Supplement	No Supplement	Supplement	No Supplement
Cows				
n	60	60	60	60
Prepartum	1[c]	0	0	0
Parturition	0	0	0	0
Cow lost fetus during study	2	1	0	0
Lost calf prior to turnout	5[d]	3[d]	0	0
Palpated not pregnant	11	11	4	6
Total (all causes)	**19**	**15**	**4**	**6**
Calves				
Prepartum	2	1	0	0
Parturition	5[d]	3[d]	0	0
Weaning	1[e]	1[e]	1[e]	0
Growing lot[a]	1[f]	0	1[g]	1[h]
Finishing lot[b]	0	3[f,f,g]	0	2[f]
Total (all causes)	**9**	**8**	**2**	**3**

[a] = only remaining steer calves were placed in growing lot; n = 27, 26, 35, and 25 for supplemented and unsupplemented BCS 4 and supplemented and unsupplemented BCS 6, respectively
[b] = only remaining steer calves were placed in finishing lot; n = 26, 27, 34, and 24 for supplemented and unsupplemented BCS 4 and supplemented and unsupplemented BCS 6, respectively
[c] = Cow got on back and suffocated
[d] = Calves born dead, no dystocia observed
[e] = Cause of death uknown
[f] = Calves died of pneumonia
[g] = Calf died of bloat
[h] = Crippling injury

vs BCS 6; Supplemented vs Not Supplemented; and the interaction of BCS and Supplementation. Binomial data (pregnancy rate, live calves at birth and weaning, and proportion of carcasses grading choice) were analyzed as a Randomized Complete Block using PROC GLIMMIX procedure in SAS. The model, random variable, and contrasts used were as described previously for the cow and calf performance data.

Results

The total number of cows that were removed from the study because of death, loss of a calf, or palpated not pregnant was 19, 15, 4, and 6 for BCS4 NCP, BCS4 CP, BCS 6NCP, and BCS6 CP, respectively (Table 1). In addition, the number of calves lost through slaughter was 9, 8, 2, and 3 for BCS4 NCP, BCS4 CP, BCS 6NCP, and BCS6 CP, respectively.

Cow Performance

The initial weight of BCS 6 cows was approximately 136 lb heavier than the BCS 4 cows ($P < 0.001$; Table 2). Likewise, the initial BCS of treatments came close to meeting our targeted values of 6 and 4 for BCS 6 and BCS 4 cows, respectively; the BCS 6 cows averaged 5.7 while BCS 4 cows averaged 4.3 ($P < 0.001$). At calving, the difference in weight and BCS between BCS 6 and BCS 4 cows remained ($P < 0.001$). However, we did note a supplementation effect with both cow weight and BCS at calving. The supplemented cows weighed more ($P < 0.001$) and carried more BCS ($P < 0.001$) than unsupplemented cows. At weaning, the BCS 6 cows were still heavier (66 lb; $P < 0.001$) and had a greater BCS (0.6; $P < 0.001$) than BCS 4 cows. In addition, the supplemented cows had a greater BCS than unsupplemented cows ($P = 0.02$).

No difference in the proportion of live calves at birth and weaning were observed due to

Table 2. Cow performance relating to body condition score (BCS) and crude protein supplementation (Supp.) during late gestation[a]

	BCS 4		BCS 6			P-value		
Item	Supp	No Supp	Supp	No Supp	SEM	BCS 4 vs BCS 6	Supp vs UnSupp	BCS X Supp
Initial wt., lb[b]	1,110	1,107	1,239	1,251	10	<0.001	0.65	0.46
Calving wt., lb	1,171	1,091	1,256	1,186	11	<0.001	<0.001	0.63
Wt. at Weaning, lb	1,151	1,130	1,214	1,198	12	<0.001	0.10	0.81
Initial BCS[c]	4.32	4.39	5.67	5.75	0.05	<0.001	0.14	0.83
Calving BCS	4.57	4.33	5.51	5.18	0.05	<0.001	<0.001	0.36
Weaning BCS	4.74	4.61	5.30	5.19	0.05	<0.001	0.02	0.84
Days to calving	76	79	76	76	2.5	0.58	0.55	0.43
Live calf at birth, %	86.7	93.3	100.0	100.0	2.7	<0.001	0.22	0.22
Live Calf at Weaning, %	85.0	91.7	98.3	100.0	3.0	<0.001	0.16	0.40
Pregnancy rate, %	77.2	80.7	92.8	90.0	4.6	0.005	0.93	0.48

[a] Pretrial period was 11/1/06 to 1/4/07 in year 1 and 11/8/07 to 1/3/08 in year 2; During pretrial, BCS 4 and BCS 6 cows were managed as 2 separate groups and fed to reach target BCS by study start date
[b] Initial pretrial wt. Averages: Overall = 1105 ± 99 lb; BCS 4 = 1105 ± 94; BCS 6 = 1105 ± 105
[c] Initial Pretrial BCS Averages: Overall = 4.30 ± 0.32; BCS4 = 4.28 ± 0.26; BCS 6 = 4.31 ± 0.36

supplementation (*P > 0.15*); however, a difference was noted because of BCS treatment. The percentage of live calves at birth for the BCS 6 cows averaged 100% compared with 90% for the BCS 4 cows (*P < 0.001*). Also, the percentage of live calves at weaning averaged 99% and 88% for BCS 6 and BCS 4 cows, respectively. Therefore, if we extrapolate our data to a couple of theoretical cow herds entering the last third of gestation with an average BCS of 6 or 4, we could expect to have almost 11% more calves at weaning with the BCS 6 herd; an extra 11 calves per hundred cows.

Cow pregnancy rate was not affected by supplementation treatment (*P = 0.93*); however, there was a difference between the BCS 6 and BCS 4 treatments. The average pregnancy rate for BCS 4 cows was 79% compared with 91% for the BCS 6 cows (*P = 0.005*). The breeding season was 60 d, so it is possible that a longer breeding season may have resulted in a greater overall pregnancy rate but the calving interval would have been longer and the consistency and weight of the calves at weaning would be less.

Calf Performance

Calf birth weight increased with cow BCS (91 vs 85 pounds for BCS 6 and 4, respectively; *P = 0.002*; Table 3) and with supplementation (90 vs 87 lb for supplemented and not supplemented, respectively; *P = 0.05*). However, no incidents of dystocia were noted during the study. There was no treatment effect on calf serum IgG level within 24 to 48 h of birth (*P ≥ 0.10*).

Calf weaning weight was greater for BCS 6 compared with BCS 4 cows (*P = 0.05*) and for supplemented cows compared with those cows not receiving supplement (*P = 0.01*). In addition, calf ADG to weaning was greater for calves from dams that received supplement during the last third of gestation (*P = 0.02*). This agrees with previous work indicating that supplementation of cows pre-calving increases weaning performance of calves (Stalker et al., 2006). No notable treatment effects were observed in steer calf performance in the growing lot or feedlot (*P ≥ 0.10*). The only carcass characteristic affected by treatment was KPH which decreased with supplementation for BCS 4 cows and increased with supplementation for BCS 6 cows

Table 3. Calf performance relating to cow body condition score (BCS) and crude protein supplementation (Supp.) during late gestation

	BCS 4		BCS 6			P-value		
Item	Supp	No Supp	Supp	No Supp	SEM	BCS 4 vs BCS 6	Supp vs UnSupp	BCS X Supp
Birth wt., lb	86.1	84.8	93.9	88.6	1.6	0.002	0.05	0.21
IgG. mg/dL	5,880	6,348	5,836	6,088	231	0.49	0.10	0.62
Weaning wt., lb	415	395	424	411	7	0.05	0.01	0.58
Weaning age, days	140	137	140	141	2.8	0.46	0.65	0.53
ADG to weaning, lb	2.36	2.28	2.36	2.30	0.03	0.81	0.02	0.70
Growing lot initial wt., lb	456	439	472	459	12.2	0.11	0.18	0.86
Growing lot final wt., lb	564	545	582	565	13.4	0.14	0.16	0.94
Growing lot ADG, lb	1.39	1.33	1.41	1.30	0.08	0.97	0.26	0.74
Feedlot initial wt., lb	564	545	582	565	13.4	0.14	0.16	0.94
Feedlot final wt., lb[a]	1,294	1,278	1,308	1,277	25	0.79	0.32	0.74
Feedlot ADG, lb	4.03	4.21	4.18	4.14	0.2	0.84	0.71	0.54
Feedlot days on feed	178	166	177	166	7	0.84	0.10	0.86
Hot carcass wt., lb	815	805	824	804	16	0.79	0.32	0.74
Backfat, inches[b]	0.70	0.66	0.64	0.66	0.04	0.32	0.83	0.36
Ribeye area, inches^2	13.5	13.1	13.5	13.4	0.28	0.65	0.37	0.66
KPH, %	2.07	1.99	1.93	2.24	0.11	0.62	0.25	0.05
Marbling[c]	423	403	434	420	14	0.33	0.24	0.84
Yield grade	3.4	3.4	3.3	3.4	0.15	0.49	0.86	0.70
Choice, %	57.6	38.6	65.7	62.4	11	0.13	0.28	0.42
Retail product, %[d]	48.7	48.8	49.0	48.9	0.36	0.50	0.88	0.66

[a] Calculated from hot carcass weight assuming a 63% dressing percentage
[b] Thickness measured at the 12th rib
[c] Marbling score: 400 = small^{00}, 500 = Modest^{00}
[d] USDA Retail Yield Equation: 51.34 – (5.78*inches backfat) – (0.0093*pounds hot carcass weight) – (0.462*percentage kidney, pelvic, and heart fat) + (0.74*ribeye area in square inches)

($P = 0.05$). None of the other carcass characteristics were affected by treatment ($P \geq 0.13$).

Economics

Table 4 lists the estimated net returns of treatments as broken down in four production phases. The phases are cow-calf, growing lot, feedlot, and retained ownership. The most notable affect on net returns was because of cow BCS. The BCS 6 cows returned approximately $71/cow more than the BCS 4 cows if calves were sold at weaning and approximately $130/cow more if we retained ownership of the calves through the feedlot. The primary reason for the disparity in net returns is due to more live calves at weaning. Supplementation had minimal effects on net returns with the greatest benefit noted in the cow-calf phase where supplemented cows had a $7/cow greater net return than unsupplemented. Nevertheless, it is interesting to note the approximately 500% greater health costs in the feedlot for calves from unsupplemented compared with supplemented cows ($8.28 vs.$1.65/hd).

Conclusions

Supplementation of beef cows during the last third of gestation resulted in cows with greater BCS at birth and weaning compared with not

Table 4. Economics relating to cow body condition score (BCS) and crude protein supplementation (Supp.) during late gestation.

	BCS 4		BCS 6			
Item	Supp.	No Supp.	Supp.	No Supp.	BCS Difference[a]	Supp. Difference[b]
Cow-Calf Phase						
Returns						
More Calves Weaned[c]	0.00	0.00	54.14	52.50		
Weaned Calf Value	488.98	465.32	499.87	484.78		
Costs						
Supplement	15.25	0.00	15.25	0.00		
Hay	90.73	96.10	90.80	90.10		
Net Returns	**383.00**	**369.22**	**447.96**	**447.18**	**71.46**	**7.28**
Growing Lot Phase						
Returns						
Calf Value	577.91	558.23	596.96	578.97		
Costs						
Purchase Cost	488.98	465.32	499.87	484.78		
Growing Lot Feed Costs	82.90	82.90	82.90	82.90		
Growing Lot Health Costs	1.95	0.93	1.80	2.14		
Net Returns	**4.08**	**9.08**	**12.39**	**9.15**	**4.19**	**(0.88)**
Feedlot Phase						
Returns						
Carcass Value	1140.04	1125.78	1152.11	1124.73		
Costs						
Purchase Cost	577.91	558.23	596.96	578.97		
Feedlot Feed Costs	501.48	468.35	495.10	468.36		
Feedlot Health Costs	0.58	4.59	2.72	11.98		
Net Returns	**60.07**	**94.61**	**57.33**	**65.42**	**(15.97)**	**(21.32)**
Retained Ownership						
Returns						
More Carcasses[c]	0.00	0.00	124.77	121.81		
Carcass Value	1140.04	1125.78	1152.11	1124.73		
Costs						
Supplement	15.25	0.00	15.25	0.00		
Hay	90.73	96.10	90.80	90.10		
Growing Lot Feed Costs	82.90	82.90	82.90	82.90		
Growing Lot Health Costs	1.95	0.93	1.80	2.14		
Feedlot Feed Costs	501.48	468.35	495.10	468.36		
Feedlot Health Costs	0.58	4.59	2.72	11.98		
Net Returns	**447.15**	**472.91**	**588.31**	**591.06**	**129.66**	**(14.26)**

[a] Difference in net returns between the average of BCS 6 and BCS 4 treatments
[b] Difference in net returns between the average of supplemented and non-supplemented treatments
[c] Increased returns resulting from increased percentage of live calves at weaning (10.83%) for the average of BCS 6 treatments compared with the BCS 4 treatments

supplementing. In addition, calves from cows that received supplement were heavier at weaning and had greater ADG from birth to weaning. However, the greatest effect of cow productivity was because of cow BCS entering the last third of gestation. The BCS 6 cows were in better condition at calving and weaning, they had approximately 10% more live calves at birth and weaning, and they had an 11% greater pregnancy rate than BCS 4 cows. As a result, estimated net returns for BCS 6 cows were approximately $71/cow greater than BCS 4 if calves were sold at weaning and $130/cow if ownership of calves were retained through the feedlot. These data demonstrate the potential economic importance of making sure your cows are in a good BCS (≈ 6) prior to entering the last third of gestation.

Acknowledgements

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Oregon State University

BEEF033

Beef Cattle Sciences

Beef Research Report

Growth and Carcass Merit of Purebred Jersey Steer Calves Finished on Grain-based Diets at Two Different Energy Levels [1]

Chad J. Mueller [2], Garrett L. Tschida [3], and Valerie Cannon [4]

Synopsis

Jersey steer calves can produce high quality beef, but growth rates and feed conversions could be considered low or poor during both the growing and finishing phase, regardless of dietary energy density.

Summary

Twenty purebred Jersey steer calves were used to evaluate lifetime growth and carcass development while finished on different caloric-dense diets. Steers were grouped by weight (GRP = LIGHT, HEAVY) then randomly assigned to either a 70% (F70) or an 85% (F85) concentrate finishing diet. Growing phase average daily gain (ADG) was not different between groups even though LIGHT calves tended to consume less feed per day versus HEAVY calves. Finishing phase ADG was greater for F85 versus F70 steers. Intake was not different between F70 and F85 steers, whereas gain efficiency was lower for F70 steers compared to F85 steers. Ultrasonography was used to track carcass changes and showed no differences in subcutaneous (backfat) or intramuscular (marbling) fat accretion, or longissimus dorsi development (muscle depth) between F70 and F85 steers. Ultrasound indicated that changes in muscle depth reached a plateau around 14 mo of age, while fat deposition continued to increase. Actual carcass data indicated no differences in backfat or KPH (visceral fat) between F70 and F85 steers. The F85 steers had greater ribeye area, and tended to deposit more marbling compared to F70 steers. Calculated yield grade and retail yield were not different between finishing diets. Jersey steers have the ability to produce highly marbled carcasses at moderate levels of caloric intake, but carcass quality must be valued against low growth efficiency.

Introduction

Dairy cattle represent approximately 18 to 20% of the total fed cattle marketed in the U.S. for beef production (Holstein cattle represent approximately 17% of total fed cattle; Cattle-Fax, 2007). Jersey, Guernsey, and Brown Swiss cattle make up the remainder of fed dairy cattle. Oregon is a top 5 producer of Jersey cattle in the U.S., therefore a larger portion of dairy calves available within the state are purebred Jersey. Currently Jersey steer calves are of little to no value to most dairy and beef operations. A small portion of Jersey steer calves are sold into veal markets, 4-H or youth programs, or as local locker beef, but a majority are being euthanized (personal communication). Jersey cattle are known for their propensity to marble, but

1. This document is part of the Oregon State University – 2010 Beef Research Report. Please visit the Beef Cattle Sciences website at http://beefcattle.ans.oregonstate.edu.
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also for their small stature and lighter-than-normal muscling (Purchas et al., 2002; Albertí et al., 2008). Beef cattle feeders are hesitant to purchase these animals due to their small size and the lack of management and nutritional information needed to efficiently grow and finish Jersey steers. As a result most beef cattle feeders refuse to feed Jersey steer calves, or group them with other dairy calves (primarily Holstein calves) resulting in over-conditioned (excess fat deposition) carcasses with higher costs of gain versus other beef-producing animals. This project was designed to begin developing strategies to optimize management schemes to efficiency grow Jersey steer calves while ensuring the production of high quality beef.

Table 1. Diet composition and nutrient analysis of growing and finishing diets fed to purebred Jersey steers.

	Growing diets		Finishing diets	
Ingredient	G1	G2	F70	F85
Ground grass hay, %	29.9	29.6	30.0	15.0
Rolled corn, %	9.8	27.4	43.1	56.6
Protein pellet, %[a]	30.1	22.8	24.5	26.2
Soybean hulls, %[b]	30.2	20.2	---	---
Molasses	---	---	4.1	4.0
Nutrient analysis[c]				
Dry matter, %	87.3	85.9	88.3	88.0
Crude protein, %	14.6	13.1	13.4	13.5
NDF, %	38.6	32.5	18.4	9.2
ADF, %	24.1	19.7	9.7	4.9
Ash, %	10.1	8.9	8.8	8.2
NEg, Mcal/100 lb	46.6	48.0	50.9	55.5

[a]Contained 1.9% non-protein nitrogen (urea) and 205 g Rumensin sodium per ton of supplement.
[b]Pelleted.
[c]Based on laboratory analysis.
[d]Estimated using published reference values.

Materials and Methods

All procedures involving animals were approved by the Oregon State University Institute of Animal Care and Use Committee. Twenty purebred Jersey steer calves were identified and managed by a local dairy producer (Martin Dairy L.L.C., Tillamook, OR) until 10 weeks of age. Steers were then transported to OSU animal facilities located in Corvallis, OR and adapted to diet and location for the next four weeks. Steers were then divided into two weight groups (LIGHT or HEAVY; two pens per group) based on allotment weights taken at sixteen weeks of age (Table 2). Steers were pen fed during the growing phase with pens receiving the G1 diet (Table 1) until the average weight per head in the pen was approximately 400 lb, then were switched to the G2 diet. Pens were fed once per day (0800 hr) with orts quantified the following day prior to feeding. Steers were then switched to their respective finishing diets (F70 or F85; Table 1) when the average weight per hd in the pen was 650 lb. Steers were randomly allotted to finishing diet within weight group. Each pen was setup with individual feeders (Calan Broadbent Feeding System, Northwood, NH) to allow monitoring of individual feed consumption of finishing diets regardless of pen environment. During the finishing period steers were fed twice per day (0800 and 1600 hr) with orts quantified the following day prior to the AM feeding. Body weight and hip height measurements were collected every 30d after initiation of the study to monitor interim growth performance.

Ultrasound measurements for intramuscular fat (marbling; UMARB), longissimus muscle depth (UMD) and subcutaneous fat depth (backfat; UBF) were obtained at the 12th to 13th-rib interface by an experienced technician every 30 d starting when steers were transitioned onto their respective finishing diets. 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 MARB were based on image analysis programming (Brethour, 1994) contained within the CPEC software program.

Steers were harvested when UMARB indicated a score of 500 or greater (which equates to low Choice or better quality grade). Steers were harvested at the OSU Clark Meat lab with carcass measurements collected 72 hr post-harvest. Rib sections (9-10-11 rib section) were removed from the right side of each carcass, vacuum-packaged and stored for consumer testing, fatty acid profile and tenderness analysis (data not presented).

Data were analyzed as a 2x2 factorial design with weight group and finishing diet as main effects. Growing data was evaluated by group only, whereas finishing performance, ultrasound measures and carcass characteristics were evaluated for both group and finishing diet.

Table 2. Cumulative growing and finishing performance of purebred Jersey steers fed finishing diets of different caloric densities.

	Weight group[a]		Finishing diet[b]			P value[c]	
Item	**LIGHT**	**HEAVY**	**F70**	**F85**	SEM	Group	Diet
Cumulative growing performance							
BW^{grow}, lb[d]	170.2	212.7	---	---	4.5	*0.02*	---
BMI^{grow}, lb/in[e]	5.0	5.9	---	---	0.2	*0.07*	---
Days on feed	169	169	---	---	---	---	---
ADG, lb/d	1.96	2.14	---	---	0.07	NS	---
DM intake, lb/d[f]	9.5	11.1	---	---	0.07	*<0.01*	---
Feed:gain, lb/lb	4.84	5.16	---	---	0.15	NS	---
Δ BMI·day^{-1}[g]	0.037	0.038	---	---	0.001	NS	---
Cumulative finishing performance							
BW^{finish}, lb[d]	501.6	575.1	532.4	544.3	11.1	*<0.01*	NS
BMI^{finish}, lb/in[e]	11.3	12.3	11.7	11.9	0.2	*<0.01*	NS
$BW^{harvest}$, lb[h]	946.3	1022.3	957.1	1011.5	16.3	*<0.01*	*0.03*
$BMI^{harvest}$, lb/in[e]	18.8	19.9	19.0	19.7	0.3	*0.02*	*0.09*
Days on feed	240	229	235	234	0.9	*<0.01*	NS
ADG, lb/d	1.85	1.96	1.81	2.00	0.05	NS	*0.02*
DM intake, lb/d[i]	16.0	18.0	17.1	16.9	0.7	*0.07*	NS
Feed:gain, lb/lb	8.70	9.23	9.51	8.42	0.35	NS	NS
Δ BMI·day^{-1}[g]	0.031	0.033	0.025	0.028	0.001	NS	NS

[a]Based on BW of steers at start of growing period.
[b]F70 = 70:30 dietary ratio of concentrate-to-roughage; F85 = 85:15 dietary ratio of concentrate-to-roughage (DM basis).
[c]NS = $P > 0.10$.
[d]Body weight obtained at start of growing (^{grow}) and finishing period (^{finish}).
[e]Body mass index (BMI) at start of growing period (^{grow}), finishing period (^{finish}), and at slaughter (^{harvest}). Calculated as BW (lb) divided by hip height (inches).
[f]Based on pen consumption (feed delivered – feed refusals).
[g]Change in BMI during the feeding period. Calculated as: Grow period = $(BMI^{finish} - BMI^{grow}) \div$ days on feed; Finish period = $(BMI^{harvest} - BMI^{finish}) \div$ days on feed.
[h]Body weight at time of slaughter, after an 18 hr fasting period.
[i]Based on individual consumption (feed delivered – feed refusal).

Results

HEAVY versus LIGHT groups

Growing and finishing gain performance and carcass characteristics for the HEAVY and LIGHT steers are summarized in tables 2 and 3. Body mass index (BMI) was reported instead of hip height in order to quantify changes in frame size since there are no frame score indexes for growing Jersey steers. Body weights were different ($P < 0.05$) between weight groups at the start of the growing period, and continued through finishing and harvest. Body mass index tended to be greater for HEAVY steers at commencement of the study and were greater at the start of the finishing period, but the rate of change ($\Delta BMI \cdot day^{-1}$) during the growing period was not different ($P > 0.10$). Once steers started on the finishing diets, the rate of BMI change was greater in HEAVY steers versus the LIGHT steers. Daily gains (ADG) and feed conversions (feed:gain) were similar during both the growing and finishing periods between the two weight groups, even though the HEAVY steers consumed more feed. The growth data indicates that selecting heavier steers at weaning should translate into heavier steers throughout the feeding period and at harvest. The HEAVY steers also had heavier carcasses, greater dressing percentage and rib eye area (REA), and higher marbling scores (Table 3). The carcass data also indicated that HEAVY steers had greater fat deposition, both subcutaneous (backfat) and KPH, which can lower the potential carcass value. Yield grade and percent retail yield was not different between the weight groups.

Ultrasound measurements (Figure 1) indicated that both groups deposited fat and muscle mass at similar rates, but around 14 mo of age (404 to 425 days) the HEAVY steers deposited more fat (both subcutaneous and intramuscular) and lean tissue. These values were supported by the carcass data reported in table 3. Both groups illustrated the ability to obtain adequate marbling to reach a Small marbling score (low choice) under 20 mo of age with minimal backfat deposition.

Table 3. Carcass characteristics of purebred Jersey steers fed finishing diets of different caloric densities.

	Weight group[a]		Finishing diet[b]			P value[c]	
Item	**LIGHT**	**HEAVY**	**F70**	**F85**	SEM	Group	Diet
Carcass weight, lb.	528.7	594.9	545.1	578.5	10.7	*<0.01*	*0.04*
Carcass dress, %[d]	55.9	58.2	56.9	57.1	0.4	*<0.01*	NS
Backfat, in.	0.20	0.28	0.24	0.23	0.03	*0.04*	NS
Ribeye area, in^2	8.4	9.5	8.4	9.4	0.3	*<0.01*	*0.02*
KPH, %	2.25	2.80	2.48	2.58	0.17	*0.03*	NS
Marbling score[e]	568.3	661.0	589.5	639.8	17.6	*<0.01*	*0.06*
Quality grade[f]	Ch-	Ch^0	Ch-	Ch^0			
Yield grade[g]	2.77	2.97	2.97	2.77	0.14	NS	NS
Retail yield[h]	50.0	49.6	49.9	49.6	0.2	NS	NS

[a]Based on BW of steers at start of growing period.
[b]F70 = 70:30 dietary ratio of concentrate-to-roughage; F85 = 85:15 dietary ratio of concentrate-to-roughage (DM basis).
[c]NS = $P > 0.10$.
[d]Calculated as (Carcass weight ÷ $BW^{harvest}$) x 100.
[e]400 = slight, 500 = small, 600 = modest, 700 = moderate.
[f]Se = select, Ch- = low choice, Ch^0 = average choice, Ch+ = high choice, Pr- = low prime.
[g]Calculated as: Yield grade = 2.5 + (2.5*backfat) + (0.0038*carcass wt.) + (0.2*KPH) – (0.32*ribeye area).
[h]Calculated as: % Retail yield = 51.34 – (5.78*backfat) – (0.0093*carcass wt.) – (0.462*KPH) + (0.74*ribeye area).

F70 versus F85 finishing diets

Caloric intake did not translate into large differences in gain or gain efficiency between steers receiving the two finishing diets (tables 2 and 3). The F85 steers had heavier final weights which resulted from greater ADG during the finishing period. Even though ADG was greater for F85 steers, their $\Delta BMI \cdot day^{-1}$ was only slightly better indicating that frame size was increasing at a similar rate to lean tissue and fat deposition for both dietary

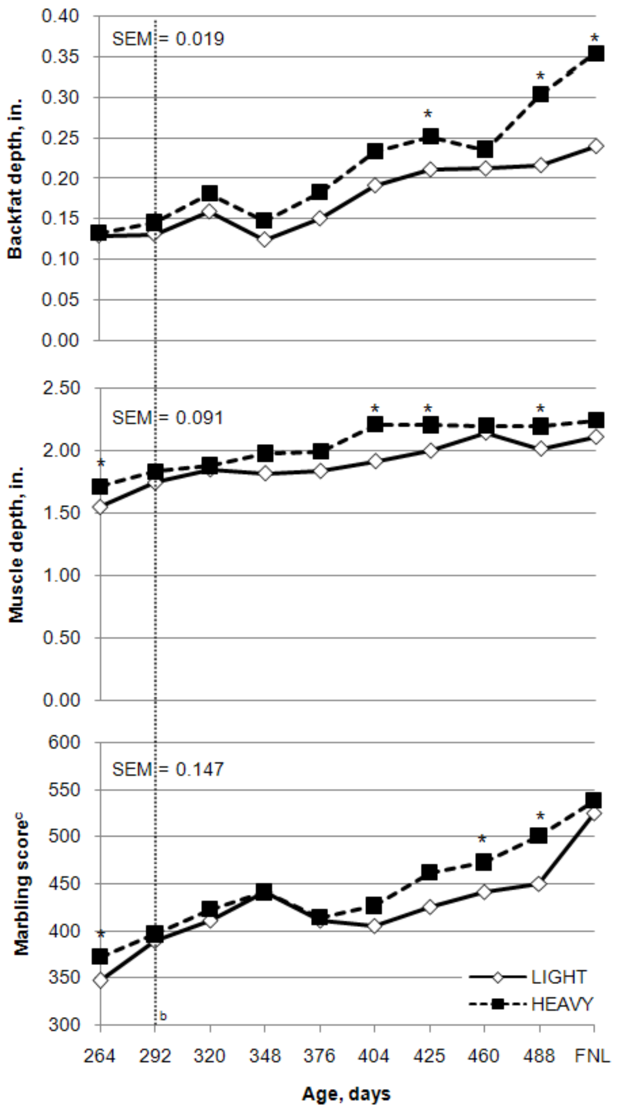

Figure 1. Ultrasound measurements of purebred Jersey steers by weight group[a] from start of finishing period through harvest. [a]Based on BW of steers at start of growing period.[b]Vertical dashed line represents the start of the finishing period. [c]300 = traces, 400 = slight, 500 = small, 600 = modest, 700 = moderate. *$P < 0.05$.

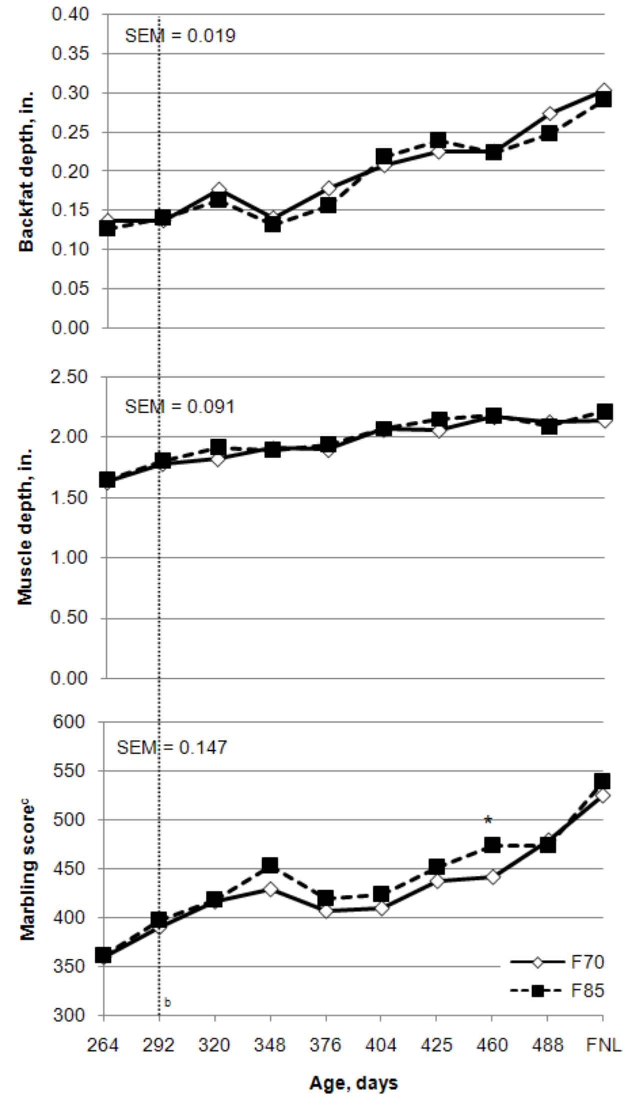

Figure 2. Ultrasound measurements of purebred Jersey steers by finishing diet[a] from start of finishing period through harvest. [a]F70 = 70:30 dietary ratio of concentrate-to-roughage; F85 = 85:15 dietary ratio of concentrate-to-roughage (DM basis). [b]Vertical dashed line represents the start of the finishing period. [c]300 = traces, 400 = slight, 500 = small, 600 = modest, 700 = moderate. *$P < 0.05$

groups. No other differences were detected between the F70 and F85 steers during the finishing period. The heavier final weights translated into heavier carcass weights for the F85 steers. These steers also produced a larger REA and tended to deposit greater amounts of marbling. No other carcass traits were different between the finishing treatments.

Ultrasound measurements (Figure 2) mimicked most of the carcass data with the exception of UMD in relation to actual REA. No sustained differences were illustrated between the finishing treatments, but both indicated that these steers could reach Small marbling under 20 mo of age with minimal amounts of backfat deposition.

Implications

Purebred Jersey steer calves have shown the ability to produce high quality carcasses (based on quality grade) at young ages with minimal removal of excess fat (backfat and KPH). This project illustrates two potential limitations for economic viability, 1) low rates of gain versus beef steers (industry standard), and 2) light carcass weights. This data also indicates that selecting heavier steers at the beginning and feeding moderate calorie diets can produce a beef carcass that is highly acceptable according to beef industry standards. Further research into extending the growing period (or use of lower caloric-dense feedstuffs) and steer size selection criteria may counter the lower gains on high concentrate diets and increase carcass weights.

Acknowledgements

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Oregon State University **BEEF030**

Beef Research Report

Beef Cattle Sciences

Mineral Assessment of Range Cattle in Oregon for Site-Specific Supplementation [1]

Fara A. Brummer [2] and Chad Mueller [3]

Synopsis

A mineral assessment of range cattle conducted by a representative herd blood sample and a baseline inventory of range forage mineral content, followed with the appropriate mineral supplement, can address local deficiencies and potentially contribute to overall health and productivity of a cattle herd.

Summary

Mineral supplementation is an important component within a cattle herd health program. Deficiencies can negatively affect cattle production. For example, selenium deficiency, common in many parts of Oregon, can cause white muscle disease in young calves. Selenium can also cause toxicity at high amounts. Therefore, in order for mineral deficiencies to be identified accurately, a baseline assessment of herd mineral status is important in designing a supplementation program. In addition, an analysis of herd diet can be a complimentary tool for understanding the overall mineral intake within a herd.

This study was conducted to look at mineral patterns in three cattle herds and two breeds of range cattle to see if range diets alone are sufficiently meeting mineral requirements, and whether mineral status is different between two different breeds in a similar environment. Although this study focused on selenium due to known deficiencies in the area, a complete mineral panel was performed for possible other deficiencies. Blood samples were drawn from thirty breeding cows in three treatment groups. Two groups consisted of an Angus based cross, and the third was a Longhorn based cross. Range plant diet samples consisting of shrubs, perennial grasses, and "weedy" annual grasses were also collected and analyzed. Results demonstrated that there was a difference in serum selenium content between a completely supplemented herd and two partially supplemented herds. There was no difference between partially supplemented herds or breeds. Plant mineral levels varied by species and season, but were mostly inadequate in sodium, zinc, and selenium except for medusahead which was adequate for zinc and selenium.

Introduction

Minerals necessary for cattle health include the macro minerals: calcium, phosphorus, magnesium, potassium, sodium and chloride, and the microminerals: cobalt, copper, iron, manganese, molybdenum, selenium, and zinc. Deficiencies vary by regional soil content and plant uptake. For example, selenium and copper are known to be low in many parts of Oregon (Ganskopp and Bohnert, 2003; Whanger et al., 1978). Some information on general mineral importance and related deficiencies are as follows:

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Calcium (Ca) is essential for bones and breeding. Low levels can cause osteomalacia or weak bones in cattle.

Magnesium (Mg) is important for nerves, muscles and bones. Low levels can cause grass tetany or grass staggers in grazing cattle.

Phosphorus (P) is essential for bone development and adequate rumen microorganism function. A deficiency may manifest as strange cravings of items such as bones.

Potassium (K) stabilizes cellular fluids, with stress increasing bodily need.

Sodium Chloride (NaCl = salt) balances bodily fluids. Deficient animals can display “pica” – chewing wood, rocks, urine, and bone, and a decrease in lactation and growth. Long term deficiency can cause death from dehydration.

Cobalt (Co) is essential for the development of vitamin B12, with a deficiency negatively affecting the ability of rumen microorganisms to produce this vitamin.

Copper (Cu) is inversely influenced by molybdenum. Deficiencies manifest as heart problems, lack of healthy color in the coat, anemia, bone problems, and a poor immune response.

Iron (Fe) is necessary for protein molecule function and for delivering oxygen to the cells of the body. Wormy animals can be at risk of anemia or an iron deficiency.

Manganese (Mn) is important in growth, maintenance, and reproduction. A deficiency may manifest in joint pains and problems with locomotion .

Molybdenum (Mo) is required for nitrogen fixation. Deficiencies are rare.

Selenium (Se) is an essential component of 12 enzymes. Deficiencies can lead to “white muscle disease”, reproductive problems, poor breed back, retained placentas, and lack of proper immune function. Selenium works in conjunction with Vitamin E (Boyne and Arthur, 1979; Maas et.al, 2006).

Zinc (Zn) is important in growth, pregnancy, and lactation. A lack is demonstrated by appetite loss, parakeratosis or hardening of the skin, and a reduced immune system (Underwood and Suttle, 1999).

Table 1. Average herd serum mineral levels.

Cattle ID	Ca mg/dl	P mg/dl	Mg mg/dl	K mmol/l	Na mmol/l	Cl mmol/l	Cu ug/ml	Fe ug/dl	Zn ug/ml	Mn mg/dl	Mo ng/ml	Co ng/ml	Se ng/ml
R1 AxS	9.52	4.8	2.37	5.26	136.8	95.9	0.577	155.1	0.759	0.66	34.08	2.23	72.5
R2 AxU	9.07	4.19	2.08	5.66	137.6	98.1	0.523	117.8	0.908	15.72	61.2	1.44	13.2
R2 LxU	9.03	3.8	2.08	5.45	136.7	98	0.485	133.4	0.874	18.61	57.75	1.24	13.6

AxS: crossbred Angus with complete mineral supplementation.
AxU: crossbred Angus without complete mineral supplementation.
LxU: crossbred Longhorn without complete mineral supplementation

Materials and Methods

Three herds of ten breeding cows each between the ages of 3 to 8 were tested in the fall of 2007. The tested herds were: I) crossbred Angus with complete mineral supplementation (AxS), II) crossbred Angus without complete mineral supplementation (AxU), and III) crossbred Longhorn without complete mineral supplementation (LxU). The AxU and LxU had access to an iodized salt block as well as a sulfur block all year long. The AxS had access to a mineral block (40 lb-pound block with 120 ppm (parts per million) of selenium in the winter, along with 200 lb. protein tubs that contained 6.6 ppm of selenium, followed by a sulfur block in the summer. Sulfur blocks were fed for external parasite control.

Blood samples were collected from the tail region of cows, placed in non-additive vacuum tubes on ice and transported to the Animal Sciences Laboratory

Table 2. Comparative reference ranges for minerals.

	Ca mg/dl	P mg/dl	Mg mg/dl	K mmol/l	Na mmol/l	Cl mmol/l	Cu ug/ml	Fe ug/dl	Zn ug/ml	Mn mg/dl	Mo ng/ml	Co ng/ml	Se ng/ml
Low End of Range	7.7	3.8	1.2	3.9	140	91	0.6	110	0.9	*NR*	*NR*	2.23	70
High End of Range	10.4	7.2	2.8	6.6	146	103	0.8	180	2	*NR*	*NR*	1.44	100
At risk of clinical deficiency below this level	-	-	-	-	-	-	0.4	60	0.6	*NR*	*NR*	-	35

NR= No reference range.

Table 3. Percent of minerals in sampled shrubs.

Shrub Type		Ca	P	K	Mg	Na	Cu	Fe	Zn	Mn	Mo	Co	Se
Bitterbrush	Oct 2008	1.03	0.1[a]	0.35[a]	0.13	0.002[a]	4[a]	184	10[a]	16[a]	1	<0.50[a]	0.04[a]
	May 2009	0.77	0.14[a]	0.68	0.11	0.004[a]	8[a]	151	11[a]	16[a]	1	13.5	0.05[a]
Sagebrush	Oct 2008	0.51	0.23	1.43	0.15	0.002[a]	8[a]	131	18[a]	31[a]	1	<0.50[a]	0.03[a]
	May 2009	0.63	0.27	1.64	0.16	0.004[a]	13	186	17[a]	51	1	<1.0	0.04[a]
Reference Range		0.34	0.2	0.61	0.12	0.07	10	51	31	41	N/A	0.1	0.1

[a] = below adequate % mineral.

Table 4. Percent of minerals in perennial grasses.

Grass Type		Ca	P	K	Mg	Na	Cu	Fe	Zn	Mn	Mo	Co	Se
Bluebunch Wheatgrass	Oct 2008	0.34	0.12[a]	0.68	0.07[a]	0.002[a]	2	141	9[a]	19[a]	1	<0.50[a]	0.02[a]
	May 2009	0.31[a]	0.26	1.93	0.09[a]	0.005[a]	15	137	22[a]	31[a]	1	5.04	0.08[a]
Idaho Fescue	Oct 2008	0.4	0.07[a]	0.4[a]	0.07[a]	0.003[a]	2	249	12[a]	39[a]	1	<0.50[a]	0.08[a]
	May 2009	0.64	0.24[a]	1.56	0.17	0.011[a]	21	472	24[a]	55	3.1	1.58	0.06[a]
Reference Range		0.34	0.2	0.61	0.12	0.07	10	51	31	41	N/A	0.1	0.1

[a] = below adequate % mineral.

Table 5. Percent of minerals in annual grasses.

Grass Type		Ca.	P	K	Mg.	Na.	Cu.	Fe.	Zn.	Mn.	Mo.	Co.	Se.
Cheatgrass	May 2009	0.5	0.26	1.38	0.19	0.018[a]	35	2502	26[a]	99	1.2	11.2	0.05[a]
Medusahead	May 2009	0.7	0.36	1.02	0.22	0.035[a]	57	6916	60	274	1.8	14.2	0.16
Reference Range		0.34	0.2	0.61	0.12	0.07	10	51	31	41	N/A	0.1	0.1

[a] = below adequate % mineral.

at Oregon State University in Corvallis where they were centrifuged at 2000 rpm to separate serum. The serum was frozen and shipped on ice to Michigan State University Diagnostic Center for Population and Animal Health (DCPAH) for a full macro and micro-mineral panel. Results were compared to a pre-determined reference range for adequacy and reviewed by a clinical veterinarian at DCPAH. All animals were processed on site to reduce stress, and possible error from shipping, moving, or changing the environment.

Range plants, representative of seasonal range cattle diets in the tested area, were randomly sampled in October 2008 and May 2009 within the study site. These included the shrubs: Bitterbrush and Big Basin Sagebrush, and two perennial grasses: Bluebunch Wheatgrass and Idaho Fescue. In May 2009, two annual grasses: Cheatgrass and Medusahead were added as sample plants. Samples were sent to Michigan State University DCPAH for a full mineral panel assessment. Results were compared with a reference range from the NRC Nutrient Requirements of Beef Cattle (NRC, 2000). The reference animal was a 454 kg. Angus-Hereford lactating cow, 5 years old, with a BCS of 5, 60 days pregnant and 120 days in milk at her third lactation, consuming 11.34 kg. of dry forage per day.

Results

Serum Mineral Results

Table 1 lists serum mineral results. Table 2 lists clinical reference ranges for the mineral panel as reported by DCPAH. Serum selenium was different between the tested herds ($p<0.001$). AxS and AxU had a significant difference with respect to selenium (1.71 > LSD value of 0.204). However, AxU and LxU did not show a difference in selenium content (0.01 < LSD value of 0.204). This is further illustrated in Figure 1.

All tested cattle were adequate in the other minerals, although the average for sodium, copper, and zinc was at the low end of adequate, but still above the clinically deficient level for all three herds. Manganese levels were low in AxS compared with AxU and LxU, but this mineral was not analyzed due to the lack of a reference range.

Plant Mineral Results

Plants tested from the study site showed variable results depending on season and type of plant. Tables 3, 4, and 5 describe the tested plants and respective mineral content. Of particular interest are the relatively high levels, all above adequate, of magnesium, copper, iron, zinc, manganese, and selenium in medusahead.

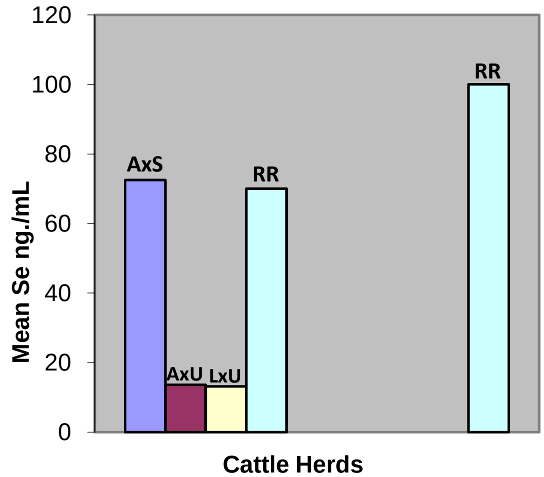

Figure 1. Mean Level of Selenium in Serum Samples. AxS: crossbred Angus with complete mineral supplementation; AxU: crossbred Angus without complete mineral supplementation; LxU: crossbred Longhorn without complete mineral supplementation; RR: Reference Range.

Conclusions

Serum mineral levels in tested cattle demonstrated that selenium was the only clinically low mineral, even between breeds, with the animals from both the AxU and LxU herds at danger of selenium deficiency. All other minerals showed adequate levels, although sodium, copper and zinc were at the low end of adequate. Plant information showed local and seasonal deficiencies. In spite of the fact that range cattle have a diverse diet and one plant may meet the mineral inadequacies of another, range forage alone cannot meet the mineral requirements of actively producing beef cattle. However, herd mineral status and diet should be determined before minerally supplementing in order to accurately determine type and quantity of supplement.

Acknowledgements

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Oregon State University

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Beef Research Report

Beef Cattle Sciences

Response of Ruminants to Protein Supplementation is Affected by Type of Low-quality Forage [1]

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Synopsis

Protein supplementation of ruminants consuming low-quality forages in the Intermountain West does not result in responses similar to other regions of the U.S.

Summary

Four steers (556 ± 18 lb; Exp. 1) and four wethers (84 ± 2 lb; Exp. 2) were used in two 2 × 2 factorial design experiments to determine the influence of protein supplementation of low-quality cool- (C3; bluegrass straw) and warm-season (C4; tall grass-prairie hay) forage (6.3 and 5.7% CP, respectively) on intake and nutrient digestion. Steers and wethers were allotted to 4 × 4 Latin squares with 20-d periods. Soybean meal (SBM; 52% CP) was used as the CP supplement. In Exp. 1, feed and digesta were collected on d 14 through 18 for estimation of nutrient digestibility and ruminal fluid was sampled on d 20. In Exp. 2, feed, feces, and urine were collected on d 16 to 20 to determine efficiency of CP use. Contrasts were: 1) supplemented (SUPP) vs unsupplemented (UNSUPP); 2) C3 vs C4; 3) SUPP × forage type. A SUPP × forage type interaction ($P < 0.01$) was noted for forage and total intake in Exp. 1, with supplementation increasing intake of C4 forage by 47% but only 7% for C3 forage. Digestibility responded similarly with a SUPP × forage type interaction ($P = 0.05$; SUPP increased digestibility 12% with C4 and 9% with C3 forage). Also, SUPP × forage type interactions were noted for ruminal liquid retention time ($P = 0.02$; SUPP decreased retention time 3.6 h with C4 and only 0.6 h with C3 forage) and particulate passage rate ($P = 0.02$; SUPP increased particulate passage 46% with C4 and 10% with C3 forage). As in Exp. 1, a SUPP × forage type interaction ($P = 0.01$; SUPP increased digestibility 18% with C4 and 7% with C3 forage) was observed with DM digestibility in Exp. 2. In contrast, only supplementation effects were noted for efficiency of CP use ($P = 0.002$) and CP digestibility ($P < 0.001$), which increased with supplementation. These data suggest that intake and digestion of low-quality C3 and C4 forages by ruminants are not similar and, more importantly, the physiological response of ruminants differs with protein supplementation of C3 versus C4 forages.

Introduction

Forages represent the predominant class of feed within most ruminant livestock operations. Due to differences in plant variety, stage of maturity, and management practices, forages vary significantly with respect to quality parameters such as digestibility, CP, and palatability. In addition,

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many ruminants consume low-quality forages (< 6% CP) for extended periods during the annual production cycle (Turner and DelCurto, 1992). Consequently, in an effort to meet the nutritional needs of these animals, supplemental CP is often provided because it has been shown to increase forage intake and digestibility (DelCurto, 1990) and animal performance (Bodine et al., 2001).

The forage types available to ruminants can be broadly grouped into cool-season (**C3**; the predominate classification of grasses in the Intermountain West) and warm-season (**C4**). Physiological and biochemical differences distinguish C3 from C4 grasses. It is generally considered that C3 grasses have a higher nutritional quality than C4 grasses, which has been attributed to higher levels of nonstructural carbohydrates, protein, and water and lower levels of fiber (Wilson et al., 1983; Barbehenn and Bernays, 1992). In addition, the vast majority of CP supplementation studies have been conducted with C4 grasses.

Despite agronomic research evaluating physiological differences between C4 and C3 grasses, information on the comparative utilization of low-quality C3 and C4 grasses by ruminants is limited. This is relevant because recent research suggests that CP supplementation of ruminants consuming low-quality C3 forages does not result in responses similar to that observed with C4 forages (Horney, et al., 1996; Mathis et al., 2000; Bohnert et al., 2002). Therefore, the objective of this experiment was to compare intake, digestibility, and CP efficiency of ruminants offered low-quality C4 (tall grass-prairie hay) and C3 (bluegrass straw) grasses with and without protein supplementation.

Materials and Methods

Experiment 1: Influence of CP Supplementation of C3 versus C4 Forage on Intake, Digestibility, and Ruminal Fermentation by Steers

Four ruminally cannulated Angus x Hereford steers (556 ± 18 lb) were used in a 4 × 4 Latin square design and housed in individual pens within an enclosed barn with continuous lighting. Steers were provided continuous access to fresh water and low-quality C3 (bluegrass straw) or C4 (tall grass-prairie hay) forage (6.3 and 5.7% CP, respectively; Table 1). A trace mineralized salt mix was provided daily. Treatments were arranged in a 2 × 2 factorial design (two forage types with or without supplemental protein). Soybean meal (**SBM**) was placed directly into the rumen via the ruminal cannula for supplemented treatments.

Table 1. Feedstuff[a] nutrient content (DM basis).

Nutrient,%	C3	C4	SBM
Experiment 1			
CP	6.3	5.7	52.6
OM	90.5	93.8	92.6
NDF	66.4	69.8	13
ADF	36.2	36.6	5.3
Experiment 2			
CP	6.3	5.7	51.8
OM	90	93.2	92.6
NDF	68.1	69.7	14.8
ADF	35.8	35.5	5.2

[a] C3 = cool season forage (bluegrass straw); C4 = warm season forage (tall grass-prairie hay); SBM = soybean meal.

Experimental periods were 20 d, with intake measured beginning d 14 and concluding d 18. On d 15, treatment effects on ruminal indigestible fiber fill and fluid contents were determined by manually removing the contents from each steer's reticulo-rumen 4 h after feeding. Total fecal collection was conducted on d 16 to 20. Steers were fitted with harnesses and fecal bags on d 16. Bags were emptied once daily, feces manually mixed, and a sub-sample obtained.

Data were analyzed as a 4 × 4 Latin square using the GLM procedure of SAS. The model included period, steer, and treatment. Because the treatment structure consisted of a 2 × 2 factorial, orthogonal contrasts were used to partition specific treatment effects. Contrast statements included: 1) C3 vs C4 forage; 2) supplemented vs unsupplemented; 3) contrast 1 × contrast 2.

Experiment 2: Influence of CP Supplementation of C3 versus C4 Forage on Efficiency of Nitrogen Use by Lambs

Four wethers (84 ± 2 lb) were used in a 4 × 4 Latin square design. Wethers were provided continuous access to fresh water and the same low-quality C3 or C4 forage used in Exp. 1 (Table 1). A trace mineral salt mix was provided daily. Treatments were the same as described in Experiment 1. Wethers were randomly allotted to treatments and housed in individual metabolism crates within an enclosed barn with continuous lighting.

Experimental periods were 20 d, with intake determined on d 14 through 18. On d 16 to 20, total fecal and urine output were collected. Urine was composited daily by wether (50% of total; weight basis). On d 16 to 20, 10 mL of blood was collected from the jugular vein 4 h after feeding. Blood samples were centrifuged and plasma harvested and stored.

Data were analyzed as described above. Plasma urea-N was analyzed using the REPEATED statement with the MIXED procedure of SAS. The model included treatment, day, treatment × day, and period. In addition, lamb was used to specify variation between animals (using the RANDOM statement). Lamb × period × treatment was used as the SUBJECT and autoregression was used as the covariance structure. The same contrasts noted above were used to partition treatment sums of squares.

Results

Experiment 1

We noted CP supplementation × forage type interactions (*P < 0.01*) for forage and total intake, CP intake, and NDF intake by steers (Table 2). In each instance, the C4 forage had decreased overall intake and intake increased more with CP supplementation compared with the C3 forage. For example, forage intake averaged 1.92 and 2.45 % of body weight for steers consuming C4 and C3, respectively. Also CP supplementation increased C4 forage intake by 47% compared with only 7% with C3. This may help explain some of the apparent inconsistencies reported in the literature for forage intake in response to CP supplementation. It is generally believed that CP supplementation of low-quality forage (< 6% CP) will increase forage intake up to 100%. This assumption has been based almost exclusively on research with C4 forages (McCollum and Galyean, 1985; DelCurto et al., 1990; Köster et al., 1996). However, forage intake has not been reported to increase in most, if not all, of the studies with CP supplementation of low-quality C3 forages (Horney, et al., 1996; Mathis et al., 2000; Bohnert et al., 2002).

Diet digestibility responded similarly to intake, with a CP supplementation × forage type interaction (*P = 0.05*; Table 2) in which diet digestibility averaged approximately 47 and 52% and increased 12 and 9% with CP supplementation for C4 and C3, respectively. Neutral detergent fiber digestibility tended (*P = 0.07*) to be greater for C3 compared with C4 forage, while CP and NDF digestibility increased with CP supplementation (*P < 0.03*). Diet digestibility has been reported to increase with CP supplementation of low-quality forage (Horney et al., 1996; Bohnert et al., 2002). We are aware of no data that has compared the in vivo digestibility of low-quality C3 and C4 forage; however, Foster et al. (1996) noted that NDF and ADF in vitro digestibility of C3 forages was greater than C4 forages sampled at the same time throughout the year.

Ruminal fluid dynamics were affected by forage type and supplemental CP. Ruminal liquid fill was greater (*P < 0.01*) for C3 than C4 (Table 2) and was not affected by CP supplementation (*P = 0.28*), whereas liquid dilution rate increased with CP supplementation (*P = 0.03*) and for C3 compared with C4 (*P < 0.01*). A CP supplementation × forage type interaction (*P = 0.02*) was noted for liquid retention time, with CP supplementation decreasing retention time from 15.3 to 11.7 h (24%) with the C4 and from 9.7 to 9.1 h (6%) with the C3 forage. In addition, a CP supplementation × forage type interaction (*P = 0.02*) was present for the passage rate of indigestible fiber within the rumen. This simply means that the C3 forage left the rumen at a faster rate than the C4 forage (2.0%/h vs 1.6%/h), and CP supplementation didn't increase passage rate to the same degree that it did with C4 (10% vs 46%). This data agrees with the increase observed in forage and total intake. The shorter liquid retention time and greater passage rate of rumen indigestible fiber for C3 compared with C4 allows for greater forage and total intake.

The quantity of CP available to the ruminal microflora responded with a CP supplementation × forage type interaction (P = 0.02; data not shown). The rumen available CP was 27% greater with C3 forage compared with C4, while providing supplemental SBM increased total rumen available CP 134% with C4 forage and 335% with C3 forage. Total volatile fatty acids (the main source of energy for grazing ruminants) was 12% greater with CP supplementation (*P = 0.03*) and tended to be greater for C3 vs C4 (8%; *P = 0.11*), suggesting greater energetic efficiency with the C3 forage.

Experiment 2

Forage and total intake by lambs was slightly greater (*P = 0.06*) with C3 compared with C4 forage (Table 2), with total intake increasing with CP supplementation (*P < 0.01*). However, CP

Table 2. Intake, digestibility, ruminal dynamics, and efficiency of CP use by ruminants consuming low-quality cool-season (C3) and warm-season (C4) grass hay with or without CP supplementation.

	Treatment					P-Value[b]		
Item	C4	C4+CP	C3	C3+CP	SEM[a]	CP vs No CP	C4 vs C3	CP x Type
Experiment 1 – Steers								
Intake, % BW[c]								
Forage	1.56	2.29	2.37	2.53	0.06	<0.01	<0.01	<0.01
Soybean meal	0	0.17	0	0.17				
Total	1.56	2.46	2.37	2.7	0.06	<0.01	<0.01	<0.01
CP Intake, % BW	0.0147	0.0356	0.0228	0.0385	0.0007	<0.01	<0.01	<0.01
NDF Intake, % BW	1.08	1.6	1.56	1.69	0.05	<0.01	<0.01	<0.01
Digestibility, %								
DM	42.8	51.8	49.7	54.2	0.9	<0.01	<0.01	0.05
CP	28.4	54.5	37.5	55.2	3.5	<0.01	0.21	0.27
NDF	43.5	50	48	52.7	1.7	0.02	0.07	0.61
Ruminal Liquid								
Fill, mL/lb BW	99.8	112.9	138.8	143.3	7.2	0.28	<0.01	0.56
Dilution Rate, %/h	6.5	8.7	10.5	11	0.5	0.03	<0.01	0.13
Retention Time, h	15.3	11.7	9.7	9.1	0.5	<0.01	<0.01	0.02
Ruminal Indigestible Fiber								
Fill, % BW	0.95	0.93	0.96	0.91	0.05	0.55	0.92	0.79
Passage Rate, %/h	1.3	1.9	1.9	2.1	0.06	<0.01	<0.01	0.02
Experiment 2 – Lambs								
DMI, % BW								
Forage	2.58	2.78	2.95	2.82	0.09	0.69	0.06	0.11
Soybean meal	0	0.36	0	0.36				
Total	2.58	3.14	2.95	3.18	0.09	<0.01	0.06	0.11
NDF Intake, % BW	1.78	1.97	2	1.96	0.06	0.25	0.13	0.09
DM Digestibility, %	44.7	52.8	48.9	52.4	0.5	<0.01	0.01	0.01
CP Intake, % BW	0.154	0.349	0.18	0.361	0.005	<0.01	0.01	0.21
Fecal CP, % BW	0.099	0.122	0.114	0.134	0.004	<0.01	0.02	0.72
Urine CP,% BW	0.041	0.138	0.05	0.163	0.011	<0.01	0.15	0.5
Efficiency of CP Use, %[d]	23.4	39.2	23.2	27.9	9.64	0.33	0.57	0.59

[a] n = 4.
[b] CP = CP supplementation; Type = forage type.
[c] BW = body weight.
[d] Calculated as the proportion of total CP digested that was retained in the body.

supplementation did not increase forage intake. A possible explanation for our lack of a forage intake response with CP supplementation is NDF intake.

Mertens (1985; 1994) suggested that forage intake is maximized when NDF intake is approximately 1.25 % of body weight. Therefore, based on the high NDF intake observed in the current study (1.78 and 2.00 % of body weight for C4 and C3 forages without supplementation, respectively), we did not anticipate an increase in forage intake with CP supplementation because intake was already maximized. This coincides with the data observed in Experiment 1 in which the C4 forage increased intake with supplementation and the C3 forage did not; NDF intake was 1.08% of body weight for C4 without supplementation and increased to 1.60% with supplementation while NDF intake was 1.56% without and 1.69% with CP supplementation for the C3 forage.

It is worth noting that there tended to be a CP supplementation × forage type interaction ($P = 0.11$) for both forage and total intake, similar to that observed in Exp. 1 (C3 forage intake decreased 5% with CP supplementation and C4 intake increased 8%). Likewise, diet digestibility had a CP supplementation × forage type interaction ($P = 0.01$) in which digestibility averaged approximately 49% for C4 and 51% for C3, with CP supplementation increasing digestibility by 18 and 7%, respectively.

Crude protein intake was increased with CP supplementation ($P < 0.01$; Table 2). Also, CP intake was greater for C3 compared with C4 forage ($P = 0.01$) because of greater forage intake and greater forage CP concentration with C3 (6.3 vs 5.7%; Table 1). Similarly, plasma urea-N (present in the blood and can be used by ruminants as a source of rumen available CP) was increased 123% with CP supplementation ($P < 0.01$) and 33% for C3 compared with C4 ($P < 0.01$). Fecal and urinary CP excretion was increased ($P < 0.01$) with CP supplementation, and the amount of CP lost in the feces was greater for C3 compared to C4 ($P = 0.02$). Nevertheless, efficacy of CP use by lambs was not effected by forage type ($P > 0.34$), while CP digestibility was greater with CP supplementation ($P < 0.01$).

Conclusions

Intake and digestibility of the C3 and C4 forages in the current study were not similar and, more importantly, the physiological response of ruminants to supplemental protein depended, in part, on the cell wall structure of the basal diet. More specifically, intake of low-quality C3 forage seems to increase little, if any, with CP supplementation. That said, CP supplementation is still necessary and advantageous with low quality C3 forages. The main take-home message is that the current intake models used by nutritionists to estimate the CP needs of ruminants consuming low-quality forages may not be appropriate for C3 forages because they were developed almost exclusively with C4 forages. Consequently, further research comparing other low-quality C3 and C4 forages is warranted to determine if the observed responses in the current study are indicative of differences in utilization of low-quality C3 and C4 forages by ruminants.

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Oregon State University **BEEF029**

Beef Cattle Sciences

Beef Research Report

Russian Knapweed - a Protein Supplement for Beef Cows? [1]

David W. Bohnert [2], Roger L Sheley [3], Stephanie J. Falck [3], and Arthur A. Nyman [2]

Synopsis

Russian knapweed is comparable, on a CP basis, to alfalfa as a CP supplement for beef cattle consuming low-quality forage.

Summary

Sustainable invasive weed control strategies may require that certain weeds are used in livestock production systems. One such weed, Russian knapweed (*Centaurea repens*), is a perennial noxious weed that has proven to be very difficult and expensive to control. It has protein values similar to alfalfa and may have potential as a protein supplement for beef cattle consuming low-quality forages. Therefore, we compared Russian knapweed and alfalfa (13 and 21% CP, respectively) as protein supplements using 48 Hereford × Angus, mid-gestation, beef cows (1,168 ± 11 lb) consuming hard fescue straw (4% CP) in an 84-d study. Treatments included an unsupplemented control (CON) and alfalfa (ALF) or Russian knapweed (KNAP) provided on an equal CP basis (approximately 1 lb CP/d). Cows were stratified by weight and body condition score (BCS) and allotted to treatments in a randomized complete block design using 12 pens (4 cows/pen; 4 pens/treatment). Means were compared using orthogonal contrasts (CON vs ALF and KNAP; ALF vs KNAP). Protein supplementation increased ($P < 0.01$) cow weight gain and BCS compared to CON with no difference between ALF and KNAP ($P = 0.47$). There was no difference ($P = 0.60$) in the quantity of straw offered between CON and supplemented groups but ALF cows were offered approximately 11% more ($P = 0.03$) than KNAP cows. Total straw and supplement offered to cows was greater ($P < 0.01$) for supplemented compared with CON cows with no difference noted between ALF and KNAP ($P = 0.79$). Russian knapweed can be used as a protein supplement for beef cows consuming low-quality forage. Thus, haying Russian knapweed in the spring and feeding in the winter may provide land managers with another management alternative to controlling large scale infestations.

Introduction

Russian knapweed (*Centaurea repens*) is a perennial noxious weed native to Eurasia that is highly competitive and invades productive habitats (Duncan, 2005). It is widely established throughout the western U. S., with infestations estimated at 1.3 million acres in 1998 (Whitson, 1999). Also, this weed is rapidly expanding its range, with annual spread in the western U.S. estimated between 8 and 14% (Simmons, 1985; Duncan, 2005).

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Russian knapweed can be controlled with herbicides for about 3 yr, but will reinvade the site, especially if cool-season grasses cannot be established (R. L. Sheley, ARS-USDA, personal communication). A single type of treatment, such as herbicide application, will not provide a sustainable means of control for Russian knapweed. As a result, an integrated management system is the most effective for controlling this weed. However, past attempts at integrated management of Russian knapweed have been very difficult and expensive (Whitson, 1999).

Russian knapweed has been reported to have protein values similar to alfalfa and may have potential as a protein supplement for beef cattle consuming low-quality forages (< 6% CP). Therefore, we compared Russian knapweed and alfalfa as protein supplements to beef cows consuming low-quality forage.

Materials and Methods

Forage Nutritional Characteristics

Alfalfa hay was grown and harvested at the Eastern Oregon Agricultural Research Center. The Russian knapweed was harvested from an infested site in Harney County, OR. The alfalfa (20.6% CP) was harvested at approximately 10% bloom and the Russian knapweed (13.4% CP) was harvested pre-flower. Three rumen cannulated steers consuming low-quality meadow hay (approximately 6% CP) were used in an in situ study to determine the digestion kinetics and effective rumen digestibility of dry matter, NDF, and CP in alfalfa and Russian knapweed. Ground samples of alfalfa and Russian knapweed were placed into 4 × 8 inch Dacron bags and then placed into the rumen of each steer and allowed to incubate for 0, 2, 8, 12, 24, 48, and 96 h. Triplicate samples, of each forage, were used at each time point. The samples were then removed from the rumen, washed, dried, weighed, and then analyzed for NDF and CP.

Performance Study

Forty-eight pregnant (approximately 120 d), 3-yr old, primiparous, Angus × Hereford cows (1,168 ± 11 lb) were used in an 84-d performance study. Cows were stratified by BCS (1 = emaciated, 9 = obese) and weight and assigned randomly, within stratification, to one of three treatments. Treatments were CON, ALF, or KNAP. Cows were then sorted by treatment and allotted randomly to 1 of 12 pens (4 cows/pen; 4 pens/treatment). A trace mineralized salt mix was available free choice (7.3% Ca, 7.2% P, 27.8% Na, 23.1% Cl, 1.5% K, 1.7 % Mg, .5% S, 2307 ppm Mn, 3034 ppm Fe, 1340 ppm Cu, 3202 ppm Zn, 32 ppm Co, 78 ppm I, 85 ppm Se, 79 IU/kg vitamin E, and 397 kIU/kg vitamin A). Cows were provided hard fescue grass seed straw (3.8% CP) twice daily as needed so that straw availability did not limit intake. The quantity of straw provided was noted daily. Alfalfa and Russian knapweed were provided Monday, Wednesday, and Friday on an equal CP basis (approximately 1 lb CP/hd/d averaged over a 7-d period). The amounts provided on Mondays and Wednesdays were 10.0 lb/hd and 15.0 lb/hd for ALF and KNAP, respectively. On Fridays, ALF cows received 15.0 lb/hd and KNAP cows received 22.5 lb/hd.

Cow body weight and BCS were independently measured every 42 d following an overnight shrink (16 h) by three trained observers. The same technicians were used throughout the experiment. Grass seed straw, ALF, and KNAP were collected weekly, dried, ground, and composited by 42-d period for analysis of ADF and NDF, and CP.

Statistical Analysis

Forage degradation data were analyzed as a completely randomized design using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). The model included steer and treatment. Treatment means were compared using Fisher's least significant difference.

Cow performance data were analyzed as a randomized complete block design using the GLM procedure of SAS. The model included block and treatment. Orthogonal contrasts (CON vs ALF and KNAP; ALF vs KNAP) were used to partition specific treatment effects.

Results

The degradation parameters and nutritional characteristics of alfalfa and Russian knapweed are presented in Table 1. Alfalfa had a 65% faster rate of dry matter degradation than KNAP ($P = 0.01$) and had an effective degradability of 74.5% compared with 70.1% for KNAP ($P < 0.01$). Likewise, the rate of NDF degradation was 6.6%/h for ALF compared with 3.8%/h for KNAP. The effective degradation rate of NDF in the forages was 8% greater for ALF compared with KNAP ($P = 0.02$). The proportion of soluble or rapidly portion

Table 1. Degradation parameters of alfalfa and Russian knapweed.

Degradation Parameters	Alfalfa	Knapweed	SEM	P-Value
Dry matter (DM)				
Fractions, %				
Soluble/rapidly degradable	41.2	42.2	0.09	0.02
Slowly degradable	39.8	36.8	0.16	< 0.01
Undegradable	19.0	21.0	0.17	0.01
DM degradation rate, %/h	10.4	6.3	0.3	0.01
Effective Degradability, %	74.5	70.1	0.15	< 0.01
NDF				
NDF, %	40.6	44.4		
Fractions, % of NDF				
Soluble/rapidly degradable	17.6	14.2	0.69	0.07
Slowly degradable	44	51.1	1.02	0.04
Undegradable	38.4	34.7	0.85	0.09
NDF degradation rate, %/h	6.6	3.8	0.3	0.02
Effective Degradability, %	51.2	47.6	0.36	0.02
CP				
CP, %	20.6	13.4		
Fractions, % of CP				
Soluble/rapidly degradable	51.5	40.2	1.24	0.02
Slowly degradable	45.9	54.6	1.41	0.05
Undegradable	2.6	5.1	0.18	0.01
CP degradation rate, %/h	11.6	8.6	2.6	0.50
Rumen degradable CP	95.9	91.7	0.05	< 0.01
Rumen undegradable CP	4.1	8.3	0.05	< 0.01
Effective Degradability, %	97.4	94.8	0.18	< 0.01

degradable CP present in ALF was 51.5% compared with 40.2% for KNAP ($P = 0.02$). However, the proportion of total CP that was slowly degraded within the rumen was greater for KNAP ($P = 0.05$; 54.6% vs 45.9% for KNAP and ALF, respectively). We noted no difference in the rate at which the CP was degraded between the two forages ($P = 0.50$); however, the overall effective CP degradability was greater for ALF compared with KNAP ($P < 0.01$). Nevertheless, even with the many differences noted above in degradation characteristics between the two forages, the magnitude of the differences are not that great and suggest that KNAP will function well as a protein supplement for beef cattle consuming low-protein forages (< 6% CP). Supplementation with protein has been shown to increase cow weight gain and body condition score (Clanton and Zimmerman, 1970; Bohnert et al., 2002), forage intake and digestibility (Kartchner, 1980; Köster et al., 1996), and can improve reproductive performance (Sasser et al., 1988; Wiley et al., 1991). The results of the current study agree with the studies of Clanton and Zimmerman (1970) and Bohnert et al. (2002) that protein supplementation of low-quality forage (< 6% CP; DM basis) increases cow BCS and weight gain compared with unsupplemented controls. The ALF and KNAP supplemented cows each gained 92 lb during the feeding period compared with a loss of 42 lb by the CON cows ($P < 0.01$; Table 2). No difference was noted between ALF and KNAP ($P = 0.70$). Likewise, final BCS of ALF and KNAP cows increased 0.3 and 0.2, respectively, while CON cows lost 0.9 BCS. Consequently, supplemented cows had the same BCS (5.6) at the end of the 84-d feeding period ($P = 0.47$) but greater scores than CON (4.2; $P < 0.01$).

The quantity of hard fescue straw offered was not affected by supplementation ($P = 0.60$; Table 2); however, the quantity offered to the ALF cows was 2.7 lb/d greater than that offered to the

Table 2. Effects of Alfalfa and Russian knapweed supplementation of low-quality, hard fescue straw offered to mid-gestation beef cows.

	Treatment[a]				*P*-Value	
Item	Control	Alfalfa	Knapweed	SEM[b]	Control vs Supplemented	Alfalfa vs Knapweed
Initial Wt., lb	1,102	1,129	1,116	19.4	0.41	0.70
Final Wt., lb	1,060	1,221	1,208	13.0	< 0.01	0.47
Initial BCS	5.3	5.3	5.4	0.06	0.72	0.74
Final BCS	4.2	5.6	5.6	0.81	< 0.01	0.47
Hard fescue straw offered, lb/d	22.5	24.3	21.6	0.71	0.60	0.03
Alfalfa or Knapweed offered, lb/d	0.00	5.0	7.5			
Total Feed offered, lb/d	22.5	29.3	29.1	0.71	< 0.01	0.79

[a] Control = hard fescue straw provided ad libitum; Alfalfa = Control + 5.0 lb/d alfalfa; Knapweed = Control + 7.5 lb/d Russian knapweed.
[b] n = 4.

KNAP (*P* = 0.03). This was probably the result of the greater quantity of supplement (2.5 lb/d) provided by the KNAP which substituted for the hard fescue straw. This was verified when the total feed offered was compared. There was no difference between ALF and KNAP (*P* = 0.79; approximately 29 lb/d for each), while supplemented cows had more total feed offered than the CON (*P* < 0.01).

Conclusions

Russian knapweed can be safely used as a protein supplement for beef cattle consuming low-quality forages. However, it should not be fed to horses because of the potential for a fatal neurological disorder, equine nigeropallidal encephalomalacia or “chewing disease”. Thus, haying Russian knapweed in the spring (before seed set) and feeding in the winter provides landowners and managers with a potential tool that can be used as part of an integrated management system to help control large scale infestations of Russian knapweed.

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Oregon State University

BEEF038

Beef Research Report

Beef Cattle Sciences

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

Reinaldo F. Cooke [2], Alexandre Scarpa [3], Chad Mueller [4], Tim DelCurto [5], and David W. Bohnert [6]

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

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affect reproductive function in cattle. Recently, we 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 $P \geq 0.10$.

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).

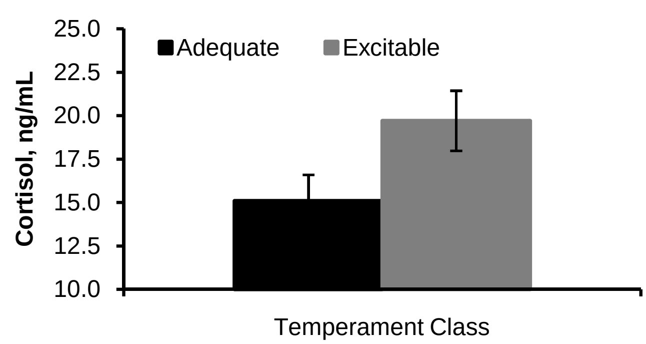

Figure 1. Plasma cortisol concentrations of cows classified according to temperament score (≤ 3 = adequate temperament, > 3 = excitable temperament). A temperament effect was detected ($P < 0.01$).

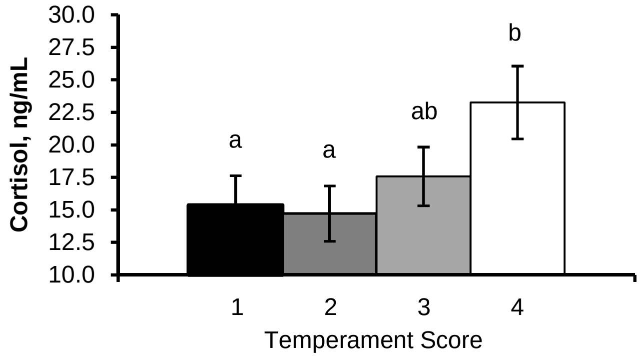

Figure 1. Plasma cortisol concentrations of cows according to temperament score (1 to 5 scale; 1 = calm temperament, 5 = excitable temperament). Values bearing a different letter differ ($P < 0.05$).

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.

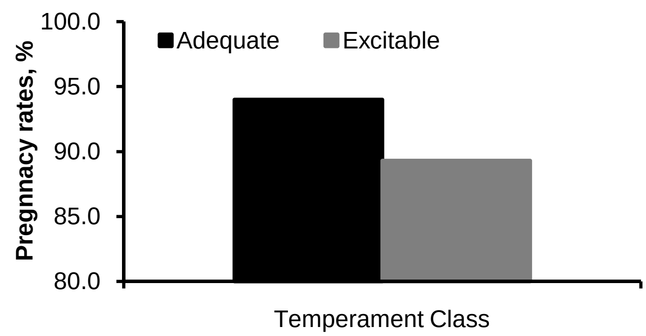

Figure 3. Pregnancy rates (pregnant cows / total cows) according to temperament score (≤ 3 = adequate temperament, > 3 = excitable temperament) in beef cows. A tendency for a temperament class effect was detected ($P = 0.10$).

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.

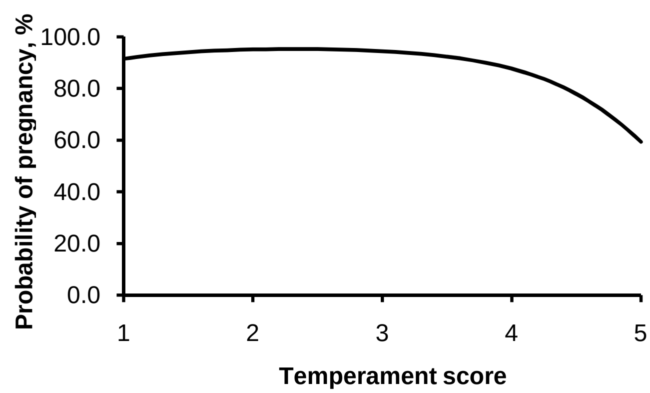

Figure 4. Effects of temperament score (1 to 5 scale; 1 = calm temperament, 5 = excitable temperament) on the probability of beef cows to become pregnant. This statistical analysis simulated probability of pregnancy in cows with temperament score of 5. A quadratic effect was detected ($P = 0.05$).

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