

LIVESTOCK RESPONSES TO COMPLEMENTARY FORAGES IN SHORTGRASS STEPPE

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ABSTRACT—Livestock gains of yearling Hereford heifers were evaluated during 1996–1999 on two complementary forage grasses, “Bozoisky-Select” Russian wildrye (*Psathyrostachys juncea* [Fisch.] Nevski) or “Hycrest” crested wheatgrass (*Agropyron cristatum* [L.] Gaertn. ssp. *desertorum* [Fisch. ex Link] A. Love). Average daily gains were similar between light and moderate stocking rates for both Bozoisky and Hycrest, and gains trended higher for Hycrest than for Bozoisky at light stocking rates. Total annual (spring + fall) beef production (kg/ha) was consistently greater for moderate (29%–46%) than for light stocking of both complementary forages. Spring gains represented >75% of the total annual beef production across forages. Average daily gains on these complementary forages were similar to those on native shortgrass steppe for the summer grazing season, but total annual beef production was two to four times greater with the complementary forages, suggesting that both Hycrest and Bozoisky can fill forage gaps and provide significant contributions to beef production.

Key Words: average daily gains, beef production, crested wheatgrass, forage gaps, livestock production systems, Russian wildrye, stocking rate

INTRODUCTION

Native vegetation of shortgrass steppe in the western North American Great Plains is dominated by the perennial warm-season grass blue grama (*Bouteloua gracilis* [H.B.K.] Lag. ex Griffiths) (Milchunas et al. 1989), thereby creating a forage gap for livestock producers in the early spring and late fall. Livestock performance during the traditional summer grazing season has been well studied (e.g., Hart and Ashby 1998; Derner and Hart 2007), as well as gains on fourwing saltbush (*Atriplex canescens* [Pursh] Nutt.)–dominated rangeland during the winter period (Derner and Hart 2005). However, there remains a need to address the forage gaps of early spring and late fall, and the livestock performance on complementary forages that would fill these forage gaps in the western Great Plains.

Increasing production costs associated with hay and grains necessitate that forages will play a more critical role in livestock production systems, especially in areas like the shortgrass steppe, where utilization of crop residues is minimal.

Forage production of native cool-season grasses in the shortgrass steppe is highly variable (Derner et al. 2008), as production levels are correlated with spring precipitation amounts, which are erratic (Milchunas et al. 1994). Cool-season forage grasses offer increased production capacity over native rangelands (Haferkamp et al. 2005) and can be effectively seeded into formerly cultivated areas that have diminished soil carbon and nitrogen (Burke et al. 1995). Thus, in addition to increasing forage production, establishment of cool-season forage grasses could provide an opportunity to reduce erosion associated with crop cultivation

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and increase soil carbon storage in these degraded lands of the Great Plains.

Increased carrying capacity and livestock gains have been achieved with crested wheatgrass (*Agropyron cristatum* [L.] Gaertn) (Lodge 1970; Laycock and Conrad 1981; Hart et al. 1983; Adams et al. 1989; Vogel et al. 1993; Haferkamp et al. 2005) and Russian wildrye (*Psathyrostachys juncea* [Fisch.] Nevski) (Adams et al. 1989; Haferkamp et al. 2005) over native rangeland in other ecosystems. Russian wildrye tends to be more drought resistant than crested wheatgrass (Haferkamp et al. 1992). Forage quality of crested wheatgrass and Russian wildrye is highest in the spring (Angell et al. 1990; Mayland et al. 1992; Gillen and Berg 2005; Haferkamp et al. 2005). Livestock gains of calves were five times greater with spring compared to fall grazing of crested wheatgrass in northern mixed-grass prairie (Hart et al. 1983). Increasing forage quality for fall grazing is likely enhanced by grazing in spring to reduce accumulation of dead inflorescences, which reduce intake and palatability (Ganskopp et al. 1992). Despite direct comparisons of forage productivity and quality, comparisons of livestock responses to these two complementary forages have not been conducted to our knowledge.

Our objective was to evaluate livestock gain responses on two complementary forage grasses in shortgrass steppe of the western Great Plains that was stocked at either light or moderate rates and in which grazing occurred in both the spring and late fall periods. We predicted that livestock performance, assessed as average daily gains (kilogram/head/day), would be (1) similar between the two complementary forage grasses, and (2) greater at light compared to moderate stocking rates. We also predicted that beef production (gains per unit of land area) would be (1) similar between the two complementary forage grasses, (2) greater at moderate compared to light stocking rates, and (3) greater in spring compared to fall.

METHODS

The USDA–Agricultural Research Service, Central Plains Experimental Range is located about 20 km northeast of Nunn, in north-central Colorado (40°49'N, 107°46'W). Mean annual precipitation (1939–2008) is 341 mm, with 49% of this occurring May–July. Total annual precipitation during this study (1996–1999) was 42% above average (mean = 483 mm), ranging from 387 mm in 1996 to 565 mm in 1997 (Table 1). April–May and September–October precipitation amounts were at, or exceeded, long-term means in each year, with the exception of September–October precipitation in 1996 (Table 1). Soils for this research area

are fine sandy loams and had been previously cultivated in the 1930s and 1950s prior to plowing again in 1994 for this experiment. Vegetation prior to plowing was characteristic of “go-back” lands. A 28.3 ha area was seeded with a grass drill to either “Bozoisky-Select” Russian wildrye (*P. juncea* [Fisch.] Nevski) or “Hycrest” crested wheatgrass (*A. cristatum* [L.] Gaertn. ssp. *desertorum* [Fisch. ex Link] A. Love) in March 1994 using 5.5 cm row spacings for Bozoisky and 2.75 cm row spacings for Hycrest. Poor seedling establishment of Bozoisky resulted in a reseeding of this species in October 1994. Plants were not grazed in 1995. Pastures were fenced to provide a two (complementary forage grass) by two (stocking rate) factorial design in which all pastures were grazed in both the spring and fall. Treatment combinations were not replicated, however. Lightly stocked pastures were 8.1 ha each, and moderately stocked pastures were 6.1 ha each, or 33% higher stocking than light. Each year, 20 yearling Hereford replacement heifers were randomly allocated to four herds of five heifers each to graze the pastures in early spring, then combined into a single herd to graze native shortgrass pastures during the summer period, and randomly allocated again into four herds for the late fall grazing periods during 1996 to 1999 (Table 1). Spring grazing periods were from mid-April to early June (1996 and 1997) and from mid-April to late June (1998 and 1999), with entry weights of heifers ranging from 258 to 282 kg/hd across years. Fall grazing periods were consistent across years, occurring from very late October to early December. Entry weights of heifers for the fall grazing periods were 399 to 409 kg/hd. Livestock gains were determined by weighing individual animals prior to and following each grazing period. Weighing was conducted following an overnight shrink without food and water. Livestock use and care protocols were overseen by the USDA–Agricultural Research Service, Central Plains Experimental Range Animal Use and Care Committee.

The fact that there was only a single replication of each treatment limits the interpretations of our findings, as they are specific to our experimental location and treatments. The potential statistical consequences and limitations of pseudoreplication have been discussed (see Hurlbert 1984; Heffner et al. 1996). Further experimentation is required to determine the applicability of results to a wider geographic area. Here we draw inferences from mean livestock responses of average daily gain (kg/hd/day) as well as beef production (kg/ha) for the following four pairs of treatments: (1) light vs. moderate stocking for Hycrest, (2) light vs. moderate stocking for Bozoisky, (3) Hycrest vs. Bozoisky for light stocking, and (4) Hycrest vs. Bozoisky for moderate stocking.

TABLE 1
SUMMARY OF PERFORMANCE PARAMETERS FOR HEREFORD HEIFERS ON COMPLEMENTARY PASTURES IN SHORTGRASS STEPPE, 1996–1999, CENTRAL PLAINS EXPERIMENTAL RANGE,
NUNN, COLORADO

Parameter	Year				
	1995	1996	1997	1998	1999
Precipitation (mm)					
Annual	471.2	387.1	565.2	421.9	557.3
Percentage of mean	139	114	166	124	164
April–May	193.0	86.1	96.5	85.3	277.9
Percentage of mean	160	99	111	98	220
September–October	71.6	40.6	70.6	68.1	70.6
Percentage of mean	142	80	140	135	140
Length of grazing period					
Spring	No grazing	April 15–June 4	April 14–June 3	April 17–June 26	April 15–June 25
Fall	No grazing	Oct. 31–Dec. 5	Oct. 30–Dec. 4	Oct. 30–Dec. 4	Oct. 29–Dec. 8
Entry weight of heifers (kg)					
Spring		282	262	258	258
Fall		399	399	402	409

RESULTS

Average daily gains (kg/hd/day) were similar between light and moderate stocking rates for both Bozoisky and Hycrest in all study years (Fig. 1). Average daily gain trended higher for Hycrest (0.83 to 1.13) than Bozoisky (0.84–0.94) at light stocking rates. Total annual (spring + fall) beef production (kg/ha) was consistently greater for moderate than light stocking for both complementary forages. Moderate stocking resulted in 29%–46% greater total beef production across the years for Bozoisky, and 29%–40% for Hycrest. Higher beef production was observed for Hycrest in three of the four study years for both stocking rates. Spring gains represented 75% or greater of the total annual beef production across forages for each stocking rate in all years except 1997, when the spring and fall gains were nearly equal. The below-average precipitation in fall 1996 may have reduced plant vigor following grazing that year, which contributed to lower animal performance in spring 1997 despite above-average precipitation in April–May 1997 (Table 1).

CONCLUSIONS

Livestock gain responses, average daily gains, and beef production of yearling heifers were evaluated for four years

following establishment of two complementary forage grasses in shortgrass steppe of the western Great Plains. Pastures were stocked at either light or moderate rates and grazing occurred in both the spring and late fall. Average daily gains were similar between light and moderate stocking rates for both complementary forages, but beef production was about one-third greater for moderate than for light stocking. Spring gains represented at least three-fourths of the total annual beef production in three of the four study years.

Observed greater livestock gain responses to Hycrest than to Bozoisky at both stocking rates are likely not explained by differences in nutritional quality, as both complementary forage grasses have been previously documented as having similar crude protein and in vitro organic matter disappearance in the boot and quiescent growth stages (Ganskopp et al. 1997). In addition, digestible nutrients decline in forage grasses as herbage matures, including Hycrest (Mayland et al. 1992; Haferkamp et al. 2002) and Bozoisky (Gillen and Berg 2005). Both Hycrest and Bozoisky have similar leaf/stem ratios, plant biomass, moisture content, and plant heights in the boot stage, but Bozoisky is taller, produces more biomass, and has a much higher leaf/stem ratio (2.7 versus 0.4) than Hycrest in the quiescent stage (Ganskopp et al. 1997).

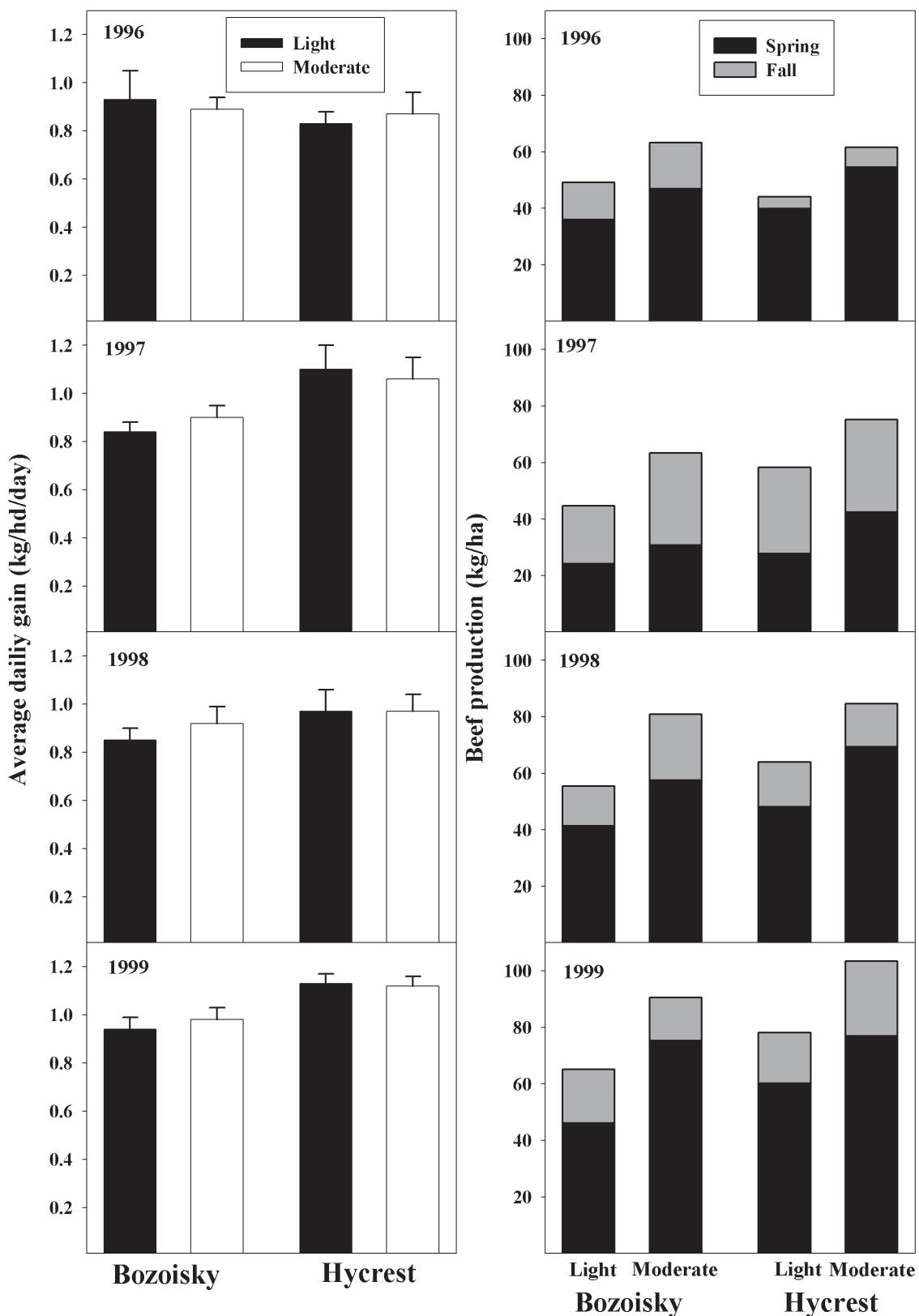


Figure 1. Average daily gain (kg/hd/day) and spring, fall, and total beef production (kg/ha) responses of yearling Hereford heifers stocked at light and moderate rates on "Bozoisky" Russian wildrye and "Hycrest" crested wheatgrass pastures in shortgrass steppe, 1996-1999, at the USDA-Agricultural Research Service, Central Plains Experimental Range, Nunn, CO.

Observed average daily gains on the two complementary forages were similar to those previously reported for the summer grazing season on native shortgrass steppe (0.83 to 1.13 kg/ha/day, Derner and Hart 2007), but these gains were substantially greater than those for late fall grazing (0.41 to 0.65 kg/ha/day) or early spring grazing (0.27 to 0.59 kg/ha/day) of saltbush-dominated rangeland (Derner and Hart 2005). Despite similar average daily gains on the complementary forages and native shortgrass steppe, total annual beef production was two to four times greater with the complementary forages (44 to 104 kg/ha) compared to native shortgrass steppe (11 to 27 kg/ha, Derner and Hart 2007). Beef production is often greater on seeded pastures compared to native rangeland (Smoliak 1968; Smoliak and Slen 1974; Hart et al. 1983; Hart and Ashby 1988; Karn et al. 1999). Besides increasing beef production, addition of these complementary forages in a “system” can extend the grazing season, both prior to and following the traditional summer grazing season. For example, including just spring grazing of these complementary pastures can at least double beef production, as the spring gains ranged from 24 to 77 kg/ha over the study years. Our results suggest that both Hycrest and Bozoisky can fill the spring and fall forage gaps for the livestock production cycle in shortgrass steppe and can provide significant contributions to beef production.

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REFERENCES

- Adams, D.C., R.B. Staigmiller, and B.W. Knapp. 1989. Beef production from native and needed Northern Great Plains ranges. *Journal of Range Management* 42:243–47.
- Angell, R.F., R.F. Miller, and M.R. Haferkamp. 1990. Variability of crude protein in crested wheatgrass at defined stages of phenology. *Journal of Range Management* 43:186–89.
- Burke, I.C., W.K. Lauenroth, and D.P. Coffin. 1995. Soil organic matter recovery in semiarid grasslands: Implications for the Conservation Reserve Program. *Ecological Applications* 5:793–801.
- Derner, J.D., and R.H. Hart. 2005. Heifer performance under two stocking rates on fourwing saltbush-dominated rangeland. *Rangeland Ecology and Management* 58:489–94.
- Derner, J.D., and R.H. Hart. 2007. Livestock and vegetation responses to rotational grazing in shortgrass steppe. *Western North American Naturalist* 67:359–67.
- Derner, J.D., B.W. Hess, R.A. Olson, and G.E. Schuman. 2008. Functional group and species responses to precipitation in three semi-arid rangeland ecosystems. *Arid Lands Research and Management* 22:81–92.
- Ganskopp, D., R. Angell, and J. Rose. 1992. Response of cattle to cured reproductive stems in a caespitose grass. *Journal of Range Management* 45:401–4.
- Ganskopp, D., B. Myers, S. Lambert, and R. Cruz. 1997. Preferences and behavior of cattle grazing on eight varieties of grasses. *Journal of Range Management* 50:578–86.
- Gillen, R.L., and W.A. Berg. 2005. Response of perennial cool-season grasses to clipping in the Southern Plains. *Agronomy Journal* 97:125–30.
- Haferkamp, M.R., P.O. Currie, J.D. Volesky, and B.W. Knapp. 1992. Mortality of crested wheatgrass and Russian wildrye during drought. *Journal of Range Management* 45:355–57.
- Haferkamp, M.R., E.E. Grings, R.K. Heitschmidt, and M.D. MacNeil. 2002. Quality and persistence of forages in the Northern Great Plains. *Journal of Range Management* 55:482–87.
- Haferkamp, M.R., M.D. MacNeil, E.E. Grings, and K.D. Klement. 2005. Heifer production on rangeland and seeded forages in the northern Great Plains. *Rangeland Ecology and Management* 58:495–504.
- Hart, R.H., and M.M. Ashby. 1998. Grazing intensities, vegetation, and heifer gains: 55 years on shortgrass. *Journal of Range Management* 51:392–98.
- Hart, R.H., J.W. Waggoner, D.H. Clark, C.C. Kaltenbach, J.A. Hager, and M.B. Marshall. 1983. Beef cattle production on crested wheatgrass plus native range vs. native range alone. *Journal of Range Management* 36:38–40.
- Heffner, R.A., M.J. Butler IV, and C.K. Reilly. 1996. Pseudoreplication revisited. *Ecology* 77:2558–62.
- Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. *Ecological Monographs* 54:187–211.

- Karn, J.F., R.E. Reis, and L. Hofmann. 1999. Season-long grazing of seeded cool-season pastures in the Northern Great Plains. *Journal of Range Management* 52:235–40.
- Laycock, W.A., and P.W. Conrad. 1981. Responses of vegetation and cattle to various systems of grazing on seeded and native mountain rangelands in eastern Utah. *Journal of Range Management* 34:52–58.
- Lodge, R.W. 1970. Complementary grazing systems for the Northern Great Plains. *Journal of Range Management* 23:268–71.
- Mayland, H.F., K.H. Asay, and D.H. Clark. 1992. Seasonal trends in herbage yield and quality of *Agropyrons*. *Journal of Range Management* 45:369–74.
- Milchunas, D.G., J.R. Forwood, and W.K. Lauenroth. 1994. Productivity of long-term grazing treatments in response to seasonal precipitation. *Journal of Range Management* 47:133–39.
- Milchunas, D.G., W.K. Lauenroth, P.L. Chapman, and M.K. Kazempour. 1989. Effects of grazing, topography and precipitation on the structure of a semi-arid grassland. *Vegetatio* 80:11–23.
- Smoliak, S. 1968. Grazing studies on native range, crested wheatgrass, and Russian wildrye pastures. *Journal of Range Management* 21:47–50.
- Smoliak, S., and S.B. Slen. 1974. Beef production on native range, crested wheatgrass, and Russian wildrye pastures. *Journal of Range Management* 27:433–36.
- Vogel, K.P., B.C. Gabrielsen, J.K. Ward, B.E. Anderson, H.F. Mayland, and R.A. Masters. 1993. Forage quality, mineral constituents, and performance of beef yearlings grazing two crested wheatgrasses. *Agronomy Journal* 85:584–90.