Heifer nutrition and growth on short duration grazed crested wheatgrass

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Abstract

Animal performance and nutrition under short duration grazing (SDG) and season-long grazing (SLG) were compared on spring-grazed crested wheatgrass [*Agropyron desertorum* (Fisch.)Schult. and *A. cristatum* (L.)Gaertn.] range to determine if SDG has the potential to improve livestock production on such rangelands. Livestock performance was evaluated by measuring weight gains twice per grazing season. Diet quality was assessed by determining crude protein concentration and in vitro organic matter digestibility of extrusa samples collected from esophageally fistulated heifers. Three variables of ingestive behavior were measured: ingestion rate, biting rate, and grazing time. Daily forage intake was calculated as the product of ingestion rate and grazing time. Animals in the SLG treatment gained significantly more than those under SDG in 1983 (1.07 vs. 0.81 kg/hd/d), but no statistical differences were detected in 1984 (1.13 vs. 1.07 kg/hd/d for SDG and SLG, respectively). In 1985, animals under SDG gained the most (1.03 vs. 0.87 kg/hd/d for SDG vs. SLG, respectively). No differences were detected in diet quality between SDG and SLG throughout the study. No treatment differences were detected in ingestive behavior during 1984, but ingestion rate was greater and grazing time less under SDG than SLG during 1985. Results indicate that forage intake was greater, while energy expenditures were lower under SDG than SLG in 1985. The hypothesis that SDG extends the season of nutritious forage was not supported.

Key Words: ***Agropyron desertorum, A. cristatum,*** **diet quality, ingestive behavior, feed intake, livestock production, grazing management**

Short duration grazing (SDG) is gaining popularity as a type of grazing management that purportedly enhances both livestock production and range condition. Livestock production is reported to be improved by increases in both carrying capacity and animal performance (Savory 1978). A salient feature of SDG is the purported effect of rapid rotation on forage maturity and diet quality. It is proposed that this allows animals to maximize selection for the most nutritious, youngest plant parts, and then they are moved to new, ungrazed vegetation. During the rest period, the plants recover from grazing and regrow. The forage on offer during the next grazing period is thus young and highly nutritious. This hypothesized maintenance of the sward in a phenologically immature state thereby may extend the season of nutritious forage. Thus, animal performance under SDG is expected to be better than under traditional grazing schemes.

Most literature concerning SDG reports weight gain as a measure of livestock response. Results have been variable; higher average daily gain (ADG) has been reported under SDG than under season-long grazing (SLG) in some cases when stocking rates were equal (Daugherty et al. 1982, Sharrow 1983), while other studies reported equivelant ADG between SDG and SLG, both when stocking rates were equal (Jung et al. 1985) and when the stocking rate was substantially increased under SDG (Heitschmidt et al. 1982, Jung et al. 1985). These results indicate that carrying capacity or gain per animal may be seasonally enhanced by using SDG, thus allowing an increase in gain per area. However, a more detailed approach focusing on potential mechanisms of animal interaction with the sward would be more likely to define causes of the weight responses and allow determination of how changes in management (length of graze and rest periods, and stocking density) might affect weight gains and carrying capacity. Such an approach should involve analysis of nutritional and behavioral factors as an interface between livestock response and vegetation characteristics that result from grazing management.

Winter-spring range, typically foothill range seeded to crested wheatgrass [*Agropyron desertorum* (Fisch.)Schult. and *A. cristatum* L.Gaertn.], is the major forage supply constraint on livestock production in the Intermountain West. This constraint is caused by two factors: (1) there is a limited amount of this seeded foothill range (Banner 1981), and (2) crested wheatgrass matures rapidly, with a concomitant decline in nutritive quality (Cook and Harris 1968). This growth characteristic limits the time span that crested wheatgrass can effectively meet the nutrient requirements of beef cattle. Because of these limitations, SDG might improve livestock nutrition and production on spring range in the Intermountain West by increasing carrying capacity or extending the season of nutritious forage.

The objective of this study was to determine if SDG alters livestock performance, diet quality, ingestive behavior, and forage intake relative to SLG.

Materials and Methods

A multi-disciplinary project to evaluate SDG on crested wheatgrass was initiated in 1983 involving several investigators studying aspects of SDG germane to their area of expertise; including vegetal, hydrologic, livestock, and economic responses to SDG.

Study Site

The study was conducted on the Tintic Experimental Pastures in Juab County, west-central Utah. The SDG cell consisted of ten 8.4-ha (21 acre) paddocks arranged radially around a central watering and handling facility. The SLG treatment was a 28-ha (70 acre) pasture located about 0.5 km from the SDG cell.

The study area was typical of most crested wheatgrass seedings throughout the Intermountain West. The site was renovated in 1951 by removing unpalatable woody species, including big sagebrush (*Artemisia tridentata* Nutt.), rabbitbrush [*Chrysothamnus nauseosus* (Pallas)Britt.], and juniper trees (*Juniperus* spp. L.), and seeding to introduced wheatgrasses (Cook 1966). The SLG treatment and most of the SDG cell was seeded to crested wheatgrass. A portion of the SDG cell was seeded to intermediate wheatgrass [*A. intermedium* (Host)Beauv.], but this area was avoided as much as possible for sampling. The vegetation in both treatments was dominated by crested wheatgrass with localized patches of western wheatgrass (*A. smithii* Rydb.). Big sagebrush and rabbitbrush were encroaching throughout both treatments. Localized stands of juniper occurred in the grazing cell.

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Grazing Management

The SDG cell was stocked with 90 black Angus replacement heifers and 3 to 5 bulls, resulting in a stocking rate of 0.7 ha (1.7 acres) per AUM[1]. The heifers weighed 230 to 270 kg (500 to 600 lb) at the beginning of each grazing season. The SLG pasture was stocked with 30 heifers and 1 or 2 bulls to achieve the same stocking rate as the SDG cell. However, the stocking density in the SDG cell was 0.14 ha (0.35 acres) per AU[1], while the SLG stocking density was 1.4 ha (3.5 acres) per AU.

Animals in the SDG cell were moved approximately every 3 days in 1983 and 1984. Two complete cycles were made through the grazing cell. In 1985, the animals were moved approximately every 2 days during the first 2 cycles, and every day during a third cycle. Length of grazing period in specific paddocks was adjusted based on forage availability (±1 day). Animals were moved at midday to avoid interference with normal morning and evening grazing activity.

Field Methodology

Livestock Performance

All animals were weighed in the morning after an overnight fast period at the beginning, middle, and end of the grazing season.

Diet Quality

Heifers having esophageal fistulae were used to collect samples of grazed forage for nutritional analysis. In 1983, 3 fistulated animals were used in each treatment. In 1984 and 1985, this number was increased to 5 animals in each treatment. These animals were cohorts of the herds that grazed the experimental pastures.

Samples were collected in the early morning or at the time of entry to a particular paddock. Animals were fasted for 5- to 10-hours before sample collection to insure grazing. Chacon and Stobbs (1977) found that bite size and diet quality were influenced more by stage of defoliation and individual animal variability than by fasting or diurnal variations in time of sampling, as long as fasting was less than 12 hours. Fistula extrusa samples were frozen in the field immediately following collection by immersion in a dry ice-alcohol bath. Samples were then stored in a freezer until laboratory analysis.

Esophageal extrusa was collected whenever animals were in 3 pre-selected paddocks. These paddocks were spaced evenly around the grazing cell. In 1983, extrusa was collected on the days of entrance to and exit from paddocks 3, 6, and 9. Extrusa was collected in the SLG treatment during intervening periods. In 1984 and 1985, extrusa was collected on each consecutive morning that the heifers occupied paddocks 1, 4, and 7. In 1985, extrusa was also collected immediately after movement into the paddocks (i.e., at midday), to gain information on response to ungrazed swards. In 1984 and 1985, the SLG treatment was sampled on 3 occasions evenly spaced through the grazing season.

Ingestive Behavior and Forage Intake

An understanding of behavioral responses to the physical characteristics of vegetation can be used to estimate forage intake (Stobbs 1973, 1974) and has been implicated with livestock performance (Ebersohn and Moir 1984). Stobbs (1974), working on tropical pastures in Australia, estimated daily forage intake from the product of 3 variables of ingestive behavior: bite size (g/bite), biting rate (bites/min), and grazing time (mins/day). This approach provides the opportunity to evaluate forage intake response to the effects of grazing management on the sward, as mediated by ingestive behavior.

Three variables of ingestive behavior were measured in this study during 1984 and 1985: ingestion rate, biting rate, and grazing time.

Ingestion rate, or intake per unit time, was measured in conjunction with collection of esophageal extrusa samples. Extrusa harvested during timed periods of sampling was weighed in the field immediately following collection. Ingestion rate per sample period was calculated for each heifer by dividing the weight by the grazing time during the sample period. Several precautions were taken to improve the probability that all forage ingested during an extrusa collection went into the bag. In 1983, foam rubber plugs were placed in the esophagus posterior to the fistula during sample periods as recommended by Stobbs (1973). However, animals were often observed to be irritated by the presence of the foam rubber plug, and thus did not graze normally. In 1984 and 1985, a cannula insert was used in lieu of the foam plugs to facilitate total sample collection (Olson and Malechek 1987).

Biting rate was measured by ocular counts during the period of intense grazing in early morning. These counts were made immediately before esophageal extrusa collections. Animals to be observed were selected in a stratified manner to maximize independence of samples. Consecutively observed individuals were separated by a distance that was subjectively deemed adequate to minimize possible effects of social facilitation on behavior. For a particular animal, time elapsed to prehend and ingest 100 to 200 bites were recorded with a stop watch while counts were made. Timing was interrupted during nongrazing intervals, such as when animals raised their heads to brush hornflies away or to walk.

Grazing time was recorded by fitting 4 animals in each treatment with vibracorders. These instruments remained on the animals throughout the grazing season. Charts were changed weekly, so grazing time was continuously recorded.

Laboratory Methodology

A subsample of each extrusa sample was used to determine dry matter (DM) and organic matter (OM) content (Harris 1970) to adjust ingestion rates to an OM basis. Another subsample of each frozen extrusa sample was freeze-dried and ground through a 1-mm screen in preparation for diet quality analysis. Extrusa samples were not composited across animals, days, or paddocks because all of these sources of variation were of interest for this or other studies. Ground samples were analyzed for Kjeldahl nitrogen (Harris 1970) and in vitro organic matter digestibility (IVOMD) by use of a cellulase technique (McLeod and Minson 1978). Crude protein (CP) was calculated as Kjeldahl nitrogen times 6.25. All results are reported on an OM basis to alleviate potential problems caused by variable salivary mineral contamination.

Data Analysis

Estimated daily forage intake was the product of ingestion rate and grazing time (Freer 1981).

Statistical differences in livestock performance between SDG and SLG were determined using Student's *t*-tests (Steel and Torrie 1960). Differences in diet quality and ingestive behavior were analyzed by least squares analysis of variance (ANOVA) using the Rummage statistical program (Bryce 1980). Main effects were treatment (SDG versus SLG), date, and their interaction. Date compares different periods in the grazing season. These dates are delineated by each sample collection period in the SLG treatment. There were 5 sample periods under SLG in 1983 and 3 each in 1984 and 1985. Data from SDG during equivalent portions of the grazing season were used for comparison. Separate analyses were run for each year with no comparisons made among years because of differences between years in sampling schedules and grazing management. Mean separations were determined by LSD for significant ANOVA main effects. Statistical significance was inferred at $P \leq 0.05$. We recognize that the lack of replication of true experimental units (pastures or grazing cells) limits the application of results to locations other than the study site.

Results and Discussion

Livestock Weight Gain

Average daily gains in both treatments appeared to be greater in

[1]AUM (animal unit month) and AU (animal unit) follow the standard definition wherein 1 animal unit equals a 454 kg cow with calf or the equivalent, and an animal unit month is the forage demand of 1 animal unit for 1 month.

Table 1. Average daily gain (ADG) of heifers (kg/hd/d) and total livestock production (kg/ha) on crested wheatgrass under short duration grazing (SDG) and season long grazing (SLG) during the springs of 1983, 1984, and 1985.

	SDG	SLG
1983		
period 1 ADG	1.09[a1]	1.21[a]
period 2 ADG	0.54[a]	0.94[b]
mean ADG	0.81[a]	1.07[a]
kg/ha	50.5	65.7
1984		
period 1 ADG	1.54[a]	1.62[a]
period 2 ADG	0.72[a]	0.52[a]
mean ADG	1.13[a]	1.07[a]
kg/ha	72.0	67.5
1985		
period 1 ADG	1.12[a]	0.96[b]
period 2 ADG	0.88[a]	0.73[b]
mean ADG	1.03[a]	0.87[b]
kg/ha	58.4	49.5

[1]Means within rows differ ($P \leq 0.05$) when followed by different letters.

Table 2. Mean annual crude protein concentration (CP) and in vitro organic matter digestibility (IVOMD) of esophageal extrusa, ingestion rate, biting rate, and grazing time by heifers grazing crested wheatgrass under short duration grazing (SDG) and season long grazing (SLG), 1983-1985.

		1983	1984	1985
CP	SDG	13.40[a1]	14.07[a]	13.66[a]
(%)	SLG	11.32[a]	14.27[a]	14.49[a]
IVOMD	SDG	65.94[a]	64.95[a]	67.93[a]
(%)	SLG	64.87[a]	64.51[a]	66.75[a]
ingestion rate	SDG	[2]	9.20[a]	10.31[a]
(g OM/min)	SLG		12.20[a]	5.42[b]
biting rate	SDG		56.13[a]	50.65[a]
(bites/min)	SLG		60.19[a]	55.10[a]
grazing time	SDG		10.67[a]	9.65[a]
(hrs/day)	SLG		9.84[a]	10.90[b]
forage intake	SDG		5.89	5.97
(kg OM/day)	SLG		7.20	3.54

[1]Means within years and dependent variables differ ($P \leq 0.05$) when followed by different letters.
[2]Ingestive behavior variables and forage intake were not measured in 1983.

1984 than in either 1983 or 1985 (Table 1). This may have been a reflection of compensatory gain resulting from a particularly hard winter and short feed supplies immediately before the 1984 grazing season. When comparing relative differences between treatments, a trend appears through the 3 years. While SLG provided greater ADG than SDG in late 1983, no differences were detected in 1984, and SDG was superior throughout 1985. There are 2 possible explanations for these responses. First, the effects of SDG on the vegetation may be cumulative over successive grazing seasons. Three years could possibly have been required for SDG to overcome its initial lower level of animal performance in 1983, and finally gain superiority by 1985. In this case, SDG would be the superior grazing method in terms of livestock production. Conclusions concerning such vegetation responses are yet to be determined from other components of the overall study of SDG. Second, grazing management in the SDG treatment was changed during 1985, from 3- to 2-day grazing periods in paddocks. Therefore, weight gains may have been higher in the SDG cell only in 1985 because animals were not forced to utilize poorer quality forage as defoliation progressed through the third day.

Gains per ha, calculated from seasonal mean weight gains, were initially greater under SLG, but subsequently greater under SDG in 1984 and 1985 (Table 1). Because there were no differences in stocking rates, individual weight gains are directly reflected in these production figures. However, increased growth does not automatically confer improved reproduction on young animals. In fact, pregnancy rates of heifers subjected to SDG were lower than for the heifers used in the SLG treatment during this study (3.6, 6.5, and 8.2 percentage units in 1983–1985, respectively) (Chuck Warner, pers. comm.). Reductions in conception rates or lifetime productivity of replacement heifers resulting from SDG would negate any benefit of increased growth. Although causes of these differences in reproductive performance have not yet been determined, the nutritional factors examined in this study were found to be adequate, and thus not the cause.

Diet Quality

Annual means for CP and IVOMD of diets between SDG and SLG were not significantly different in any of the 3 years (Table 2). Taylor et al. (1980) compared CP and IVOMD of livestock diets under SDG to that under high intensity-low frequency (HILF) and Merrill deferred-rotation grazing systems on west Texas native range. Both dietary CP and IVOMD were the same for SDG and Merrill grazing, but significantly less for HILF. Their results for SDG and their most extensive grazing system (Merrill deferred-rotation), which uses season-long grazing periods, are in agreement with our results.

Crude protein and IVOMD annual means were relatively uniform among years, and sufficiently high to provide adequate nutrition for heifer growth (i.e., the NRC (1976) CP requirement for 250 kg growing heifers to gain 1.1 kg/day is 11.4%). Apparently, animals were able to maintain adequate overall diet quality in both grazing teatments, although SDG may have altered the seasonal pattern of forage quality.

Significance of the method by date interaction term would suggest that the seasonality of diet quality was altered by SDG. Although the annual means were not different in 1984, method by date was significant for both CP and IVOMD (Table 3). Method by date was not significant for either variable in 1983 or 1985. In 1984, CP was the same under both SDG and SLG in period 1 and declined as the season progressed, as would be expected (Cook and Harris 1968). However, CP declined more rapidly in SLG than SDG, possibly indicating an extension of the season of nutritious

Table 3. Grazing method by period means for variables within years when the method by date interaction was significant ($P \leq 0.05$).

		period 1	period 2	period 3
		1984		
CP	SDG	17.93[a1]	13.55[b]	10.72[c]
(%)	SLG	19.84[a]	11.62[c]	11.34[c]
IVOMD	SDG	71.02[a]	67.25[b]	56.59[c]
(%)	SLG	77.96[d]	62.39[e]	53.17[f]
biting rate	SDG	64.01[a]	52.68[b]	51.69[b]
(bites/min)	SLG	59.73[a]	59.82[a]	60.73[a]
grazing time	SDG	10.18[a]	11.02[b]	10.81[ab]
(hrs/day)	SLG	8.69[c]	10.38[a]	10.45[a]
		1985		
grazing time	SDG	9.79[a]	9.50[a]	9.67[a]
(hrs/day)	SLG	10.69[b]	11.04[b]	10.98[b]

[1]Means within years and dependent variables differ ($P \leq 0.05$) when followed by different letters.

forage under SDG. This difference was short-lived, however, because it was eliminated by the end of the grazing season, as indicated by the lack of significant difference in period 3. IVOMD was higher under SLG than SDG in period 1, but it declined more rapidly by period 2, and was significantly less under SLG throughout periods 2 and 3. Again, this suggests an extension of the season of nutritious forage. Because years when growth of heifers differed among grazing methods (i.e. 1983 and 1985) did not correspond with years when the method by date interaction was significant (i.e. 1984), the differential gains are not explained by diet quality responses.

Ingestive Behavior and Daily Forage Intake

Annual mean ingestion rates were the same in both treatments in 1984, although they approached being significantly ($P<0.10$) greater under SLG than SDG (Table 2). Ingestion rates were significantly less under SLG in 1985 (Table 2). Ingestion rate can be considered a measure of foraging efficiency because it approximates intake of nutrients or energy per expenditure of time, with grazing time serving as an estimator of energy expenditure (Osuji 1974). Thus, animals foraged more efficiently under SDG during 1985. Method by date interactions were nonsignificant for ingestion rate during both years.

Annual mean biting rates did not differ among grazing methods in either year (Table 2). Method by date interaction was significant for biting rate in 1984 (Table 3), but not in 1985. While biting rates remained constant through the grazing season under SLG in 1984, they declined from period 1 to period 2 under SDG, and remained lower than SLG throughout periods 2 and 3. Biting rate is a component of ingestion rate, along with bite size (Freer 1981). Because of the lack of seasonal treatment differences in ingestion rate, this seasonal response of biting rate is of minor importance. It appears that animals in different treatments made adjustments in bite size to maintain equal ingestion rates as the season progressed.

Annual mean grazing time did not differ begween SDG and SLG in 1984, but was significantly greater under SLG in 1985 (Table 2). Method by date interaction was significant for grazing time in 1985 (Table 3), and approached significance in 1984 ($P=0.06$). In 1984, grazing time was significantly less under SLG at the beginning of the grazing season. As the grazing season progressed, grazing time increased under both grazing methods, but did so to a greater degree under SLG. By the third period, no difference was detected in grazing time. In 1985, the method by date interaction occurred because grazing time tended to decrease as the season progressed under SDG, while it tended to increase under SLG. However, grazing time was significantly less under SDG throughout all 3 periods of the grazing season.

Because of the selective nature of livestock grazing, variations in canopy structure, determined by plant species, stage of maturity, and prior grazing affect ingestive behavior (Chacon and Stobbs 1976). The main behavioral response of cattle to the changes in canopy structure caused by defoliation was a decrease in bite size (Chacon et al. 1976, Chacon Stobbs 1976). Biting rate and grazing time increased to compensate for this decline in bite size (Chacon and Stobbs 1976). Apparently, increased ingestion rate, as found under SDG in 1985, allows a concomitant decrease in grazing time, which agrees with Chacon and Stobbs (1976). Because biting rate annual means did not differ in this study, changes in ingestion rate directly reflect bite size. The result was that time, and thus energy, expended to graze was reduced by SDG in 1985. Walker et al. (1986) found that mean grazing time was an hour longer under continuous grazing than under SDG (10.9 vs. 9.8 hrs.). Their values are remarkably similar to our 1985 results.

Mean daily forage intake was a mathematical product of ingestion rate and grazing time (Table 2). Because ingestion rate and grazing time were determined on 2 different sets of animals, the mean for each variable was used. The product was 1 date point for each sample date, with no valid measure of variability around that data point. Therefore, statistical analyses on these data would be inappropriate. These calculated intake values range from 1.3 to 2.6% OM of body weight. NRC (1976) recommendations for minimum DM intake, when converted to a percent of body weight basis, range from 2.3 to 2.9% DM to obtain weight gains comparable to those observed in this study. If calculated intake values are converted to a DM basis, assuming an average OM content of 90%, they range from 1.4 to 2.9% DM. Under these conditions, all values except intake under SLG in 1985 fall between 2.4 and 2.9% DM. These values, that are very similar to expectations based on NRC (1976) requirements, lend credibility to these calculated values as estimates of daily forage intake.

It appears that forage intake was largely a function of ingestion rate, with the compensatory response of increasing grazing time under SLG during 1985 having little effect on the decline in forage intake as ingestion rate declined. This agrees with conclusions of Stobbs and Hutton (1974) and Chacon and Stobbs (1976) that bite size is a better indicator of sward effects on intake than is grazing time.

The ingestive behavior and resultant forage intake responses may explain the differences in animal performance (Tables 1 and 2). This is in contrast to the lack of differences in diet quality (Table 2). In 1985, animals under SDG appeared to forage more efficiently, as evinced by a greater intake per unit time and less time (energy) expended grazing to gain a higher total daily forage intake. Apparently, sward characteristics that determine ingestive behavior can directly affect animal performance. Identifying these sward attributes might make it possible to design grazing management methods (SDG or others) to further improve animal performance. These relationships have been explored, and the results are presented in Olson et al. (1986).

Conclusions

In terms of animal performance, ADG was significantly greater under SLG during the latter half of 1983, no differences were detected during 1984, and the SDG animals gained significantly more weight throughout 1985. However, it is not possible to conclude that a trend in favor of SDG was developing over the 3-year period because there were several confounding factors, including cumulative grazing management effects and changes in grazing management.

Diet quality was the same under both treatments throughout the study. However, ingestion rate was significantly greater and grazing time was significantly lower under SDG in 1985, providing possible reasons for the differences in animal performance. Because of the inconsistent method by period interaction results there is little indication that SDG alters the seasonal dynamics of diet quality and ingestive behavior responses. Therefore, the hypothesis that SDG extends the season of nutritious forage was not supported.

Although SDG provided significant improvement in livestock weight gain by the end of the study that may translate into economic gain, caution should be exercised before SDG is widely recommended for crested wheatgrass ranges. Despite the apparent adequate plane of nutrition for animal growth found in this study pregnancy rates of heifers under SDG were 3.6 to 8.3 percentage units lower than heifers under SLG. Until causes for this difference are understood and can be overcome, use of SDG with reproductive livestock cannot be recommended. If it is assumed that the difference in animal growth can be maintained over time, then SDG may be a promising method for use with stocker cattle.

Livestock response appears to be very sensitive to the rapid changes in sward conditions as SDG paddocks are defoliated, as indicated by the increased performance in 1985 when the grazing period was a day shorter. This indicates that proper rate of rotation through paddocks is critical to successful maintenance or improvement of livestock performance. A subsequent paper will discuss daily changes in animal nutrition as paddocks were defoliated in this study. Further research to enlighten the mechanisms of plant animal interaction will be fruitful in improving SDG management, as well as grazing management in general.

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