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Seasonal Acceptance of Fourwing Saltbush by Sheep When Crested Wheatgrass is the Alternative

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Summary

Many sagebrush-grass ranges have been seeded to crested wheatgrass [*Agropyron desertorum* (Fischer ex Link) Shultes]. These ranges are generally nutritionally inadequate for sheep (*Ovis aries* L.), except for short grazing periods in the spring and fall. To increase production and diversity, particularly crude protein for late-season grazing, fourwing saltbush [*Atriplex canescens* (Pursch.) Nutt.] was planted in an existing stand of crested wheatgrass. Quantification of sheep forage preferences on these improved ranges aids in determining the length of the grazing season and the extent to which shrubs provide the supplemental nutrition required. This seasonal grazing study was conducted on a characteristic wheatgrass-saltbush, mixed-range pasture to determine sheep acceptance of fourwing saltbush when crested wheatgrass was the alternative available forage. Sheep preferences for grass and shrub in spring and winter were similar, averaging 84 percent grass and 16 percent shrub. Summer dietary preferences ranged from 69 percent to 93 percent grass and 7 percent to 31 percent shrub. Preference for fourwing saltbush was consistently lower than crested wheatgrass in all seasons. Sufficient amounts of the mixed pasture were grazed to reduce the need for supplemental feed, when compared to crested wheatgrass monoculture. The results of these grazing trials suggest fourwing saltbush can be useful in improving pasture nutrition for sheep in different grazing seasons.

Introduction

Sheep ranchers in the United States comprise the smallest, yet most dependent fraction of public land grazing permittees (Gentner and Tanaka, 2002). For sheep producers in the Intermountain Region, federal forage is critical for summer and early winter grazing (Gentner and Tanaka, 2002). Lower elevation sagebrush-grass ranges are commonly used for sheep grazing, especially in the early spring and throughout the winter. Limited carrying capacity of these ranges (Blaisdell and Holmgren, 1984) suggests sheep may need supplemental feed earlier in the grazing season due to decreased nutritional quality of the grasses.

Shrub-grass ranges may be a possible solution for improving summer and winter grazing. Unfortunately, some of these lands have been historically overgrazed resulting in the domination of perennial grasses by thick stands of shrub species (Provenza and Richards, 1984). Efforts to improve ranges have led to the seeding of 5 million ha of range with crested wheatgrass, often in monoculture (Rumbaugh et al., 1982; Pendery and Provenza, 1987). In recent years, planting a more diverse array of forage species has been a frequent approach to improve forage quality and extend the grazing period. One common practice worldwide has been to interseed crested wheatgrass ranges with palatable shrub species (Pendery and Provenza, 1987).

Appropriate supplementation levels for sheep foraging grass-shrub mixtures are difficult to determine due to variable preference for shrubs during different seasons. Several successes with exclusive feeding of fourwing saltbush have been reported. Fourwing saltbush has been introduced as winter-maintenance forage for small ruminants in Pakistan (Rasool et al., 1996). Fourwing saltbush is readily consumed by sheep, goats, and cattle (Rumbaugh et al., 1982; Atiq-ur-Rehman et al., 1990) when other feed is limited. In Iran, palatability of fresh cuttings of fourwing saltbush to sheep was found to be intermediate between prostate kochia [*Kochia prostrata* (L.) Shad.] and wild armoise (*Artemesia herba alba* Asso; Nemati, 1977). However, to completely fulfill dietary requirements, Otsyina et al. (1982) calculated fourwing saltbush would have to comprise a minimum of 56 percent of a sheep's daily intake. The preference of sheep for fourwing saltbush, when crested wheatgrass is the available alternative, is unknown.

Range sheep demonstrate preference by selecting among available forages to regulate nutrition (Launchbaugh and Provenza, 1991). If selection is quantified and the nutritional quality of vegetation available is known, ranchers may establish appropriate levels of supplemental feed or grazing management to compensate for nutritional deficiencies. Determining the seasonal contribution of fourwing saltbush to the range sheep diet will aid in estimating the length of the grazing season and formulating appropriate supplements for sheep grazing ranges composed of crested wheatgrass and fourwing saltbush.

This series of grazing trials was initiated to test the hypothesis that sheep preference for fourwing saltbush does not vary among seasons when crested wheatgrass is the alternative forage.

Materials and Methods

Study Site

The study was conducted at the Brigham Young University-Sam and Aline Skaggs Research Ranch, 14.4 km north of Malta, Cassia County, Idaho, in the Raft River Valley. The experimental site consisted of a 4-ha pasture in the NE 1/4 of the NW 1/4, Section 22, Township 11 South, Range 26 East (Salt Lake Baseline and Meridian). This 4-ha fourwing saltbush parcel was further divided into 10 pastures, each 0.4 ha in size. Preferences of sheep for individual plant species (crested wheatgrass and fourwing saltbush) and forage production were evaluated as influenced by season. Pastures were grazed in May, July, and December in 2000 and 2001.

At 1,340 m in elevation, the site receives an average of 22.8 cm of precipitation annually, with 45 percent as rain during the period April through June. The average daily temperature is 2 degrees C in January and 18.5 degrees C in July. Soils at the site are characterized in the Bahem silt loam series—fine-loamy, mixed, mesic, Xerollic calciorthids with a pH of 8.0 and a semi-hard pan layer at approximately 38 cm (Stevens, 1992). Crested wheatgrass seeding followed historic overgrazing of the site.

In 1985, existing shrubs were removed with 2,4-D (2,4-dichlorophenoxyacetic acid). In addition, 25 rows, 1.5-m wide, were mechanically treated to remove crested wheatgrass. Fourwing saltbush seedlings were transplanted at 1.5-m spacing within the cleared strips. This resulted in 3-m wide strips of undisturbed grass and 1.5-m wide rows of transplanted shrubs. After a two-year establishment period, cattle were allowed to graze the area up to 50 percent utilization in a series of palatability trials. At the commencement of our study, saltbush was mature and had not been grazed during the previous 10 years.

Pastures were randomly assigned by intended season of use. Each grazing season consisted of three replicates. Because the same pasture randomization scheme was used in both years, changes in forage production from one year to the next that may have resulted from the season of initial defoliation could be accounted for.

Vegetation Sampling

Vegetation samples were taken in each pasture to determine current year forage production prior to sheep grazing. Ten transects, spanning the entire length of each pasture, were placed at equal intervals. At each interval, one transect was placed in the untreated grass strip and one in the transplanted shrub row for a total of five transects in each forage class. A sampling frame (1 m^2) was used to sample vegetation along each transect.

In grass strips, the current annual growth in the sampling frame was clipped to stubble height of 2.5 cm at a previously determined random point along each transect. Old growth, because it was easily recognized, was removed from the samples. Grasses between transplanted shrubs along the shrub row transects were sampled similarly.

Shrub sampling consisted of clipping one-fourth of the current annual growth from the shrub located closest to a random point along each transect. Height and crown measurements were taken prior to clipping each shrub. All samples were weighed in the field immediately after clipping and set out to air dry while awaiting transport to the laboratory. Fifteen to 30 green weights were recorded for each vegetation class each grazing season. Dry weights were recorded in the laboratory following a minimum of 24 hr in a 65 degrees C oven and annual forage production was expressed in kg ha^{-1}.

To estimate the relative value of these species in the diet of sheep, we utilized the extensive nutritional data derived from samples taken at this site at two-week intervals from May through December by Memmott (1995). These data were assumed to be representative for grazable vegetation.

Sheep Response Measurements

The U.S. Sheep Experiment Station near Dubois, Idaho (Clark County) provided 30 randomly selected, white-faced, dry, non-pregnant range ewes for each of the six grazing periods (180 ewes total). The sheep were Columbia-Targhee crosses accustomed to foraging on Idaho rangelands (Gade and Provenza, 1986). For each grazing period, sheep were randomly divided into three groups of 10 and distributed among the three replicated pastures previously designated for that grazing period (May, July, or December). Sheep were individually identified by different colors of tape secured around their necks as well as unique numbers painted on their backs.

At the beginning of each grazing period, at least three days were allotted for sheep to become familiar with pasture characteristics. Even though they had previous exposure to both forages, this adaptation period was intended to reduce social factors that reportedly override food preferences of sheep in a novel environment (Scott et al., 1996). During this adjustment period, field technicians spent at least six hours a day among the sheep to accustom them to the presence of humans during observation (Martin and Bateson, 1986).

Recorded observation commenced on the designated day at dawn. One unconcealed person observed sheep in each pasture for 30 minutes of continuous grazing, two times each day, in the morning at dawn and evening an hour prior to dusk. The actual time of day varied with the season.

Either focal-animal or scan sampling methods were used to estimate sheep preference for available forage. Focal-animal sampling, in the form of bite counts, estimates the percentage of bites taken in each available forage class, as well as the percentage of time spent grazing in each class (Altmann, 1974; Martin and Bateson, 1986; Lehner, 1987). Each of six randomly selected ewes was observed for a five-minute period of undisturbed, continuous grazing each morning and evening session. The total number of bites of each forage class was recorded using a hand-held tally device. Bites were classified as either grass or shrub. The event of taking a bite was defined as the visible and audible prehension of food. If sheep paused or went out of sight, the clock was stopped and started again when activity resumed or the observer changed positions. This method was used successfully in the 2000 spring and summer trials, in which the get-acquainted period worked well and we were able to get within 1 to 2 m of the dry ewes without disturbing their grazing. The winter 2000 grazing period was not so successful, however, since the sheep delivered were flighty and unapproachable by the investigators. Due to the inherent difficulties in using this method of observation with unruly animals (Martin and Bateson, 1986; Kronberg and Walker, 1999) we decided to switch to scan sampling in 2001 to prevent the loss of further data due to state of the sheep.

Instantaneous scan sampling estimates the percentage of time spent grazing each forage class (Tyler, 1979; Martin and Bateson, 1986; Lehner, 1996). This method also allows a record of behavioral synchrony among gregarious animals to be kept. An instantaneous scan of the entire group of 10 sheep in each pasture was made at one-minute intervals for a 20-minute period in the morning and evening of each day. The state of each animal at that instant, eating grass or shrub, was recorded.

Sheep Selection, Data Presentation, and Statistical Analyses

Random selection of three new groups of 10 sheep from the population for each grazing period was done to avoid introducing bias as the sheep aged over the two-year period. It is recognized that bias may have been introduced by the method we followed, but we concluded that randomly selected groups for each grazing period would represent the population and would not introduce as much bias as would aging. A second reason for following this protocol was the impracticality of trying to maintain the same 30 head of ewes throughout the two-year experimental period.

Preference indices were tabulated based on a ratio of diet composition in 2000 and time spent in each forage class to availability of each species on the range (% composition) in 2001. A value greater than 1.0 indicated a preference, whereas values less than 1.0 indicated avoidance by the animals (Ali and Sharrow, 1994).

Data were analyzed within years using SAS procedures for general linear models (Littell, et. al., 2002).

Results and Discussion

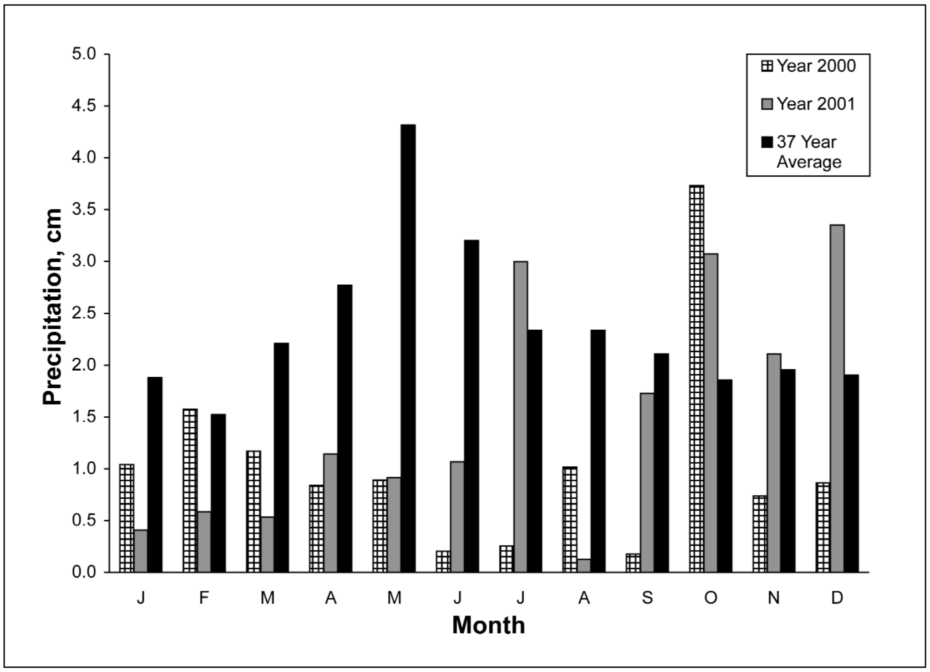
Except for winter 2000, data were successfully collected for each planned grazing period. The sheep provided for winter 2000 were extremely flighty and were unapproachable. Satisfactory alternative plans for animal preference measurements were not determined in time to collect data for this period.

Seasonal Forage Production and Sheep Preference

Sporadic growing conditions during the study make it difficult to describe trends in forage production. Generally, forage production was below normal. Low potential and actual yields at this site may be due to a combination of below-average precipitation during the growing season (Figure 1) and decadence, i.e., stand age and the 10-year rest period prior to study initiation.

Forage Production. Total biomass (dry-weight basis) ranged from 332 kg ha^{-1} to 688 kg ha^{-1} across the two years (Table 1). Biomass available for each sheep was sufficient, though not plentiful, in each grazing season (Table 1). Forage class distribution was somewhat variable within years across pastures with grasses making up 42 percent to 65 percent of the total biomass in 2000 and 53 percent to 87 percent in 2001. Crested wheatgrass yielded an average of 324 kg ha^{-1}. A 35-yr study conducted in the same valley reported an average crested wheatgrass yield of 560 kg ha^{-1} (Sharp et al., 1992) when grown in monoculture. A primary factor in successful production of seeded crested wheatgrass stands is precipitation levels from April to June (Rauzi, 1975; Leyshon and Campbell, 1992). Precipitation during these three

Fig. 1. Monthly precipitation at the Brigham Young University-Sam and Aline Skaggs Research Ranch near Malta, Idaho, during 2000 and 2001 compared to the 37-year average in the area.



months accounted for 72 percent of the variability in crested wheatgrass production over a 35-year period (Sharp et al., 1992). During our study, precipitation levels during this period, in both years, were less than 35 percent of the 37-year average for the area (Figure 1). Within years, grass growth was related to precipitation patterns—decreasing from spring to summer in 2000, and increasing from spring to summer in 2001, when above-average precipitation occurred in July.

Bleak and Plummer (1954) reported seeded crested wheatgrass pastures yielded 55 percent less biomass by the ninth year of age due to decadence. The current study was conducted in a 25-year-old stand. Crested wheatgrass when grown in association with fourwing saltbush, compared to grass grown in monoculture, has been reported to produce increased dry matter yields (Rumbaugh et al., 1982; Pendery and Provenza, 1987). In our study, grasses in shrub rows did not have higher average yields than grasses in grass strips, suggesting all grasses were within a beneficial proximity of the shrubs.

Shrubs yielded an average of 239 kg ha^{-1}. Potential production of fourwing saltbush as high as 1,480 kg ha^{-1} has been reported (Rumbaugh et al., 1982). In addition to lower than normal rainfall during the study period, the generally low shrub production may be due, in part, to the 10-year period without grazing. Price et al. (1989) reported saltbushes rested more than one year began to decline in growth and that dry matter yields of shrubs protected for 20 years were similar to those subjected to continuous grazing. Pieper and Donart (1978) reported fourwing saltbush shrubs protected for four years, or not browsed at all, did not produce basal leaders because terminal buds were left intact. In the current study, shrub height ranged from 12 to 162 cm with an average of 94 cm. Crowns ranged from 8 to 343 cm with an average of 144 cm. The average canopy volume calculated was 479,328 cm^3. The bulk of the new growth was concentrated near the top of the canopy, and sheep were only able to graze peripheral growth. New growth above a height of 110 cm was considered inaccessible to the sheep (Mbabaliye et al., 1999).

Greater variation in growth production occurred in saltbush than in grasses. Time of initial defoliation, as well as precipitation patterns, may account for much of the growth variation. In general, saltbush yields increased from spring to summer within years (Rumbaugh et al., 1982) and decreased in all treatments between years (Buwai and Trlica, 1977).

Spring Grazing Periods 2000 and 2001. The highest grass yields were recorded prior to the first spring grazing trail. The lowest forage amounts were recorded in the same spring-grazed pastures the following year (Table 1), a decline in grass production of 36 percent from 2000 to 2001. Miller et al. (1990) also observed defoliation during mid May through early June reduced crested wheatgrass production by 50 percent to 55 percent in the subsequent year.

Similar to grasses, the lowest average shrub yield of 43 kg ha^{-1} was recorded in the spring-grazed pastures prior to grazing the second year (Table 1). This 82 percent decrease in production from 2000 to 2001 indicates little regrowth occurred after spring defoliation in 2000. Similar to this, Trlica and Cook (1971) and Buwai and Trlica (1977) have reported little regrowth in saltbush heavily defoliated during this same growth period (about 10 May). Price et al. (1989) suggested browsing of fourwing plants before leader bases become woody results in the

Table 1. Total biomass production of crested wheatgrass and fourwing saltbush and biomass available per day for each of 10 sheep.

Grazing Period	Grass[a]	Shrub[a]	Total	Per Pasture	Per Sheep-day
	(………………	kg ha^{-1}	………………)	(…………	kg…………)
Spring 2000	449^{a}	240^{a}	688^{a}	172	2.2
Spring 2001	289^{b}	43^{b}	332^{b}	83	1.4
Summer 2000	287^{b}	401^{a}	687^{a}	172	2.5
Summer 2001	297^{b}	252^{a}	548^{ab}	137	2.7
Winter 2001	298^{b}	261^{a}	559^{ab}	140	1.8

[a] Means within a column followed by the same letter do not differ, P = 0.05

(Student-Newman-Keuls Multiple-Range Test) entire leader being pulled off, leaving few axillary buds intact from which regrowth may occur. Trlica et al. (1977) reported that 14 months of rest was not sufficient for recovery of heavily defoliated saltbush. This suggests the 11 months of rest in our study between the 2000 and 2001 spring grazing period may have been inadequate for these shrubs to reach production levels in 2001 similar to those attained in 2000.

Summer Grazing Periods 2000 and 2001. Unlike pastures defoliated in spring, pastures grazed in summer showed no differences in 2000 and 2001 biomass production (Table 1). This result supports the finding of Leyshon and Campbell (1992) that highest-mean yields of crested wheatgrass occur when the first defoliation is between June and July.

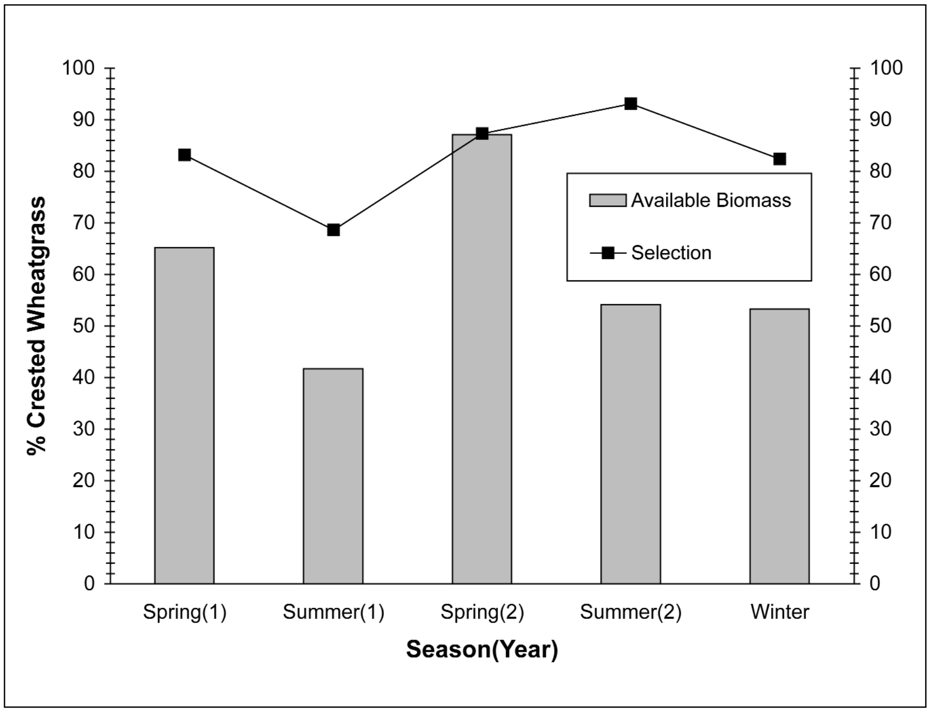
The highest shrub yield (401 kg ha-1) was recorded in the summer-grazed pastures prior to grazing initiation in 2000 (Table 1). Saltbush biomass in summer-grazed pastures decreased 37 percent ($P \leq 0.10$) from 2000 to 2001 (Table 1). Trlica et al. (1977) showed defoliation of fourwing saltbush near maturity stage to be most detrimental to subsequent growth, even after a 14- to 26-month rest period.

Winter Grazing Period 2001. Grass production in winter-grazed pastures was not significantly different from spring 2001 and summer-grazed pastures (Table 1). Biomass was not recorded for the failed winter trial of 2000; however, 10 sheep grazed these pastures for a similar number of days as the other trials. In 2001, shrub production by these winter-grazed pastures did not differ from production in pastures grazed in the other seasons (Table 1).

Sheep Preference. As in similar studies (Reppert, 1960; de Vries and Daleboudt, 1994; Bartolome et al., 1998), sheep preference for grass or shrub was related to their respective availability. In this study, preference for grass was consistently higher than the proportion of available biomass (Figure 2) and preference for shrub was lower than the proportion available (Figure 3), similar to observations by de Vries and Daleboudt (1994).

In 2000, sheep spent from 69 percent to 83 percent of their time grazing grass (Figure 2). Preference indices computed for each season within 2000 indicated a strong preference for grass over shrub (Table 2). In 2001, sheep spent from 82 percent to 93 percent of their time grazing grass (Figure 2). Unlike 2000, preference indices in 2001 did not consistently indicate a preference for grass in all grazing seasons (Table 2) since preferences for grass and shrubs were equal in spring 2001.

Fig. 2. Percentage of sheep selection devoted to crested wheatgrass compared to the percentage of available biomass composed of crested wheatgrass.



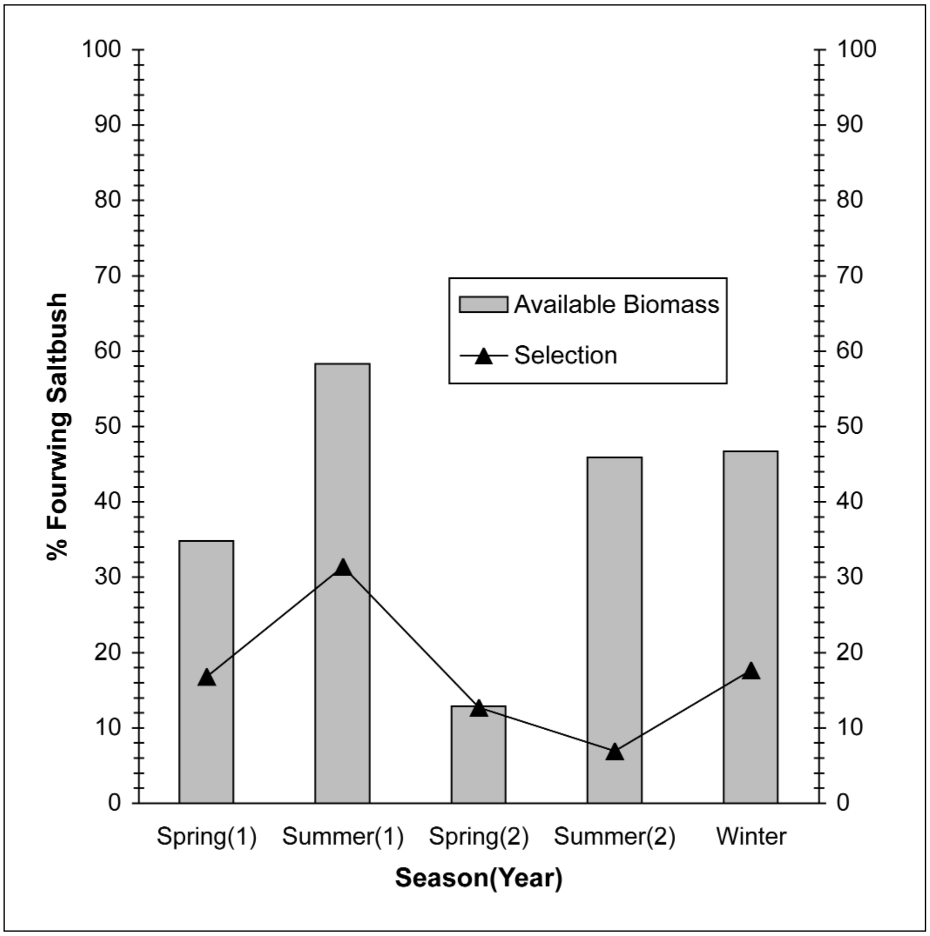
Summer grazing exhibited the most variable preference for shrubs in this grazing trial (Figure 3). Preference in summer 2000 and summer 2001 were different ($P \leq 0.01$). Within 2000, preference for shrub increased nearly 50 percent from spring to summer. When shrub production was at its highest in summer 2000, preference for shrub peaked at 31 percent. Eleven months later in summer 2001, the lowest shrub intake was recorded at 7 percent, a decrease of 60 percent from spring to summer and 24 percent from 2000 summer levels. Biomass availability decreased 21 percent during the same period. At that time (summer 2001), grass preference increased by 36 percent (Figure 2). Sheep "avoidance" of shrubs, as indicated by the computed preference indices for summer 2001, may be due to poor shrub condition or inability of the sheep to reach the higher crown growth. Despite the apparent improved growing conditions, sheep spent 9 percent less time grazing grasses and 8 percent more time browsing shrubs in winter 2001 than in summer 2001 (Table 2).

Table 2. Relative preferences indices of sheep for crested wheatgrass and fourwing saltbush.

Grazing Period	Crested Wheatgrass	Fourwing Saltbush
	(……………Preference Indices[a]	……………)
Spring 2000	1.24	0.53
Spring 2001	1.00	1.00
Summer 2000	1.89	0.36
Summer 2001	1.72	0.15
Winter 2001	1.55	0.38

[a] Indices greater than 1 indicate a preference for a forage; equal to 1, no preference or random selection; and less than 1, avoidance (Ali and Sharrow, 1994)

Fig. 3. Percentage of sheep selection devoted to fourwing saltbush compared to the percentage of available biomass composed of fourwing saltbush.



During winter 2001, sheep dug through the snow to reach the green portions at the base of bunchgrasses. Harrison and Thatcher (1970) reported sheep dug through snow for needleand-thread grass (*Stipa comata* Trin. and Rupr.), but basically avoided more readily available sagebrush. Even though sheep increased their preference of fourwing saltbush, compared to other times of the year, preference was still approximately 82 percent for grass and 18 percent for shrub (Table 3). The lower preference for shrub during this period supports the suggestion that the digestibility of fourwing saltbush during dormancy may be lower than grasses (Shoop et al., 1985).

The initial hypothesis of this study that preference for fourwing saltbush did not differ when crested wheatgrass is the alternative forage was rejected. Differences among the grazing seasons existed ($P \leq 0.05$) within each year (Tables 2 and 3). Selection of fourwing saltbush more than doubled from spring to summer 2000 and selection among the three grazing seasons in 2001 also differed ($P \leq 0.05$).

Seasonal Forage Nutrient Content

Using previously published data (Memmott, 1995) the comparative nutritive values of crested wheatgrass and fourwing saltbush were evaluated by estimating their apparent ability to supply nutritional requirements of sheep. These requirements are categorized according to the main physiological functions of maintenance, flushing and breeding, early to mid gestation, late gestation, early lactation, and late lactation (Cook, 1971). Metabolizable energy, crude protein, calcium (Ca), and phosphorus (P) are most often limiting factors on rangelands (NRC, 1985). Similar to other forage and browse plants, crested wheatgrass and saltbush are high in nutrients during the first part of the growing season, but these progressively decline with maturity as lignification occurs (Figures 4 and 5).

Crested wheatgrass, by itself, did not satisfy energy and protein requirements of ewes at any time during the season (Figure 4). However, crested wheatgrass contained enough Ca and P in all phenological stages of development to meet ewe requirements in each stage of the sheep production cycle (Figure 5; Murray, 1984).

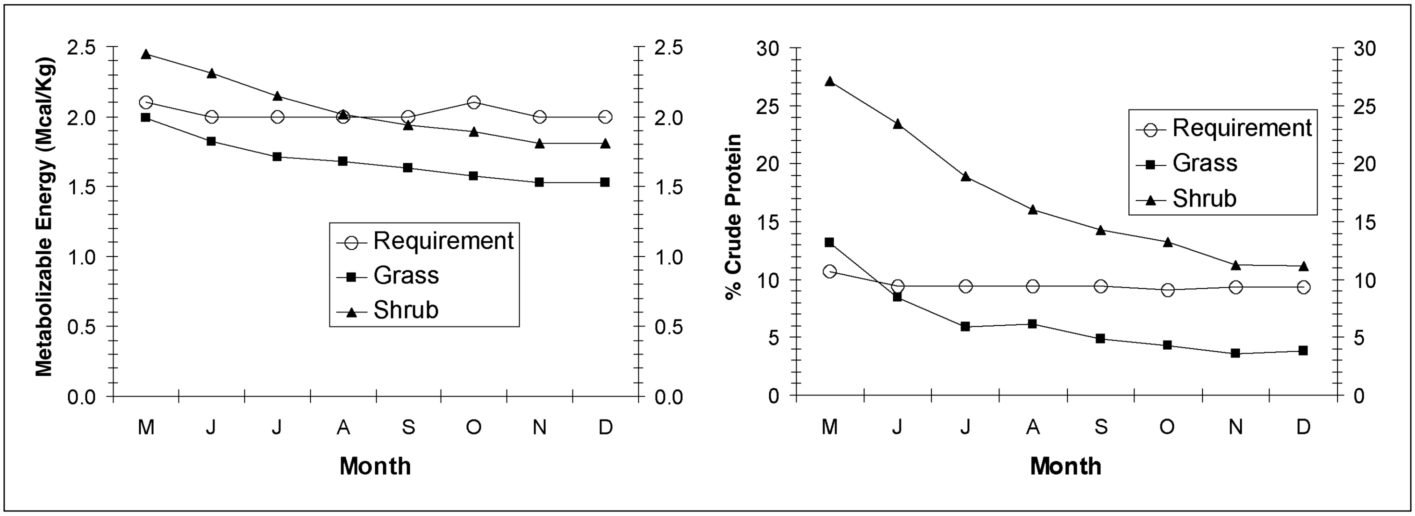
Fourwing saltbush contained higher nutrient levels than crested wheatgrass at all sampling dates. At each phenological stage of development, saltbush met all nutrient requirements for sheep except for metabolizable energy, which became deficient in late summer (Figure 4). These results support those in other studies (Chatterton et al., 1971; Schweitzer et al., 1993). Nutrient values for December may be extrapolated for January and

Table 3. Average number of bites taken per minute or the average number of sheep grazing each forage class each minute.

Grazing Period	Number of Bites			Grazing Period	Sheep Foraging on		
	Grass	Shrub	Total		Grass	Shrub	Total
	(.........bites min^{-1}.........)				(.........Sheep min^{-1}.........)		
Spring 2000	104^{a}	20^{b}	124^{b}	Spring 2001	8.7^{b}	1.3^{b}	10
Summer 2000	107^{a}	45^{a}	152^{a}	Summer 2001	9.3^{a}	0.7^{c}	10
Winter 2000	—	—	—	Winter 2001	8.2^{c}	1.8^{a}	10

^{ab} Means within a column followed by the same letter do not differ, P=.05 (Student-Newman-Keuls, Multiple-Range Test).

Fig. 4. Metabolizable energy (left) and protein content (right) of crested wheatgrass and fourwing saltbush. Metabolizable energy and protein content data collected by Memmott (1995) and shown here compared to requirements of 70-kg ewes (NRC, 1995).



February as little change occurs in the nutritive value during plant senescence (Oelberg, 1956).

The estimated ability of crested wheatgrass and fourwing saltbush to supply nutrient requirements of sheep during different times of the year is summarized in Table 4. Under the conditions experienced in this study, deficiencies in protein were most pronounced in the winter when 4.21 percentage points, 45.3 percent of protein required, must come from supplement. Requirements for metabolizable energy would not have been met for any of the physiological stages of the sheep in any of the grazing periods.

Need for Supplementation

Ueckert et al., (1990) reported ewes grazing fourwing saltbush-crested wheatgrass pastures without supplementation have low performance. However, this same study determined performance of ewes grazing fourwing saltbush-grass combination pastures was superior to performance of ewes grazing grass monocultures without supplementation.

In the current study, sheep did consume shrub, and at the prevailing nutrient levels (Memmott, 1995) and dietary proportions, the need for supplementation could be reduced, although not eliminated. Considering an average ewe live weight of 70 kg and rearing a single lamb as given in NRC data (1985), simple Pearson-square calculation of nutrients required would reduce the need for supplementation when shrubs are incorporated into the diet (Table 4). A need for crude protein supplement would have occurred in summer and winter 2001 grazing periods only; but the need for additional protein could be reduced by 14 percent and 25 percent, respectively.

Table 4. The estimated contribution of grass and shrub to fulfilling sheep nutrient requirements for a 70 kg ewe with a single lamb at different stages of production. Calculations are based on the requirement (NRC, 1985), nutrient content of forage (Memmott, 1995) and selection of either grass or shrub measured each grazing period.

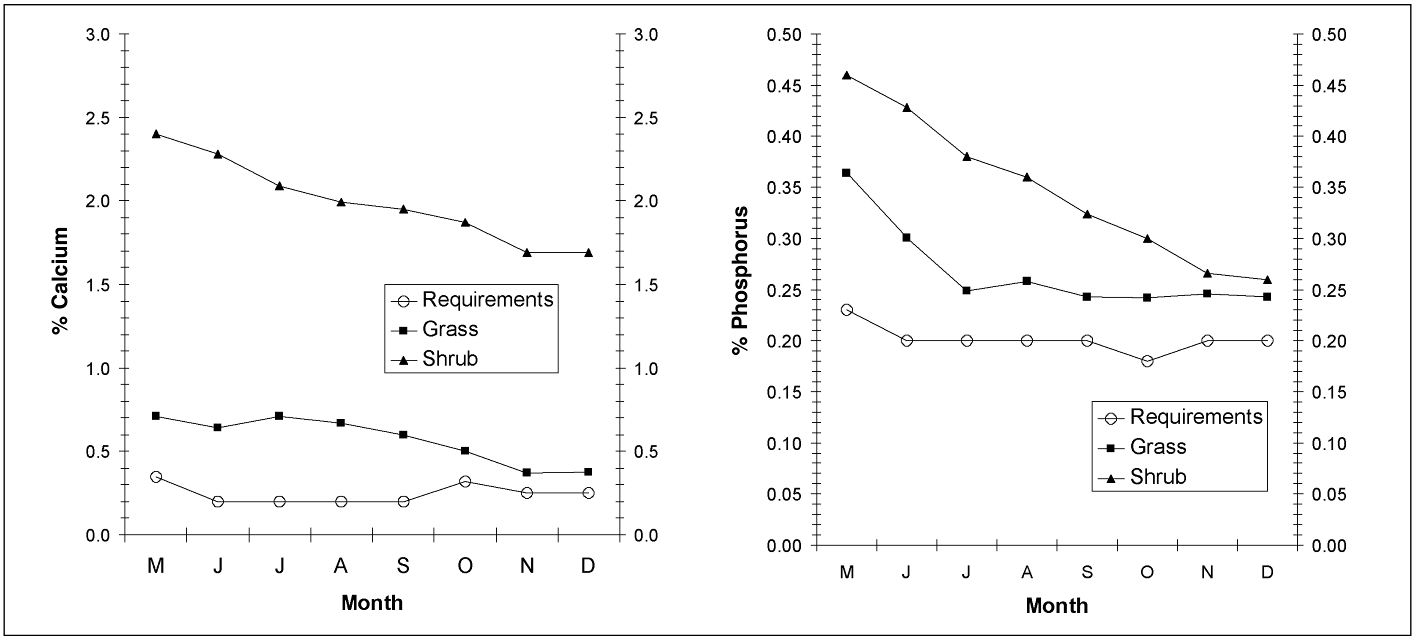
Production Stage Requirement	Grass	Shrub	Deficient
	% of Required Crude Protein Derived from[a]		
Early Lactation 13.4			
Spring 2000	11.65	4.57	0.00
Spring 2001	11.48	3.45	0.00
Maintenance 9.42			
Summer 2000	4.06	5.94	0.00
Summer 2001	5.51	1.31	2.60
Early Gestation 9.30			
Winter 2001	3.12	1.97	4.21
	Metabolizable Energy (Mcal kg^{-1}) Derived from[a]		
Early Lactation 2.40			
Spring 2000	1.66	0.41	0.33
Spring 2001	1.74	0.31	0.35
Maintenance 2.00			
Summer 2000	1.17	0.68	0.15
Summer 2001	1.59	0.15	0.26
Early Gestation 2.00			
Winter 2001	1.26	0.32	0.42

[a] The contribution of each forage class to fulfilling sheep dietary requirements and any needed supplement was calculated thusly:

Shrub contribution in meeting protein needs = ((% shrub in diet)/100) ((% protein in shrub)/100) (100). Grass contribution was calculated in a similar manner.

Grass contribution to metabolizable energy = ((% grass in diet)/100) (metabolizable energy in grass), etc.

Fig. 5. Calcium (left) and phosphorus (right) content of crested wheatgrass and fourwing saltbush. Nutrient content data were collected by Memmott (1995) and are shown here compared to the calcium requirements of 70-kg ewes (NRC, 1985).



An energy supplement was needed in every trial, but the requirement would have been reduced by 8 percent to 34 percent, depending on the grazing season. Calcium and phosphorus supplements would not have been required. Levels of supplementation required to meet the nutritional needs of sheep grazing a crested wheatgrass-fourwing saltbush range may have been overestimated since sheep have the ability to selectively choose the more nutrient-rich portions of plants (Hanley, 1982; O'Reagain, 1993; Ramirez-Perez, 2000), which may not have been as meticulously sampled by humans for nutrient analysis (Wilson, 1956).

Conclusions

Productivity and length of grazing season on crested wheatgrass range may be improved by establishing high-quality shrubs in perennial grass monocultures. Quantifying sheep acceptance and intake levels of these shrubs when grass is available is necessary for calculation of grazing season length and the formulation of appropriate supplements.

Despite the relatively high nutrient content of fourwing saltbush and the nearly uniform distribution of grass and shrubs in this study, sheep consistently preferred crested wheatgrass to fourwing saltbush. However, addition of fourwing saltbush to crested wheatgrass monocultures can improve the diet quality of range sheep, extend the grazing season, and reduce, but not eliminate, the need for supplementation in the spring, summer, and winter grazing seasons evaluated.

Preference or selection of fourwing saltbush differed among grazing seasons each year.

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