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Utilization of globemallow *(Sphaeralcea)* taxa by sheep

M.D. RUMBAUGH, H.F. MAYLAND, B.M. PENDERY, AND G.E. SHEWMAKER

Authors 1 and 3 are retired research geneticist and range scientist, respectively, USDA-ARS Forage and Range Research Laboratory, Logan, Ut. 84322; 2 and 4 are soil scientist and biological technician (soils), respectively, USDA-ARS Snake River Conservation Research Center, Kimberly, Ida. 83341.

Abstract

Globemallows (*Sphaeralcea* spp.) are well adapted to semiarid and arid environments. They are potentially useful as the forb component of seeding mixtures for rangeland improvement in the western states. However, the degree of acceptability of globemallow forage to livestock has not been well established. We tested 13 globemallow accessions representing 4 species and compared their utilization by sheep *(Ovis aries)* with that of crested wheatgrass [*Agropyron cristatum* (L.) Gaertn. × *A. desertorum* (Fisch.) Schult.] and alfalfa (*Medicago sativa* L.) during fall 1988 and 1989, and spring 1990 and 1991. Alfalfa consistently produced more forage per plant than wheatgrass or globemallows, and a greater portion of the alfalfa was eaten than of the other species. Sheep utilized wheatgrass more than globemallows in the fall, but the converse was true during spring pasturing. Over the 4 years, sheep ate similar proportions of wheatgrass and individual globemallows. The percentage of *S. coccinea* (Pursh) Rydb. forage consumed equaled that of crested wheatgrass or alfalfa in the fall but did not equal the percentage of alfalfa consumed in spring. However, *S. coccinea* produced much less total forage than the other species evaluated. Pre-grazing plant dry weight, dry matter content, and the occurrence of rust caused by *Puccinea sherardiana* Körn were negatively associated with globemallow utilization. Over-winter mortality of grazed globemallow exceeded that of ungrazed plants. Crested wheatgrass and alfalfa stands were not reduced by grazing. Globemallows are acceptable, but not highly preferred, forbs which can be seeded in environments where alfalfa and other more desirable species are not adapted.

Key Words: ***Agropyron*, alfalfa, crested wheatgrass, forage *Medicago*, pasture, range**

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Globemallow *(Sphaeralcea)* species are indigenous in many of the same areas in which crested wheatgrass (*Agropyron* spp.) is adapted and are logical candidates for inclusion as a forb component of seed mixtures (Pendery and Rumbaugh 1986). The responses of globemallows to grazing have not been extensively documented. *S. coccinea* stands increased in density under severe grazing during 7 years in which annual precipitation ranged from 109 to 658 mm (Hyder et al. 1975). Grazing in May or June was most detrimental, and grazing in August or December was least harmful to that species. Trlica et al. (1977) found that *S. coccinea* was resistant to frequent, intensive clippings. However, Menke and Trlica (1981) noted that *S. coccinea* maintained carbohydrate reserves at a relatively low level for most of the growing season, perhaps making the plant highly dependent on leaf area for replenishment during a short period in the fall.

Globemallows are considered moderately palatable to sheep but less palatable to cattle (Parker 1983, Shaw and Monsen 1983, Stevens et al. 1985, Wasser 1982). Hyder et al. (1975) reported that scarlet globemallow *(S. coccinea)* was an important dietary component of insects, small mammals, pronghorn (*Antilocapra americana* Ord), sheep, and cattle. Because of its abundance and importance in animal diets, they rated scarlet globemallow second only to blue grama [*Bouteloua gracilis* (H.B.K.) Griffiths] as a forage plant on some of the upland soils of their Central Great Plains study site. Similar results were obtained in a cattle grazing study on a semidesert rangeland in southern New Mexico by Fatehi (1986). *S. coccinea* was 1 of 4 key forage species for both sheep and pronghorn on the desert prairie subtype of southern mixed prairie range in New Mexico (Howard et al. 1990). Other globemallow species are known to be grazed by sheep, goats *(Capra hircus)*, and bighorn *(Ovis canadensis)*, (Kearney and Peebles 1960). *S. angustifolia* formed 23% of the diet of goats on desert grassland in northern Mexico during April (Mellado et al. 1991). Nevertheless, rancher experience has been variable, with some indicating very low utilization by either sheep or cattle.

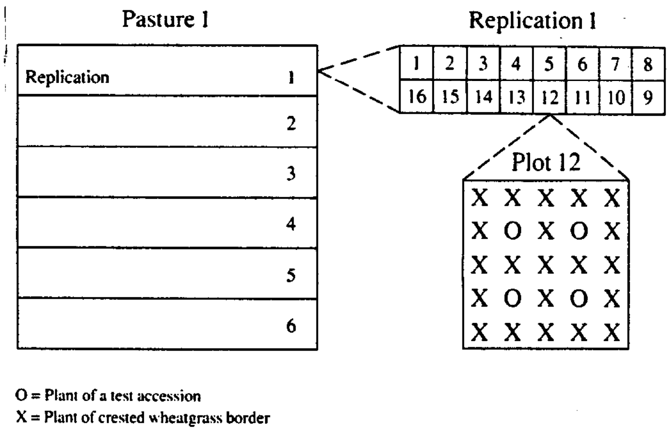

Fig. 1. Diagram of 1 of the 4 pastures in the grazing trial at Kimberly, Idaho, with expanded views of 1 replication in a pasture and of 1 plot in a replication. Each of the 4 pastures contained 6 replications with 16 plots in each replication. Each plot contained 4 plants of 1 of the 16 accessions (14 globemallows, alfalfa, and crested wheatgrass) to be tested plus border plants of crested wheatgrass.

Our objectives were (1) to compare the forage production of 14 globemallow accessions representing 4 species to that of alfalfa and crested wheatgrass, (2) to compare the utilization of globemallow forage by sheep to that of alfalfa and crested wheatgrass, and (3) to determine the relationship of morphological and physiological attributes of globemallows to the degree of forage utilization by sheep.

Materials and Methods

Establishment of Pastures

Seeds of 14 globemallow accessions representing 4 species indigenous to the Intermountain region (*S. coccinea, S. grossulariifolia, S. munroana,* and *S. parvifolia* A. Nels.) plus 'Hycrest' crested wheatgrass [*A. cristatum* (L.) Gaertn. × *A. desertorum* (Fisch.) Schult.], (Asay et al. 1985) and 'Spredor 2' alfalfa *(Medicago sativa* L.) seeds were planted in a sand/peatmoss mixture in containers in the greenhouse. Three-month-old plants were transplanted to the field 18 through 20 April 1988. The site was on a Portneuf silt loam (coarse, silty, Durixerollic calciorthid) soil near Kimberly, Ida. Plant-rooting depth on this site varies from 30 to more than 100 cm and precipitation averages 230 mm annually. Plants that did not survive transplanting were replaced in May 1988. Plants that died during the subsequent winter were replaced 4 and 5 April 1989. Subsequent to establishment, one of the accessions grown from a purchased lot of globemallow seed was found to be a mixture of 2 species and results are not shown for that accession.

Experimental Design

The experiment had 4 pastures each of which contained 6 replications of the 16 plant accessions in a randomized complete block design (Fig. 1). Each plot consisted of 4 plants of an accession separated by single plants of Hycrest. Each plot was separated from adjacent plots by 2 plants of Hycrest. All plants were spaced 1.0 m apart within and between rows. Pasture 4 was used only as a sheep conditioning area to accustom the animals to the experimental environment and forage and data were not obtained from pasture 4. Replication 6 was harvested for shoot biomass immediately prior to and after grazing of replications 1 to 5 in each pasture. Replications within a pasture were not separated by fencing. Pastures were enclosed by electric fences with 4 wires positioned at 15, 30, 51, and 76 cm heights. Water was provided in 4–23 liter plastic tubs located next to the fence on each side of each 43 m × 53 m pasture.

Grazing Procedures

Ten to 15 range ewes with previous rangeland grazing experience were introduced into the conditioning pasture each grazing period and permitted to adjust to the experimental site for approximately 4 days. The other pastures were then grazed in sequence by the same animals for as long as required to consume some foliage from nearly all globemallow accessions. Different animals were used each year. Pastures were grazed in the fall of 1988 and 1989, and spring of 1990 and 1991. The timing, duration, and intensity of grazing varied with the amount of seasonally available forage (Table 1).

Plant Measurements

Trichome densities were determined on each plant in replication 1 of pasture 3 prior to grazing. A piece of transparent plastic tape was pressed firmly against the lower surface of the youngest mature leaf of each plant. The trichomes adhered to the tape when it was removed from the plant. The tape was fastened to a glass microscope slide and all trichomes counted in each of five 6.5 mm^2 fields per slide at 25X magnification. Trichome length also was measured at 25X magnification.

The phenology of each test plant in all replications was scored by

Table 1. Grazing management.

Grazing period		Pasture	Date grazing use initiated	Date grazing use terminated	Sheep-days	forage use[1]
					(number)	(%)
Fall 1988		1	8 October	12 October	56	63
		2	12 October	15 October	42	65
		3	15 October	19 October	56	58
	Mean				51	62
Fall 1989		1	4 October	7 October	42	62
		2	9 October	11 October	28	64
		3	11 October	14 October	42	50
	Mean				37	59
Spring 1990		1	30 April	3 May	39	84
		2	4 May	6 May	26	83
		3	7 May	10 May	39	80
	Mean				35	83
Spring 1991		1	10 May	12 May	30	79
		2	12 May	15 May	45	78
		3	15 May	17 May	30	79
	Mean				35	79

[1]Based on consumption of test plants only.

an experienced observer just prior to initiation of grazing. The scale was 1 = dormant, 2 = vegetative growth only, 3 = flower buds present, 4 = flowers open, 5 = globes formed, and 6 = seed shattering. Phenology scoring of grass and alfalfa followed this same system except that stage 5 corresponded to seed set.

A natural infestation of rust incited by *Puccinea sherardiana* Körn occurred on the globemallows in September and October 1989. This also was scored just prior to initiation of grazing using a score based on the percentage of the total mature leaf area damaged by the pathogen. The scale ranged from 0 = no infection and 1 = a trace to 10% of the leaf surface damaged to a maximal value of 9 = 91 to 100% of the leaf surface damaged.

Plant size (shoot biomass) was assessed visually prior to grazing on a modified 0 to 5 scale with 0 indicating no vegetative growth and 5 indicating growth of the larger plants. A single plant representing each score class was selected for each accession and photographed. The photographs were used as references when scoring plants. Scores were adjusted by 0.25 or –0.25 increments when a plant did not exactly match the plant in the appropriate reference photograph. Plants were scored in pastures 1 through 3 by 2 observers in 1988 and by 5 observers in subsequent years. Plants in replication 6 of the pastures also were scored for size just prior to grazing.

Two randomly selected plants of each plot in replicate 6 of each pasture were harvested just prior to grazing replications 1 to 5 of that pasture and the remaining 2 plants of each plot were harvested just after grazing of that pasture. Plants were clipped at a stubble height of 5 cm in 1988 and 10 cm in subsequent years. Shoot biomass samples were dried in a forced draft oven at 60° C and weighed.

After grazing, all plants in replications 1 through 5 also were clipped at a 5 cm height in 1988 and at a 10 cm height in subsequent years. All samples were oven-dried (60° C) prior to weighing. Quadratic regression equations were computed for each accession at each harvest using shoot weights of plants in replication 6 of each pasture as the dependent variable and the corresponding mean-size scores as the independent variable. Oven dry weights of plants in replications 1 through 5 at the time of grazing were then estimated using the appropriate quadratic function for each accession and plant size scores as the independent variable. Post-grazing plant dry weights were subtracted from the estimated pre-grazing weights to compute the amount of plant tissue consumed and percent consumption.

Utilization of fine stems (<2 mm diameter) and leaves was independently scored by ocular estimation after grazing had been completed. Four observers scored each plant on a scale which ranged from 0 = no use to 5 = 100% use. The procedure was similar to that used by Johnston (1988a, 1988b) to assess palatability of a grass taxa complex.

Forage selection ratios were computed for each accession in each pasture and year (Stuth 1991). The selection ratios compared the proportion of forage of an accession or species in the diet of the test animals to the proportion of forage of that accession or species available in the pasture. It was calculated as

$$\text{selection ratio} = \frac{\dfrac{\text{dry weight of accession consumed}}{\text{dry weight of all forage consumed}}}{\dfrac{\text{pre-grazing forage dry weight of an accession}}{\text{pre-grazing forage dry weight of all accessions}}}$$

The ratios were based only on the 4 test plants in each plot, i.e., weights of border grass plants were considered to be a constant within each pasture at each grazing period.

Statistical Analyses

Data were reduced and analyzed by the method of least squares to fit general linear models (SAS Institute Inc. 1987). Experimental units were the individual test plants within plots (Fig. 1). Pastures and replicates within pastures were absorbed as needed to reduce computer space requirements. Orthogonal differences between the grass and forb accessions and between alfalfa and globemallows were assessed by single degree of freedom contrasts. Percent globemallow forage consumption was regressed on independent variables using a full model with the regression coefficents standardized. Independent variables included a dichotomous variable representing the season of evaluation as well as the continuous variables of pre-grazing forage dry weight (g plant^{-1}), forage dry matter (%), phenological stage (score), trichome density (number mm^{-2}), and rust reaction (score). The difference in mortality of grazed versus ungrazed plants were analyzed by Chi-square procedures.

Results

The experiment provided more pasturage in 1988 than in subsequent years and more during fall than spring (Table 1). During the 4 years, 71% of the available forage of test plants was eaten. Initial plant stands of all species were nearly 100%. However, mortality during the winter of 1988 to 1989 was high (38%), probably due to the 5 cm after-grazing cutting height. Plant loss was significantly greater among the globemallow species than for crested wheatgrass or alfalfa (Table 2). Plant loss also was greater in those replications which had been grazed than those in which had not been grazed. After the first winter, mortality was only 7% for the duration of the experiment.

Table 2. Mortality of plants of globemallow (*Sphaeralcea* sp.), crested wheatgrass, and alfalfa from October 1988 to May 1989.

Species Accession	Mortality of plants that were grazed	not grazed	Chi-square
	----- (%) -----		x^2
S. coccinea	41	4	12.0**
RP 40	42	8	5.0*
RP 76	40	0	7.2**
S. grossulariifolia	43	24	4.1*
RP 33	45	10	4.4*
RP 58	41	27	0.7
RP 59	43	33	0.4
S. munroana			
RP 53	62	50	0.6
S. parvifolia	57	40	8.2**
RP 34	63	17	8.8**
RP 35	47	0	9.2**
RP 36	36	42	0.2
RP 54	63	27	4.8*
RP 55	73	45	3.2
RP 56	75	75	0.0
RP 73	45	75	3.6
Globemallows:	54	34	21.8**
Wheatgrass:	0	0	0.0
Alfalfa:	8	0	1.1
Average	47	29	20.6**

*$P<0.05$, **$P<0.01$

Both the average estimated available forage per plant and the amount of forage consumed during the fall were more than threefold that during the spring grazing periods (Table 3). However, a greater proportion of the available forage was consumed in spring than in fall of all accessions except Hycrest wheatgrass ($P<0.05$, Tables 3 and 4). Wheatgrass was utilized less in the spring when the sheep consumed only 50% than in the fall when they consumed

Table 3. Average plant characteristics and forage production of globemallows (*Sphaeralcea* sp.), crested wheatgrass, and alfalfa during fall (1988 and 1989) and spring (1990 and 1991) grazing seasons.

Season Species	Dry forage weight Pre-grazing	 Consumed	Forage Consumption	 Selection	 Use[1]	Phenological stage[2]	Dry matter	Stellate trichome density	Rust[3]
	---- (g plant^{-1}) ----		(%)	(ratio)	(score)	(score)	(%)	(number mm^{-2})	(score)
Fall:									
S. coccinea	22	19	78	1.4	2.8	3.4	53	6.8	1.4
S. grossulariifolia	102	63	63	1.0	2.1	4.5	42	11.7	1.7
S. munroana	123	70	63	0.9	2.6	4.9	42	15.3	1.6
S. parvifolia	151	84	58	0.9	1.9	4.6	43	11.0	1.8
Globemallows:	117	68	63	1.0	2.2	4.4	44	10.7	1.6
Wheatgrass:	34	26	74	1.3	4.1	5.4	44	—	—
Alfalfa:	258	190	76	1.2	4.8	4.9	38	—	—
Average	122	74	65	1.0	2.5	4.4	44	10.7	1.6
LSD (0.05)	26	18	6	0.1	0.3	0.3	7	3.0	0.5
Spring:									
S. coccinea	3	2	81	0.8	1.2	2.5	40	4.9	—
S. grossulariifolia	8	6	70	0.9	2.6	2.9	34	6.2	—
S. munroana	7	6	80	1.1	3.6	2.8	29	6.8	—
S. parvifolia	10	8	76	1.0	2.8	2.7	31	6.1	—
Globemallows:	9	7	75	1.0	2.6	2.7	33	6.0	—
Wheatgrass:	73	37	50	0.6	1.8	2.0	30	—	—
Alfalfa:	137	127	95	1.1	4.8	2.0	21	—	—
Average	26	21	76	1.0	2.7	2.6	32	6.0	—
LSD (0.05)	8	7	7	0.0	0.3	0.1	10	1.9	—

[1]Forage use was scored immediately after grazing on a scale of 0 = no forage eaten to 5 = 100% consumption of fine stems (<2 mm diameter) and leaves.
[2]Phenological stage was scored immediately prior to grazing as 1 = dormant, 2 = vegetative growth only, 3 = flower buds present, 4 = flowers open, 5 = fruit formed, and 6 = seed shattering.
[3]Rust reaction was scored on a scale of 0 = no infection, 1 = trace to 10% of the leaf surface diseased, —, 9 = 91 to 100% of the leaf surface diseased. Data are for the 1989 infection.

Table 4. Statistical significance of sources of variation affecting globemallow (*Sphaeralcea* sp.), crested wheatgrass, and alfalfa accessions during fall (1988 and 1989) and spring (1990 and 1991) grazing seasons as determined by analysis of variance.

Source of variation	Dry forage weight Pre-grazing	 Consumed	Forage Consumption	 Selection	 Use[1]	Phenological stage[2]	Dry matter	Stellate trichome density	Rust[3]
	---- (g plant^{-1}) ----		(%)	(ratio)	(score)	(score)	(%)	(number mm^{-2})	(score)
Year	**	**	**	**	**	**	**	**	–
Seasons	**	**	**	**	**	**	**	**	–
Years in fall	**	**	**	*	**	**	NS	**	–
Years in spring	**	**	**	**	**	**	NS	**	–
Accessions	**	**	**	**	**	**	**	**	**
Grass vs. forbs	**	**	**	NS	**	**	NS	–	**
Alfalfa vs. mallows	**	**	**	NS	**	*	**	–	**
Among mallows	**	**	**	**	**	**	**	**	**
Years × accessions	**	**	**	**	**	**	**	**	–
Seasons × accessions	**	**	**	**	**	**	NS	NS	–
(Years × accessions) in fall	**	**	**	NS	**	**	**	NS	–
(years × accessions) in spring	**	**	**	**	**	**	NS	NS	–

[1,2,3] See footnotes Table 3.
* $P<0.05$, ** $P<0.01$, NS $P>0.05$

74%. The rankings for percent of available forage consumed in the individual years were:

1988 (fall) : alfalfa>grass>mallow,
1989 (fall) : grass>alfalfa>mallow,
1990 (spring) : alfalfa>mallow>grass, and
1991 (spring) : alfalfa>mallow>grass.

It is clear that the sheep utilized forbs to a greater extent than grass in the spring and generally consumed alfalfa rather than mallow or grass forage. Eighty-five percent of the plants available to the sheep were crested wheatgrass. Plants were leafy and green during the spring and fall grazing periods. Because of the design of the experiment, globemallows comprised 14% of the plant population and alfalfa only 1%.

When the sheep entered a pasture during the fall, they first selected crested wheatgrass to eat, then alfalfa, and finally the globemallows. During the spring grazing periods, the sheep first selected alfalfa, then the mallows, and finally, the wheatgrass. Mean percent consumption of available globemallow forage during the 4 years was 80% for *S. coccinea,* 72% for *S. munroana,* 67% for *S. parvifolia,* and 66% for *S. grossulariifolia* ($P<0.01$). Alfalfa was most utilized with 86% of the available forage eaten by sheep.

The proportion of crested wheatgrass eaten (62%) was less than any other species included in the experiment. In all 4 years the relative consumption of *S. coccinea* was greater than that of the other globemallow species. Plants of this species are small and would not contribute much herbage to grazing animals.

Plants were more mature and contained significantly ($P<0.01$) more dry matter during fall grazing than in spring (Table 3). Plants also were more mature in 1988 than in 1989 (phenological stage of 5.4 versus 3.5) although the mean dry matter contents were not greatly different (43.6 versus 43.0%). Differences among the accessions and species in plant size and pre-grazing forage dry weight were significant ($P<0.05$) for many contrasts (Table 3). *S. parvifolia* plants tended to be larger than those of other mallow species in 1988 but there were few differences among *S. grossulariifolia, S. munroana,* and *S. parvifolia* in 1989. These 3 species consistently weighed more than *S. coccinea.* Alfalfa plants were larger than globemallows or crested wheatgrass in each year of experimentation. Both alfalfa and crested wheatgrass provided more spring forage than the mallows but the forbs were larger than the grass in the fall. Although statistically significant ($P<0.05$) differences were observed among the mallow species and accessions during the spring grazing periods, these differences were small when compared to contrasts involving wheatgrass and/or alfalfa.

Globemallow stellate trichome density was significantly ($P<0.05$) greater in the fall than in the spring (Table 3), significantly greater in 1989 than in 1988, and significantly greater in 1990 than in 1991. In each grazing period, the single *S. munroana* accession developed significantly ($P<0.05$) more trichomes per unit leaf surface area than other species. *S. grossulariifolia* consistently had more trichomes than *S. parvifolia* ($P>0.05$). *S. coccinea* had fewer, but larger, trichomes than each of the other 3 species ($P<0.01$). Rust, incited by *P. sherardiana,* was detected only in 1989. The pathogen did not attack crested wheatgrass or alfalfa. Small but significant ($P<0.05$) differences in susceptibility were detected among the globemallow species and accessions (Tables 3, 4).

Simple correlations (data not shown) among the attribute means of the globemallow accessions averaged for the 4-test years showed that the estimated amounts of globemallow forage consumed were positively associated with phenological stage ($r = 0.87$, $P<0.01$) and trichome density ($r = 0.32$, $P<0.05$). Consumption was more strongly associated with plant characteristics during the fall than during the spring. In the fall, the amount of forage consumed was positively correlated with phenological stage ($r = 0.79$, $P<0.01$), but negatively correlated with, dry matter content ($r = -0.59$, $P<0.01$) and rust score ($r = -0.66$, $P<0.01$). In the spring, the amount of forage consumed was correlated only with trichome density ($r = 0.58$, $P<0.01$).

For the 4 years of experimentation, the mean proportion of available globemallow forage consumed was not significantly ($P>0.05$) associated with any of the plant variables measured (data not shown). In the fall, the proportion of available globemallow forage consumed was positively associated with dry matter concentration ($r = 0.52$, $P<0.01$). In the spring, the proportion of available globemallow forage consumed was positively associated with plant dry weight ($r = 0.72$, $P<0.01$), and trichome density ($r = 0.55$, $P<0.01$), but negatively associated with dry matter concentration ($r = -0.41$, $P<0.05$). The computed percent of available forage consumed and the post-grazing scores of the utilization of leaves and fine stems were significantly ($P<0.01$) correlated in both fall and spring.

Regression analysis of the percentage of available forage that was consumed was restricted to the globemallows. When all 4 years of data were included for all accessions, the predictive capability was extremely limited with $R^2 = 0.19$. Analogous equations for the 4 species individually were heterogeneous but 3 of the 4 coefficients of the determination were greater than when the data were pooled. Coefficients of determination ranged from 0.20 ($P<0.01$) for *S. coccinea* to 0.37 ($P<0.01$) for *S. munroana.* Season of grazing was the most important single independent variable determining consumption percent of *S. munroana.* For *S. coccinea* it was forage dry matter content and for *S. grossulariifolia* and *S. parvifolia* it was pre-grazing plant dry weight. Predictive capability was slightly greater for spring than fall trials. Pre-grazing plant dry weight and dry matter percentage tended to be the most important plant attributes determining percent consumption.

For the individual years, the proportions of the variance in percent of forage consumed attributed to multiple regression on plant attributes were significant ($P<0.01$) but low with R^2 equal to 0.44, 0.24, 0.26, and 0.19 for 1988 through 1991, respectively. Pre-grazing plant dry weight negatively affected percent consumption and was the most important independent variable in each of the 4 years. In 1988 and again in 1991, dry matter percent was the next most important variable determining percent consumption. In 1989, the only year in which a rust infection occurred, the rust score and trichome density became the second and third most important variables determining consumption of mallow foliage.

Forage selection ratios of alfalfa and wheatgrass were greater than those of all globemallows species except *S. coccinea* during fall grazing (Table 3) but differences among the accessions at this season were not significant ($P>0.05$, Table 4). During spring grazing, the selection ratio for wheatgrass was less than that for alfalfa and each of the globemallow accessions. The ratio for alfalfa was greater than for any other accession in each year of the experiment although the average for alfalfa was not significantly ($P>0.05$) greater than the average for the globemallows, and grass was not significantly ($P>0.05$) different than forbs (Table 4).

Discussion

Globemallow plant mortality was high in our experiment during the winter of 1988–89 (Table 2). While this partially may be attributed to the severity of the post-grazing cutting height of 5 cm in 1988, grazing significantly ($P<0.05$) increased the mortality of globemallows. Ungrazed globemallows survived well in dry land spaced-plant nurseries in Idaho and Utah (Pendery and Rumbaugh 1990). West (1979) found that approximately 5% of *S. grossulariifolia* seedlings survived after 34 years in a salt desert shrub community of southwestern Utah. Grazing had no impact on survival rate. Wright and Howe (1987) found that mortality of juvenile desert mallow (*S. ambigua* Gray) plants occurred independently of density of conspecifics, and of distance to the nearest conspecific adult. It apparently occupied the narrow interspaces between larger shrubs and existed with little interaction with its neighbors (Howe and Wright 1986). Crested wheatgrass and alfalfa survival was not affected significantly by grazing in our experiment. Pelton et al. (1988) also concluded that fall grazing of alfalfa did not cause a loss of stand or reduce subsequent forage production. The ability of crested wheatgrass to withstand grazing is well known (Mayland 1986).

Differences among globemallow accessions in mortality and in the effect of grazing on mortality were apparent (Table 2). Both accessions of *S. coccinea* and 1 accession of *S. parvifolia,* RP 35, suffered stand losses of less than 10% when not grazed but of 40% or more when exposed to sheep activity. Heterogeneity in reaction among accessions within a species was apparent as some *S. parvifolia* accessions, e.g., RP 36 and RP 56, had similar mortalities in ungrazed and grazed plots.

S. coccinea plants were lower in stature than the other species included in the experiment and also spread by rhizomes. A lesser proportion of their shoot biomass appeared to be removed by post-grazing clipping than was true for the other species. Trlica et al. (1977) also found that *S. coccinea* was resistant to defoliation. Density of *S. coccinea* shoots in a shortgrass range increased under severe grazing (Hyder et al. 1975). Similarly, we noted that surviving *S. coccinea* plants spread throughout the plot area during the 4 years of experimentation despite grazing and clipping. By years 2 and 3, daughter plants could be found throughout a 1-m radius from each mother plant.

Pronghorn will starve to death on ranges where both forbs and shrubs are not available (Buechner 1950). Parker (1983) stated *S. munroana* was a preferred feed of antelope. Due to its ecological abundance and importance in animal diets, *S. coccinea* was the most important perennial forb on a Central Great Plains study site and rated second only to blue grama as a forage plant on some of the upland soils (Hyder et al. 1975). Howard et al. (1990) found that *S. coccinea* forage was of major importance to sheep and pronghorn in east central New Mexico. Similarly, *Sphaeralcea* spp. were second only to black grama [*B. eriopoda* (Torr.) Torr.] as a dietary component of cattle grazing 3 vegetation types in southern New Mexico (Fatehi 1986). When offered the choice of fall growth of crested wheatgrass, alfalfa, or globemallows, the sheep in our experiment consumed more of the available grass and alfalfa than mallow (Table 3). However, during early spring, alfalfa was utilized more than either globemallows or wheatgrass, and mallows were consumed more readily than the wheatgrass. The comparative intake of globemallows by livestock pastured on mixed species stands may in part depend upon the availability and maturity of the associated species.

Clipping test plants and border grass after each grazing season forced the grasses to maintain a largely vegetative growth habit for the subsequent grazing season. Hycrest plants grazed during the fall of 1988 and 1989 retained an abundance of green-leafy material with few reproductive tillers. This may contrast with situations frequently encountered on rangeland where fall-growth, or more specifically regrowth, is limited by available soil moisture. Thus the abundant green-leafy grass, as appeared during fall of 1988 and 1989, is not often observed. This may have influenced the consumption ranking of grass, especially in 1989.

There was little difference among the globemallow species in the proportion of forage consumed when averaged for the 4 years of testing. *S. coccinea* was utilized heavily in the fall but the other 3 globemallow species were utilized more than *S. coccinea* in spring. Of the variables we measured, pre-grazing plant dry weight and dry matter content consistently were among the more important attributes determining percent consumption. In the year in which rust damaged the foliage, it was the second most important independent factor determining percent consumption.

A plant attribute that could alter intake is the density of leaf hairs (Woodman and Fernandes 1991). Trichomes reduce ruminant utilization of some forages (Burns 1978). Neither crested wheatgrass nor alfalfa have stellate trichomes. Hycrest had numerous (35 mm^{-2}) simple but small trichomes. Alfalfa had fewer (10 mm^{-2}) simple, nonglandular trichomes which were approximately 4 times as long as those of Hycrest. In some alfalfa populations, these are interspersed with shorter, club-shaped, procumbent, glandular trichomes (Kreitner and Sorensen 1979). Previous research showed that these glandular trichomes did not reduce the nutritive value of glandular alfalfas compared with eglandular populations (Lenssen et al. 1988), or their acceptability by sheep (Lenssen et al. 1989). We found that stellate trichome density affected consumption of globemallows in the spring but was of less consequence in the fall. However, since trichome density was positively correlated with percent consumption in 3 of the 4 years, our results with globemallows are not consistent with the findings of Burns (1978) for other species. This may have occurred because *S. coccinea* had fewer trichomes and was smaller statured than the other globemallow species. Correlation of trichome density with percent consumption for the 3 globemallow species other than *S. coccinea* was $r = 0.03$ ($P>0.05$), $r = 0.11$, ($P<0.05$), $r = -0.02$, ($P>0.05$), and $r = 0.03$ ($P>0.05$) for the 4 years of experimentation.

The post-grazing utilization scores appropriately indicated the relative amounts of available forage consumed. Johnston (1988a, 1988b) also found this approach to be suitable for determining the palatability of *Eragrostis curvula* to sheep. In a study of preference of cattle for *Panicum* taxa, Burns et al. (1988) also found that scores could be used to assess animal preference for plant species.

Grazing was quite intense and brief in our experiment. If the grazing periods had been extended and availability of grass and alfalfa reduced, the animals might have consumed a higher proportion of the globemallows. However, longer grazing periods would have incurred the risk of greater autogenic changes in the plant populations (Peterson and Renaud 1989). Rapidly senescing populations might be less utilized as grazing progressed (Colebrook et al. 1990). Stuth (1991) used "palatability" to refer to those factors inherent to a plant species that elicit a selective response by the animal and "preference" to indicate a proportional choice by the animal of 1 plant species from among 2 or more species. Under the conditions of our experiment, alfalfa was both more palatable and more preferred by sheep than crested wheatgrass or the globemallow species. In general, globemallow forage consumption (%) declined as plants matured and size and dry matter content increased. In some grazing periods, consumption declined as stellate trichome density increased or rust infection became more severe.

Conclusions

Grazing significantly increased the winter mortality of most, but not all, globemallows but did not affect the stands of crested wheatgrass and alfalfa. *S. parvifolia* plants provided more forage than *S. coccinea, S. grossulariifolia,* and *S. munroana.* Judged by the proportion of available forage that was consumed by sheep and by utilization scores, *S. coccinea* was equally as acceptable as crested wheatgrass or alfalfa in the fall and all globemallows were used more than crested wheatgrass in the spring. *S. grossulariifolia* was utilized slightly less than *S. munroana* or *S. parvifolia* during fall but *S. munroana* was used more during spring. Pre-grazing plant dry weight and dry matter content were important factors determining sheep utilization among the globemallow accessions. Stellate trichome density was of less consequence than occurrence of a rust incited by *P. sherardiana* in determining consumption. Morphological and physiological variation among the globemallow plants accounted for only 19% of the differences in utilization. Sheep preferred forbs rather than grass, and alfalfa rather than globemallows or grass in the spring. Alfalfa, wheatgrass, and *S. coccinea* were the most heavily utilized forages in the fall. Throughout the experiment, alfalfa provided a greater amount of forage than either wheatgrass or globemallows.

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