Diet Selection of Cattle and Bonded Small Ruminants Grazing Arid Rangeland

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Summary

Cattle, sheep and goat grazing behavior, fecal botanical composition and liveweight change under semidesert mixed species grazing using bonded and non-bonded (control) livestock groups were studied between July 13 and September 7, 1988 on the Jornada Experimental Range, 37 km north of Las Cruces, New Mexico. Precipitation between January and September was 30 mm above the long term mean of 187 mm. Cattle with non-bonded sheep grazed areas higher in grass while cattle with bonded sheep grazed areas higher in forbs between August and September. Diets of bonded and non-bonded lambs were similar and differed < 5% in grasses ($P = 0.437$), forbs ($P = 0.079$) and shrubs-cacti ($P = 0.761$). Bonded small ruminants and cattle maintained two or three interspecific subgroups while non-bonded small ruminants and cattle rarely intermixed (< 6%). Grazing occurred throughout the day; however, irrespective of treatment or species, more animals were observed to graze between 0600 and 1200 hrs compared to 1300 to 1900 hrs. The number of bonded sheep and goats grazing during the morning was less than the number of non-bonded small ruminants grazing during the same time interval. Areas within the 410 ha paddock in which the intra and interspecific livestock groups grazed were similar ($P > 0.05$) in standing crop. Overall liveweight changes (gains) were similar ($P > 0.05$) for bonded and non-bonded sheep. Goat numbers were too low to make accurate conclusions.

Key Words: Mixed stocking, grazing behavior, microhistological analysis, liveweight, sheep, goats.

Introduction

Cattle, sheep and goats, when together on the same range are referred to as grazing in common, or as being managed under mixed grazing (Allen, 1991). Most mixed grazing schemes are designed to take advantage of dietary differences among livestock species. Grazing strategies involving more than one animal species should promote more uniform forage utilization and greater livestock production than is possible under single species grazing (Anderson et al., 1985).

Rangeland vegetation is composed of grasses, forbs and shrubs that provide food for livestock and wildlife. Mixed species grazing is becoming increasingly important as production costs rise and opportunities for acquiring additional land decrease (Thetford et al., 1971). Today diversified production systems are truly mixed species and often include cattle, sheep, goats and white-tailed deer. These are particularly common among commercial producers in the Edwards Plateau of Texas (Taylor, 1985; Glimp, 1988). In central and southeastern New Mexico (Gee and Magleby, 1976), mixed grazing of sheep and cattle is common. The use of cattle, sheep and goats on the same rangeland may increase not only biological but also economic efficiency, because these livestock are usually complementary rather than competitive (Harrington, 1982; Cook, 1985; Merrill, 1985; Wood, 1987).

In small groups (≤ 16) bonding has been shown to alter animal behavior (Anderson et al., 1987) and diets (Anderson et al., 1990). However, this is the first study on grazing behavior and diet selection using larger groups of bonded and non-bonded animals. The objectives of this research were: 1) determine the effect bonding has on grazing behavior and diet selection; and 2) compare liveweight change between bonded and non-bonded lambs.

Materials and Methods

This study was conducted on the Jornada Experimental Range, 37 km

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north of Las Cruces, New Mexico between July 14 and September 7, 1988 (perennial growing season). Only diurnal data between sunrise and sunset were collected (table 1). The undulating topography of the predominantly sandy study site averages 1,260 m above sea level. The climate is typical of the Northern Chihuahuan Desert with two precipitation peaks: summer rains during July through September and a smaller precipitation peak between December and February. Annual precipitation averages 230 mm with 52% occurring between July and September. Mean temperatures vary from a high of 36°C in June to -13.3°C in January. The vegetation has been classified as a semidesert grass-shrub complex (Paulsen and Ares, 1962). Plants of major importance in either standing crop, diet or both were black grama, mesa dropseed/spike dropseed, purple threeawn, burrograss, alkali sacaton, woolly paperflower, flax, leatherweed croton, scarlet globemallow, dwarf dalea, honey mesquite, soaptree yucca, and broom snakeweed. Scientific names of plants important in both standing crop and diet are given in table 2.

Forty-two Hereford and Brangus females between 18 and 40 mo of age and three available bulls were randomly allocated to each of two treatment groups containing Rambouillet x Polypay lambs (6 mo of age), and ewes (14 mo of age). The flerd, defined by Anderson et al. (1988) as a flock of sheep which have been bonded to cattle plus the cattle or herd, received two bulls while the control group had only one bull. Thirty-one lambs and 13 ewes which had previously been bonded to cattle as described by Anderson et al. (1987), comprised the bonded treatment group (flerd). The control treatment group consisted of 30 lambs and 18 ewes. In both groups, the sheep to cattle ratio was approximately 2:1. This ratio was judged to be appropriate for the plant life form (grass, forb and shrub-cacti) composition of this range (Anderson et al., 1985). Eleven 6 to 8 mo old Angora goats, previously bonded to sheep, were randomly allotted to each of two treatment groups. The goats behaved like sheep and functioned as an integral part of the sheep groups. However, because of their small numbers they did not contribute meaningfully to diet and liveweight data. Therefore, goat data were deleted from analysis and discussion for the sake of accuracy. One to 5 Akbash guard dogs stayed with each livestock group. They were essential for protection of the control sheep.

Control and flerd animals were maintained as separate groups and rotated every 14 d between a 410 ha paddock (10B) and a 320 ha paddock (11D). Both had similar topography and vegetation. However, data were only recorded while livestock were grazing paddock 10B. The sequence of observing each treatment group, for two consecutive weeks, was randomized beginning with the control animal group.

Grazing activity of each animal was recorded at hourly intervals. The percentage of animals grazing each hour between 0600 and 2000 hr was determined. Activity data were then categorized into one of ten areas, nine within the pasture and a corral area in which drinking water was located. The corral area was defined to include the corral and a portion of paddock, 10B, 300 m x 300 m surrounding the corral. Watering points may be the major factor influencing the dispersion of sheep (Squires, 1974). Therefore, the corral area was deleted from grazing behavior data analysis. Paddock geometry tended to "funnel livestock" when they were in the corral area. This caused an atypical intermixing compared to that occurring under free-ranging conditions in the other nine areas.

Weather data recorded at the beginning of each hour included ambient air temperature, wind speed and direction, and a descriptive category of atmospheric conditions.

Following each 7 d period of grazing in paddock 10B, midday fecal samples were collected when animals came to the corral to drink water. These samples were used to estimate the botanical composition of livestock diets. Samples were taken within each treatment group from six lambs and six cattle which had been randomly selected. Cattle samples were collected

Table 1. Percent of animals grazing by animal species/treatment categories between 0600 and 1900 hrs for the period July 13 to September 7.

Animal species	Treatment	Hour													
		0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900
Cattle	Control	9.5	15.7	10.7	4.0	4.2	5.0	4.5	3.5	5.8	7.1	3.5	7.5	13.2	5.7
	Bonded	13.0	14.8	13.6	4.3	2.4	2.5	3.6	1.1	9.5	5.1	2.1	6.3	9.3	12.3
Sheep	Control	14.6	16.8	21.1	9.8	4.7	0.8	5.1	0.0	0.1	0.0	0.8	4.5	13.3	8.2
	Bonded	13.2	14.7	13.9	6.4	1.4	2.9	1.9	1.0	7.3	5.2	3.6	7.9	9.7	10.8
Goats	Control	12.4	14.8	18.6	9.3	7.9	3.8	4.1	0.7	0.0	0.0	1.0	6.2	12.4	8.9
	Bonded	12.7	14.5	12.4	7.4	3.5	3.8	2.1	0.0	5.0	5.9	1.5	7.7	9.8	13.6
Means		12.6	15.2	15.1	6.9	4.0	3.1	3.6	1.0	4.6	3.9	2.1	6.8	11.3	9.9

cattle, χ^2 (13) = 127.127, P < 0.0005
sheep, χ^2 (13) = 504.461, P < 0.0005
goats, χ^2 (13) = 50.941, P < 0.0005

Table 2. Least square mean frequency of occurrence (%) of key forage species and totals for all grasses, forbs and shrub/cacti in paddock 10B and diets of cattle, and bonded and non-bonded sheep managed under simultaneous stocking between July and September 1988.

					Diet							
	Paddock plant frequency				Cattle				Lambs			
	July 13 - Aug 10		Aug 10 - Sept 7		July 13 - Aug 10		Aug 10 - Sept 7		July 13 - Aug 10		Aug 10 - Sept 7	
Plant life forms	Control[1]	Bonded	Control[1]	Bonded	Control	Bonded	Control	Bonded	Control	Bonded	Control	Bonded
Sporobolus spp[2] (Dropseed)	22.8^{a}	17.8^{a}	19.8^{a}	19.0^{a}	16.3^{a}	14.2^{a}	13.3^{a}	20.7^{b}	12.2^{b}	9.4^{a}	15.7^{a}	14.8^{a}
Bouteloua eriopoda (Torr.) Torr. (Black grama)	2.0^{a}	5.3^{a}	4.6^{a}	4.1^{a}	9.2^{a}	11.4^{a}	13.7^{a}	13.2^{a}	8.5^{c}	12.4^{d}	9.6^{a}	10.2^{a}
Hilaria mutica (Buckl.) Benth. (Tobosa)	0.0^{a}	0.0^{a}	0.0^{a}	0.0^{a}	1.7^{a}	3.1^{a}	4.3^{a}	6.0^{a}	3.0^{a}	3.4^{a}	3.8^{a}	2.1^{a}
All grasses	38.5^{a}	38.6^{a}	43.0^{a}	45.5^{a}	28.9^{a}	32.2^{a}	37.4^{a}	53.7^{b}	25.1^{a}	30.1^{a}	33.3^{a}	31.4^{a}
Psilostrophe tagetinae (Woolly paperflower)	5.4^{a}	4.8^{a}	5.6^{a}	6.6^{a}	4.9^{a}	8.4^{a}	8.1^{a}	6.7^{a}	18.1^{c}	23.8^{d}	20.9^{a}	18.9^{a}
Linum australe Heller (Flax)	1.6^{a}	1.8^{a}	1.0^{a}	1.7^{a}	5.1^{a}	4.7^{a}	3.8^{a}	10.0^{b}	5.6^{a}	6.3^{a}	4.8^{a}	9.3^{b}
Croton corymbulosus Egelm. (Leatherweed croton)	15.9^{a}	17.3^{a}	12.9^{a}	13.0^{a}	11.3^{a}	8.4^{a}	12.1^{d}	4.6^{c}	3.3^{a}	1.4^{a}	3.1^{a}	4.0^{a}
Sphearalcea coccinea (Pursh) Rgdb. (Scarlet globemallow)	0.6^{a}	1.1^{a}	0.8^{a}	0.8^{a}	10.3^{a}	6.0^{a}	2.8^{a}	1.7^{a}	7.9^{b}	1.4^{a}	4.3^{b}	0.9^{a}
Dalea nana Torr. (Dwarf dalea)	1.3^{a}	1.3^{a}	1.1^{a}	1.1^{a}	10.1^{a}	9.5^{a}	6.3^{a}	3.2^{a}	1.5^{c}	3.1^{d}	5.0^{a}	1.8^{b}
All forbs	45.6^{a}	48.7^{a}	35.9^{a}	40.7^{a}	65.3^{a}	59.8^{a}	55.1^{b}	43.3^{a}	66.7^{a}	65.1^{a}	63.9^{a}	65.2^{a}
All shrubs	13.5^{a}	13.5^{a}	18.7^{a}	16.4^{a}	6.9^{a}	7.3^{a}	5.0^{d}	1.6^{c}	8.2^{a}	5.3^{a}	1.7^{a}	3.5^{a}

[a,b] Row means within the same plant species or life-form with different letters differ ($P \le 0.01$).
[c,d] Row means within the same plant species or life-form with different letters differ ($P \le 0.05$).
[1] Data represents plant species composition for areas where all animal species were grazing; however, control cattle and small ruminants were seldom found together.
[2] *Contractus* and *flexuosus* could not be identified by species in the field.

from the ground immediately upon observing defecation while fecal samples were collected rectally from lambs. Fecal samples were oven-dried (50°C) to constant weight before being ground to pass a 1 mm screen. Each animal's feces within treatment group and 7 d period were pooled using an equal mass (2 g) of material from each fecal collection. Fecal material was then soaked in hot water for 20 minutes followed by bleaching (sodium hypochlorite) to remove plant pigments. A metal template was used to allocate equal amounts of the washed fecal material onto each of 5 microscope slides to be observed per composite fecal sample. Cover slips were mounted on the slides using Hoyer's mounting solution (Holechek and Gross, 1982). Slides were allowed to air dry for 2 or 3 days. Reference slides of the predominant plant species growing in paddock 10B were prepared using the same techniques as those for the fecal material. These were used to aid in correctly identifying the plant fragments contained in the feces.

Microhistological analyses of fecal material followed the procedures of Holechek and Gross (1982). Plant fragment identification was based on epidermal characteristics (Davies, 1959). Each fecal sample analysis was based on systematically observing 20 fields per slide (N = 100) at 200 X magnification (Holechek and Vavra, 1981). Observer accuracy was judged based on evaluating 5 different hand-compounded mixtures containing various combinations of the plant species located on the study area. Percentage composition by species within diet was calculated using the frequency addition procedure described by Holechek and Gross (1982).

Species composition in paddock 10B was sampled immediately following removal of each treatment group from the paddock using a modified step-point procedure described by Evans and Love (1957). The locations sampled corresponded to areas in which an animal specie or species had been observed to have grazed or browsed. The plant frequency data were obtained in 5 to 10 transects per location sampled, depending on size and homogeneity of the area. Relative frequency of each species was expressed as a percentage based on the number of points encountered for each species divided by the total number of points encountered for all species within a transect.

Sheep were weighed immediately upon entering and leaving paddock 10B, without prior fasting. This decision was made on the assumption that fasting could potentially disturb subsequent animal behavior. Because facilities to weigh large animals were not readily available, cattle were not weighed. In addition, earlier research by Anderson et al. (1990) found cattle diets under flock and flerd management to be quite similar, hence cattle liveweight was not considered an important variable to monitor.

Statistical Analyses

Activity: Percentage of animals grazing on an hourly basis is summarized in table 1. Chi-square tests of independence were conducted for each animal species to determine differences in the temporal grazing patterns between bonded and control groups.

Weather: Relations between weather data and both animal location and animal behavior were examined using chi-square tests of independence. No obvious relations between the animal and weather data were found; hence these results are not discussed.

Standing crop: A one-way analysis of variance was run on all plant species and on grasses, forbs and shrubs-cacti to test for plant composition homogeneity of standing crop by grazing locations of different associations of animal species (cattle, sheep-goats, and cattle-sheep-goats), and by treatment.

Fecal: Diet similarity between sheep and cattle was evaluated as a split plot using a completely randomized design in the whole plot. Treatments and animal species were the main plot factors while time was the subplot factor. Dependent factors were individual plant species and plant life form groups, i.e., grass, forbs and shrubs-cacti. Because of interactions, one-way analyses of variance were run to compare animal species for each treatment x period combination and to compare treatments for each animal species x period combination.

Liveweight: Liveweight change for sheep was analyzed using an analysis of variance in a completely randomized design, with treatment (flerd vs control) as the independent factor.

All statistical analyses were performed using the SAS statistical package (SAS Institute, 1985).

Results and Discussion

Behavior

The flerd was first observed from July 27 to August 10. The flerd split itself into two interspecific subgroups, each containing cattle, sheep and goats. Even though the separation between subgroups was 360 m, the distances within cattle, sheep, goat subgroups were always between 0 m and 90 m. During the second observation period (August 24 to September 7) the flerd separated into three interspecific subgroups separated by 340 and 710 m. These data suggest that the flerd, composed of 31 lambs, 13 ewes, 6 goats and 21 cows, tended to divide into two or more subgroups that were widely spread out over the paddock. Similar interspecific separation distances were observed by Anderson et al. (1987). Throughout the study, sheep and/or goats in the control group rarely (<6%) intermixed with the cattle.

Arnold (1985) defined social facilitation as the social interaction of animal groups having different grazing time which when the animals grazed together modified their grazing time. This modification takes the form of reducing the grazing time of the animal which previously grazed longer and lengthening the grazing time of the species which when grazing alone had a shorter grazing period. Bonding appeared to increase the amount of time sheep and goats spent grazing while that spent by cattle decreased. The modification of grazing time, which includes searching and grazing, was possibly altered through social facilitation due to the close association of cattle with sheep and goats in the flerd.

Grazing apparently governs daily behavior, hence other activities adapt to the grazing routine (Arnold, 1985). Cattle, sheep and goats were observed to graze throughout the day, yet more animals of each species were observed to be grazing during the morning (0600 to 1200 hrs) than during the afternoon (1300 to 1900 hrs). Regardless of treatment, 54% of the cattle were observed to be grazing between 0600 and 1200 hrs. However, treatment influenced the number of sheep and goats grazing. Overall 73% and 71% of the control sheep and control goats, respectively, were grazing between 0600 and 1200 hrs. In contrast, the number of bonded sheep and bonded goats grazing during the morning decreased to 54% and 57%, respectively. The percent of bonded small ruminants grazing was very similar to the percent of cattle grazing. Cattle apparently influence the temporal grazing pattern of bonded small ruminants. The chi-square analysis indicated the general trend was for more control sheep to have grazed than expected between 0600 and 1200 hrs and fewer than expected to have grazed between 1300 and 1900 hrs. This pattern reversed for the bonded sheep with more animals grazing than expected during the afternoon as compared to the morning. In general, the percent of goat grazing throughout the day reflected that of the particular treatment to which the goats had been allocated. Comparison of daylight grazing indicated a circadian pattern between the control group and flerd with differences ($P < 0.0005$) for all three animal species throughout this study (table 1).

Standing Crop Composition

Sixty-seven plant species were collected from paddock 10B standing crop between July 13 and September 7. Total and green herbage production was high during the perennial growing season of 1988 (Gibbens, personal communication). Between July and September 1988, 15 mm more precipitation was recorded compared to the long term mean (1915 - 1988) of 129 mm for this 3-mo period. Overall 30 mm more precipitation was recorded between January and September compared to the 9-mo long term mean of 187 mm. The 10 grasses, 52 forbs and 5 shrub/cacti identified were collected from locations that were grazed or browsed. Grasses and forbs comprised 38% and 46% of the standing crop, respectively, between July 13 and August 10 (period 1). In contrast, between August 10 and September 7 (period 2), the grasses in the standing crop increased to 40% while the forbs

Table 3. Least square means (lsmean) and standard errors (SE) of plant life form composition by paddock area for different animal species associations between July and September 1988.

Paddock areas delineated by grazing/browsing groups	July 13 to August 10						August 10 to September 7					
	Grasses		Forbs		Shrub/Cacti		Grasses		Forbs		Shrub/Cacti	
	lsmean	SE	lsmean	SE	lsmean	SE	lsmean	SE	lsmean	SE	lsmean	SE
Cattle with												
Control sheep	36.6[a]	5.29	40.0[a]	6.22	17.1[a]	2.17	68.8[b]	5.36	18.2[a]	4.37	12.4[a]	2.91
Bonded sheep	38.6[a]	3.74	48.7[a]	4.40	13.5[a]	1.54	43.0[a]	2.68	40.7[b]	2.19	16.4[a]	1.45
Sheep-goats within												
Control group	39.2[a]	5.19	50.2[a]	5.15	10.8[a]	1.71	36.0[a]	5.36	33.5[a]	4.37	29.8[b]	2.91
Flerd	38.6[a]	3.67	48.7[a]	3.64	13.5[a]	1.21	43.0[a]	2.68	40.7[a]	6.19	16.4[a]	1.45
Cattle-sheep-goats												
Control group	40.6[a]	8.35	47.7[a]	8.40	11.5[a]	2.49	40.8[a]	3.39	42.6[a]	3.07	17.1[a]	2.36
Flerd	38.6[a]	4.17	48.7[a]	4.20	13.5[a]	1.24	43.0[a]	2.94	40.7[a]	2.66	16.4[a]	2.05

[a,b] Column means within the same life form with different letters differ ($P \leq 0.05$).

decreased to 38%. The botanical composition of standing crop by plant life form was similar ($P > 0.05$) between July 13 and September 7 (table 2). Minor differences (<2%) were found in only three plant species: fineleaved wildbuckwheat, euphorbia, and strapleaf spineaster. Mesa and spike dropseeds (18-23%), leather weed croton (13-17%) and broom snakeweed (11-15%) were the predominant grass, forb and shrub/cacti species, respectively, in both periods.

The standing crop composition based on plant life form by grazing locations for different associations of animal species is shown in table 3. Cattle grazing locations or sheep-goat grazing locations for control group livestock were compared with cattle-sheep-goat grazing locations for the bonded group. Total grasses, forbs and shrub/cacti were homogeneous ($P > 0.05$) in the locations in which cattle grazed between July 13 and August 10 (period 1). However, between August 10 and September 7 (period 2), the grazing location of cattle with bonded and non-bonded sheep differed ($P < 0.05$) in total grasses and forbs.

The locations in which the bonded group grazed contained more than twice as many forbs and only 37% as much grass as the locations in which the cattle in the control group grazed (table 3). Small ruminants, regardless of treatment or period, grazed grasses and forbs in areas having similar ($P > 0.05$) standing crop composition. Between July 13 and August 10 (period 1) the sheep and goats browsed in areas containing similar amounts of shrubs-cacti. However, during period 2 the control group of sheep and goats were found in areas which contained about 13% more ($P < 0.05$) shrubs-cacti than the small ruminants in the flerd.

Diet Composition

Cattle consumed more grasses ($P = 0.0001$) and fewer forbs ($P = 0.0004$) than sheep during the perennial growing season. Similar findings have been reported by Thetford et al. (1971), Kautz and Van Dyne (1978), Howard et al. (1983) and Holechek et al. (1986). Overall the control animals consumed smaller amounts of grass ($P = 0.003$) compared to animals in the flerd. Regardless of treatment, diets during the two periods differed ($P < 0.01$) for all plant life forms. Eight grasses, 26 forbs and 5 shrub/cacti were identified in composite fecal samples of both animal species. Key grasses were dropseed, black grama and tobosa. These plants consistently contributed between 1.7% and 20.7% to cattle and lamb diets in both treatments during both collection periods (table 2). In contrast, red threeawn, burrograss, vine mesquite, bush muhly and fluffgrass were each of lesser importance (0.1% to 3.6%) in the diets of both cattle and lambs. Even though Lehman lovegrass accounted for 3.6% in cattle diets in the flerd during period 2 it contributed only 0.1% to 1.6% to all other diets collected. Plant fragments, not identifiable by genus but known to be from a grass, forb or shrub-cacti were designated as other within these plant life form categories. Split plot analysis of variance in which animal species and treatment were main effects and period was considered a subplot showed interaction of animal species x period for grasses and forbs in the diets, treatment x animal species x period for grasses and shrub/cacti, and treatment x animal species for grasses and near-significant effects for forbs; while no interactive effect for treatment x period was noted for any plant life form consumed.

Because of interactions, these one-way analyses of variance with period comparing animal species were conducted for each treatment-period combinations. Difference in total grasses consumed by control cattle and sheep approached significance ($P = 0.055$) while utilization of forbs and shrub/cacti remained similar ($P = 0.774$ and $P = 0.698$, respectively) during period 1, July 13 to August 10. During the second period control cattle and sheep consumed different amounts of grasses ($P = 0.025$), forbs ($P = 0.0003$) and shrub/cacti ($P = 0.007$). This agrees with data of

Langlands and Sanson (1976) who reported that similarity between sheep and cattle diets was inversely related to total or green herbage production. Howard et al. (1990) found that forbs declined relative to grasses during droughts. When this happened sheep adjusted their diets by switching to more grasses and shrubs. Therefore, our results may have been different during a drought year.

Diet content of cattle and bonded sheep was similar for grasses ($P = 0.6365$), forbs ($P = 0.210$) and shrub/cacti ($P = 0.492$) during period 1. In contrast, between August 10 and September 7, diets selected by cattle and bonded sheep were different in grass content ($P = 0.001$) and forb content ($P = 0.005$).

Grazing behavior is determined not only by learning but also by morphological, and neurological systems (Hanley, 1982; Robbins et al., 1987). Intraspecific gregariousness has been shown to be a major force influencing plant selection by livestock during grazing (McNaughton, 1984). Learning which foods to select begins early in life for livestock (Provenza and Balph, 1987). Bandura (1977) hypothesized that either the dam or a dominant member of the group is the social model. Squires (1981) reported that socially, cattle are hierarchically dominant over sheep. Anderson et al. (1988) reported that as bonded lambs grew and matured they became more independent of each other, yet maintained a close association with cattle. Since the bonded lambs used in this study were reared in close confinement with cows during penning, cattle could have influenced lambs in food selection while grazing together in paddock 10B. However, it appears that our cattle had more influence on where, rather than on what the small bonded ruminants ate.

Again because of interactions one-way analyses to compare treatments for each animal species period combination was done. Bonded and non-bonded lamb diets were similar over both periods in major plant life forms. Diets of bonded and control lambs were similar in total grasses ($P = 0.437$), forbs ($P = 0.079$) and shrub/cacti ($P = 0.761$) for both sampling periods. During the first period of grazing (July 13 to August 10), bonded lambs consumed more ($P < 0.05$) black grama, Lehman lovegrass, burrograss, dwarf dalea and woollypaper flower than did control lambs. Non-bonded lamb diets were higher ($P < 0.05$) in dropseeds, globemallow and twinleaf senna than bonded lambs. During the second period (August 10 to September 7) bonded and control lamb diets were different ($P < 0.05$) in purple threeawn, bush muhly, other grasses, globemallow, dwarf dalea, yellow flax, flameflower, goathead, fineleaved wildbuckwheat and Mormon tea. Although bonded sheep stayed close to the cattle, it appears that the bond did not modify the type of diet selected by sheep under these forage conditions. Research by Anderson et al. (1990) demonstrated that 4-month-old bonded lambs grazed 7% more grass, 5% and 4% fewer forbs and shrubs, respectively, than non-bonded lambs. However, in spite of these influences, diets of bonded and non-bonded lambs averaging 6 months of age differed by <5% for any plant life form during both sampling periods.

Cattle diets between July 13 and August 10 were similar in grasses ($P = 0.436$), forbs ($P = 0.266$) and shrub/cacti ($P = 0.904$) regardless of whether they were grazing with bonded sheep or non-bonded sheep (table 2). However, during the second period, ending September 7, cattle with bonded sheep consumed more total grasses ($P = 0.003$), and less forbs ($P = 0.008$) and less shrub/cacti ($P = 0.016$) than did control cattle. Cattle selectivity apparently overcame differences in grass standing crop composition since the mean percentage of all grasses was greater in the locations where control cattle grazed compared to locations where cattle were grazing with bonded sheep (68.8% vs 43.0%). These data do not agree with Fraps and Cory (1940) and Everitt et al. (1981) who reported that livestock selection is closely related to the most abundant plant species. Thetford et al. (1971) reported that cattle diets reached a peak in total grasses in August in southcentral New Mexico. Phenological stage of plant growth may modify livestock diets under free-ranging conditions. Bowns and Matthews (1983) showed that cattle utilize more grass inflorescences than grass leaves and stems. However, the reverse is normally true. In this study large amounts of grass inflorescences, specifically dropseeds, were observed in the standing crop during the end of the perennial growing season compared to the first interval of diet sampling.

Liveweights

Liveweight gains of non-bonded and bonded sheep differed ($P = 0.004$) for the period July 13 to August 10 (period 1). On average non-bonded sheep gained 2.0 kg/hd more than bonded sheep. However, between August 10 and September 7, the liveweight gains were similar ($P = 0.296$). Prior to release into the flerd, the bonded lambs had been confined with cattle in small pens and fed alfalfa hay. Osuji (1974) reported that livestock spend 25% more time and energy foraging in unfamiliar environments when presented with novel food compared to livestock reared in the environment in which it is used to foraging. Also, sheep in unfamiliar environments ingested less food than livestock reared in similar environments (Arnold and Maller, 1977). Provenza and Balph (1988) reported on non-published data by J.N. Stellflug that ewes reared in drylot lost 5% in body weight when grazing summer range, while ewes raised on rangeland maintained body weight. Lack of experience to free-ranging-conditions and the close pen confinement with cattle to facilitate bonding may have influenced initial dietary selection of the bonded lambs used in this study. However, by period 2 the bonded lambs may have adapted to the range environment. However, without further research this hypothesis remains speculative.

Conclusion

The interpretations are limited by only one year's data. Results may have been different in a drought year.

The temporal grazing/browsing profile of cattle with bonded sheep differed from cattle paired with non-bonded sheep. Cattle in the flerd reduced their grazing time relative to the controls, while the bonded sheep lengthened their grazing time. Irrespective of treatment, the major grazing bout for the three animal species was early morning.

Botanical composition of cattle and sheep diets differed ($P < 0.05$) in total grasses and forbs consumed regardless of bonding treatment. There were distinct dietary patterns for each animal species/treatment combination between the two time periods. Bonded and non-bonded lamb diets differed only slightly < 5% for any plant life form during both sampling periods. Differences between cattle and bonded and non-bonded lambs was insignificant indicating no competition during perennial growth under above average precipitation. Therefore, spatial pattern of livestock associations during grazing did not appear to influence diets. Overall total liveweight gains for bonded and non-bonded sheep were similar between July and September. However, within this time interval control sheep gained 2.0 kg/hd more than did bonded sheep during period 1. However, liveweight differences were small (0.6 kg/hd) and not significant ($P > 0.05$) during the last half of the study.

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