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Diet Selection of Bonded and Non-Bonded Free-Ranging Sheep and Cattle*

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ABSTRACT

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Compared with monospecies stocking, numerous studies substantiate that multispecies stocking can efficiently increase use within and among the mosaic pattern of rangeland plant life forms. However, multispecies stocking may fail to bring anticipitated biological and financial results because of severe small ruminant losses, often because of coyote (*Canis latrans*) predation. Previously published data have demonstrated that when young lambs are bonded to cattle, they will follow cattle under free-ranging conditions. This close association under free-ranging conditions has been shown to reduce coyote predation on lambs. However, in addition to protection, lambs that stay with cattle may have their diet selection influenced. Differences between cattle and sheep diets were estimated using microhistological analysis of heifer and lamb feces. The data indicated differences between pastures, animal species, and bonded and non-bonded lamb diets. Lambs bonded to cattle grazed 7% more grass, 5% fewer forbs and 4% fewer shrubs between April and June than non-bonded lambs. Cattle diets were not influenced by either bonded or non-bonded lambs grazing in the same pasture and averaged 57% grass, 35% forbs and 8% shrubs. In contrast, bonded sheep diets averaged 35% grass, 59% forbs and 5% shrubs. The relatively large differences between heifer and lamb diets, and the relatively small differences between bonded and non-bonded lamb diets, do not negatively impact the potential benefits to be gained from multispecies stocking using bonded sheep. Managing bonded sheep with cattle under free-ranging conditions may result in more uniform spatial use of the vegetation than would occur if either species were managed alone.

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INTRODUCTION

Diets selected by free-ranging animals result from the interaction of many individual processes arising from both plant (palatability) and animal (preference) factors (Van Dyne et al., 1980). Differences in rumen volume and body size, in physiological variation in the shape of mouth, lip and tongue parts, and in sensitivity to the taste of various compounds all contribute to diet diversity among animal species (Provenza and Balph, 1988). In addition, dietary preference can be shaped by early learning experiences arising from the foraging environment (Hafez et al., 1962; Provenza and Balph, 1987, 1988). Where and what an animal selects for its diet is not only influenced by palatability and preference factors, but by water distribution, wind direction and velocity, shade and shelter, time of day and social factors, or the complex interaction of some or all of these factors (Kothmann, 1966; Squires, 1978).

Rats (Galef, 1976) and lambs (Green et al., 1984) learn which foods to eat through interactions with adults. The grazing behavior of lambs is affected by social models (Key and Maciver, 1980). Tribe (1950) reported that young sheep imitate their parents during feeding. Therefore, the best models may be dams and familiar respected peers (Bandura, 1977; Thorhallsdottir et al., 1987).

Previous research by Anderson et al. (1987) demonstrated that young lambs, when penned together with heifers for 60 days, will form a cohesive bond to cattle that will endure under free-ranging conditions. The close association of sheep with cattle gives the smaller ruminants protection from coyote (*Canis latrans*) predation. During a 163-day study, no bonded lambs were lost to predation while non-bonded lambs were lost to coyotes at an average rate of one every 5 days (Hulet et al., 1987). Adult sheep which have not had their behavior altered through close association with cattle are seldom found grazing in association with cattle (Anderson et al., 1985). If there is abundant mixed vegetation, cattle and sheep diets seldom overlap when they are managed together because of differences in diet preference along with unique behaviors which influence the temporal and spatial use of pastures (Low, 1979; VanDyne et al., 1980; Anderson et al., 1985). Therefore if bonded lamb diets differ from non-bonded lamb diets, it could be caused by differences in the lambs's spatial location which is dictated by the cattle, or a result of the cattle acting as social models, or the interaction of the two. The object of this research was to determine if lambs bonded to heifers select diets different from non-bonded lambs grazing in the same pasture with heifers.

MATERIALS AND METHODS

The study was conducted between April and June 1986 on the Jornada Experimental Range in south-central New Mexico, near Las Cruces. Growing conditions preceding and during the study were favorable for perennials because of above-average precipitation. However, because of the temporal and spatial distribution of the precipitation, annual forbs were not abundant. The botanical composition of diets of lambs bonded to heifers was compared with that of heifers and non-bonded lambs (control). The two multispecies groups were maintained in separate pastures, ~1.6 km apart. The arid rangeland pastures averaged 324 ha in size with each pasture initially stocked with 7 heifers and 9 lambs. The livestock consisted of 18 Rambouillet×Polypay male and female lambs, and 14 heifers of Hereford×Angus and Brangus genotypes. The lambs and heifers averaged 4 and 11 months of age, respectively. Heifer liveweights initially ranged between 219±30 and 255±23 kg in the control and bonded groups, respectively. Lamb liveweights were similar in the control and bonded groups, and initially averaged 35±5 g.

To provide both animal groups with equal exposure to the inherent differences in rangeland vegetation, livestock were rotated between the two pastures. Fecal samples were taken from the same 4 lambs and same 4 heifers on each of two dates in each of the pastures. Fecal samples were considered to accurately represent the vegetation being grazed or browsed within a pasture, and were collected only after the animal had been in a pasture for a minimum of 7 consecutive days. Fecal samples were oven dried at 60 °C and then ground to pass a 1.0-mm screen. Two grams from each of the prepared samples were composited over dates within pasture by animal. Five slides were prepared from each of these 32 composite samples and analyzed using the microhistological technique described by Sparks and Malechek (1968), following sample preparation and computation procedures outlined by Holechek and Gross (1982a, b) and Holechek (1982). Twenty random locations on each slide were examined for 22 possible plant species or categories. The percent diet composition by species was calculated based on the frequency of occurrence of each species in the sample analyzed.

Vegetation was sampled twice in each pasture to quantify the frequency of occurrence by species using a modified step-point procedure (Evans and Love, 1957). At each sampling date, a maximum of 1200 points arising from 12 lines, each 100 paces long, were taken in each pasture within areas where livestock had been observed to have grazed. The vegetation data were categorized into only those species identified in the microhistological analysis. The remaining 9 grasses, 27 forbs, and 5 shrubs and cacti found in the pastures were lumped into "other" categories for grasses, forbs, and shrubs and cacti, respectively.

Data percentages were analyzed first over animal species to evaluate differences in heifer and lamb diets, and second by animal species to evaluate treatment effects and the differences in diets resulting from pasture differences. The first statistical analysis was a split-plot with treatment and animal species on the whole plot in a completely randomized design, and pasture on the split-plot. The second statistical analysis was a split-plot design with treatment (bonded or control) on the whole plot in a completely randomized design, and split-plot effects assigned to pastures. These models were analyzed using SAS Proc GLM (Statistical Analysis Systems (S.A.S.) Institute, 1985). Normality tests performed on the residuals from the analysis of variance models indicated that no transformations were needed for the fecal data. Because of non-normality of percentages, differences in the species composition of the two pastures were evaluated using a χ^2 test of homogeneity.

RESULTS

Pastures

The two pastures contained 60 plant species, composed of 15 grasses, 35 forbs, and 10 shrubs and cacti. Scientific and common names are given in Table 1. Grasses composed $\geqslant 50\%$ of the herbaceous vegetation in both pastures with burrograss being predominant in both pastures. Pasture 7BS contained almost three times as many forbs as 7D, while 7D contained twice as many shrubs and cacti compared with 7BS (Table 1). Broom snakeweed was the predominant shrub species in both pastures. The frequency of Russian thistle ($<1\%$), James rushpea ($<1\%$), broom snakeweed (11%), soaptree yucca ($<1\%$) and honey mesquite (1%) was similar in the two pastures, while the 14 other species identified in the livestock diets were not found in similar amounts in the two pastures (Table 1).

Diets

Six grasses, eight forbs and five shrubs were identified in fecal samples of both animal species. Additional species not identified were categorized as other grasses, other forbs, and other shrubs and cacti (Table 1).

The initial statistical analysis in which heifer and lamb diet differences were evaluated indicated that heifers and lambs consumed similar ($P>0.05$) amounts of alkali sacaton, tobosa, deer's tongue, desert baileya, James rushpea, Russian thistle, broom snakeweed, honey mesquite beans, Mormon tea, other shrubs, and total shrubs and cacti. Heifers consumed more ($P<0.05$) burrograss, mesa dropseed, red threeawn, other grasses, woolly paperflower, soaptree yucca and total grass than did lambs. Conversely, lamb diets were higher ($P<0.005$) in black grama, fendler bladderpod, globemallow, leatherweed croton, other forbs, total forbs and four-wing saltbush than heifer diets. In the analysis used to compare heifer and lamb diets, the diets differed ($P<0.0001$) in the amount of grass, and averaged 57 and 31%, respectively. Forbs comprised 62% of the lamb diets compared with only 35% of heifer diets ($P<0.0001$), while the shrub component in the diets for heifers and lambs was similar at 8 and 7%, respectively.

Diets of both animal species contained more ($P<0.05$) alkali sacaton, mesa dropseed, red threeawn, Russian thistle and total grass when grazing Pasture 7D compared with 7BS. Conversely, the heifer and lamb diets contained more ($P<0.05$) deer's tongue, woolly paperflower, fendler bladderpod, Mormon tea, honey mesquite beans and total forbs when grazing Pasture 7BS compared with 7D. Heifer diets contained more ($P<0.05$) burrograss, desert baileya and other grasses, and less ($P<0.05$) leatherweed croton, soaptree yucca, and total shrubs and cacti when grazing 7D in contrast to 7BS. Lambs grazed more ($P<0.05$) desert baileya, other forbs, and other shrubs and cacti in 7BS compared with 7D. The reverse was true for James rushpea and four-wing saltbush and the lambs consumed more ($P<0.05$) of these two species in 7D compared with 7BS.

Heifer diets did not differ ($P>0.05$) between pastures in the amount of black grama, globemallow, James rushpea, broom snakeweed, four-wing saltbush, other forbs, and other shrubs and cacti. Pasture did not ($P>0.05$) influence the amount of black grama, burrograss, globemallow, leatherweed croton, broom snakeweed, soaptree yucca, other grasses, and total shrubs and cacti consumed by the lambs. No tobosa was found in the lamb diets, while heifer diets only contained tobosa when grazing Pasture 7BS.

Although the differences in the diets of bonded and non-bonded lambs were quantitatively small, some differences were significant, i.e. total grass (35 vs. 28%, $P=0.0048$) and total shrubs (5 vs. 9%, $P=0.0189$). Differences in total forbs between groups approached significance (59 vs. 64%, $P=0.0858$). These differences resulted from three grass species, four forb categories, and the category of other shrubs and cacti (Table 1). Percentages of red threeawn, burrograss, other grasses, deer's tongue, leatherweed croton, Russian thistle, desert baileya, James rushpea, broom snakeweed, Mormon tea, soaptree yucca and honey mesquite beans were not different ($P>0.05$) in bonded and non-bonded lambs' diets. Bonded lambs' diets contained more ($P<0.05$) mesa dropseed, alkali sacaton, black grama, woolly paperflower and some shrubs compared with diets of non-bonded lambs. In contrast, diets of non-bonded lambs contained more ($P<0.05$) globemallow, fendler bladderpod, other forbs and four-wing saltbush compared with bonded lamb diets. Bonded lambs stayed with the cattle and it appeared that the cattle, not the sheep, selected the area to be grazed. Therefore sheep preference for a particular area within the pasture may be reduced through bonding, which in turn may quantitatively and qualitatively influence the type of diet selected by bonded sheep.

Diet $\times$ treatment (bonded vs. control) and animal species were compared. Diets of cattle grazing with bonded and non-bonded lambs did not differ ($P>0.05$) in total grasses, forbs or shrubs. Except for five diet categories (Table 1), selection for individual species also did not differ. Cattle grazing the same pasture with non-bonded lambs selected diets higher ($P<0.05$) in red threeawn and black grama compared with heifers grazing with bonded lambs (14 vs. 11% and 4 vs. 1%, respectively). In contrast, heifers grazing with bonded

TABLE 1

Frequency of occurrence (%) of grasses, forbs and shrubs in two pastures and diets of cattle, and bonded and non-bonded (control) sheep managed under simultaneous stocking between April and June 1986 in two pastures located on the Jornada Experimental Range. Note that honey mesquite identified in diets represents only beans and not the vegetative portion of the plant

Plant	Pasture		Diet											
	7D	7BS	Heifers						Lambs					
			Pasture				Mean		Pasture				Mean	
			7D		7BS		Bonded	Control	7D		7BS		Bonded	Control
			Bonded	Control	Bonded	Control			Bonded	Control	Bonded	Control		
Mesa dropseed *Sporobolus flexuosus* [Thurb.] Rydb.	8[a]	2[b]	31	23	18	20	25[a]	21[a]	11	8	2	2	7[a]	5[b]
Alkali sacaton *Sporobolus airoides* [Torr.] Torr.	8[a]	1[b]	6	8	0	2	3[a]	5[a]	6	3	1	2	4[a]	2[b]
Red threeawn *Aristida longiseta* Steud	2[a]	8[b]	13	17	9	12	11[a]	14[b]	8	9	2	<1	5[a]	5[a]
Black grama *Bouteloua eriopoda* [Torr.] Torr.	<1[a]	1[b]	1	3	1	5	1[a]	4[b]	7	6	9	4	8[a]	5[b]

Burrograss *Scleropogon brevifolius* Phil.	36^a	33^b	9	13	8	8	8^a	10^a	7	11	8	6	8^a	8^a
Tobosa *Hilaria mutica* [Buckl.] Benth	5^a	2^b	0	0	2	<1	1^a	$<1^a$	0	0	0	0	0^a	0^a
Other grasses	3^a	4^a	8	4	5	4	7^a	4^a	4	3	3	2	3^a	3^a
Total grass	62^a	50^b	68	68	43	50	56^a	59^a	44	40	26	15	35^a	28^b
Deer's tongue *Cryptantha crassisepala* [T & G.] Greene	0^a	$<1^b$	<1	0	3	1	2^a	1^a	0	0	5	2	3^a	1^a
Woolly paperflower *Psilostrophe tagetinae* [Nutt.] Greene	0^a	1^b	<1	0	8	8	4^a	4^a	0	0	10	<1	5^a	$<1^b$
Globe mallow *Sphaeralcea* spp	2^a	4^b	10	13	14	13	12^a	13^a	25	24	16	30	21^a	27^b
Leatherweed croton *Croton corymbulosus* Engelm	1^a	6^b	8	4	12	7	10^a	6^b	13	12	16	17	14^a	15^a
Russian thistle *Salsola iberica* Sennen & Pav.	$<1^a$	0^a	1	5	0	0	$<1^a$	2^a	5	2	1	1	3^a	1^a

TABLE 1 (*continued*)

Plant	Pasture		Diet											
	7D	7BS	Heifers						Lambs					
			Pasture				Mean		Pasture				Mean	
			7D		7BS		Bonded	Control	7D		7BS		Bonded	Control
			Bonded	Control	Bonded	Control			Bonded	Control	Bonded	Control		
Fendler bladderpod *Lesquerella fendleri* [Gray] Watts.	$<1^{a}$	8^{b}	1	0	2	6	2^{a}	3^{a}	0	1	7	12	4^{a}	6^{b}
Desert baileya *Baileya multiradiata* Harv. & Gray	0^{a}	1^{b}	2	2	0	0	1^{a}	1^{a}	1	0	4	4	2^{a}	2^{a}
James rushpea *Caesalpinia jamesii* [Torr. & Gray]	0^{a}	$<1^{a}$	2	2	0	0	1^{a}	1^{a}	4	3	0	3	2^{a}	3^{a}
Other forbs	11^{a}	18^{b}	4	5	5	5	4^{a}	5^{a}	6	6	5	11	6^{a}	8^{b}
Total forbs	13^{a}	37^{b}	27	31	44	39	35^{a}	35^{a}	55	49	64	79	59^{a}	64^{a}
Broom snakeweed *Gutierrezia sarothra* [Pursh.] Britt. & Rusby	12^{a}	11^{a}	0	0	<1	0	$<1^{a}$	0^{a}	0	0	<1	0	$<1^{a}$	0^{a}

Mormon tea *Ephedra trifurca* Torr.	0^a	$<1^b$	0	0	3	<1	1^a	$<1^b$	0	<1	2	1	1^a	$<1^a$
Soaptree yucca *Yucca elata* Engelm.	$<1^a$	1^a	2	1	4	7	3^a	4^a	<1	1	1	2	1^a	1^a
Four-wing saltbush *Atriplex canescens* [Pursh] Nutt.	$<1^a$	0^b	1	0	0	0	1^a	0^a	0	11	0	0	0^a	6^a
Honey mesquite *Prosopis glandulosa* var. *glandulosa* Torr.	$<1^a$	1^a	3	3	1	1	0^a	0^a	2	2	1	1	1^a	1^a
Other shrubs and cacti	12^a	1^b	3	<1	3	2	3^a	1^b	1	<1	4	1	2^a	1^b
Total shrubs and cacti	25^a	12^b	6	1	12	11	9^a	6^a	1	13	10	6	5^a	9^b

[ab]Pasture means and animal group means in the same row within animal species with the same superscript are not significantly different ($P>0.05$) according to the Proc GLM procedure of S.A.S.

lambs selected diets higher ($P<0.05$) in leatherweed croton, Mormon tea and other shrubs compared with heifers grazing with non-bonded lambs (10 vs. 6%, 1 vs. <1% and 3 vs. 1%, respectively).

A significant ($P<0.05$) pasture × treatment interaction indicated that bonded and non-bonded lambs selected different proportions of alkali sacaton, globemallow, James rushpea, woolly paperflower, other forbs, total forbs, four-wing saltbush, other shrubs and total shrubs when grazing Pasture 7D compared with 7BS. A significant ($P<0.05$) two-way interaction between bonding treatment and pasture was found for heifer diets containing burrograss, mesa dropseed, other grasses, globemallow and Mormon tea.

DISCUSSION

Diet and vegetation sampling were not replicated over seasons, years or within pastures having various combinations of plant life forms. Since 1986 was a year of above-average precipitation, this too must be considered if these data are to be used in formulating management decisions. Examining fecal material using microhistological techniques may have limitations for determining free-ranging animal diets. Microhistological analysis of fecal material from sheep (Mcinnis et al., 1983) and cattle (Vavra et al., 1978) may overestimate grasses, while forbs may be underestimated. Woody plants may be overestimated (Anthony and Smith, 1974) or underestimated (Westoby et al., 1976) using fecal analysis. Therefore it appears that generalizations in over- or underestimating plant species using microhistological analysis of fecal material cannot be made (Holechek and Valdez, 1985).

Heifers and lambs were able to be selective in choosing their diets as a result of moderate to light stocking. In addition, intraspecific diet differences were enhanced as a result of adequate herbaceous vegetation resulting from the effective precipitation received.

Bonded lambs consumed diets that differed from those of non-bonded lambs in the proportion of grasses and shrubs consumed, while total forb consumption was not different between bonded and non-bonded lambs. If these small differences exist over all seasons, diet differences caused by bonding suggest that the value of multispecies grazing will not be reduced through competition between heifers and lambs, even if they graze close together rather than in separate areas. Bonding may actually increase the number of plant species and their amount in lamb diets without seriously increasing interspecific plant competition with heifers as a result of lambs using areas which non-bonded lambs may normally not frequent. However, further research will be required to elucidate the contribution learning may have on diet selection from that of spatial location in explaining differences between diets of bonded and non-bonded lambs.

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