SUPPLEMENTATION EFFECTS ON SHEEP DIET AND WEIGHT ON SEMI—DESERT RANGE

S.K. Hamadeh[1], C.V. Hulet[2], R.R. Rouda[1] and J.L. Holechek[3]

Summary

Season and supplementation effects on weight, diet botantical composition and fecal chemical composition of mature nonpregnant fine-wool ewes were examined over nine months during fall 1984, winter 1985 and spring 1985 on semi-desert grassland range in southcentral New Mexico. Ewes were fed .33 kg/head/day pinto beans (24.6% crude protein), .45 kg/head/day alfalfa pellets (17.4% crude protein) or no supplement (15 ewes/treatment) and rotated monthly among three pastures. Supplemented ewes gained more weight (P<.01) than unsupplemented ewes during the spring and fall when forage was growing. Differences did not occur (P>.2) between treatments in ewe weight loss during forage dormancy in winter. Forage availability during our study was above average because of superior growing conditions (precipitation 142% of annual average). Sheep diets averaged 80% forbs, 17% grasses and 3% shrubs. Diets were similar among treatments in all seasons (similarity = 89%). Crude protein in simulated diets ranged from 12.0 to 14.4% during the study. Total fecal nitrogen and fecal available nitrogen were lowest (P<.01) in winter compared with fall and spring. Fecal acid pepsin disappearance was higher (P<.05) in spring than fall or winter. Fall nitrogen was higher (P<.10) in supplemented than unsupplemented ewes. Our data indicate protein supplementation can improve performance during forage dormances, but has small influence on seasonal trends in sheep diet selection. We speculate sheep would respond more positively to supplementation in years of more normal or subnormal precipitation.

(Key Words: Rangelands, ruminants, livestock production, nutrition)

[1] Assistant professors, faculty of Agricultural and Food Sciences, American University of Beirut, Lebanon;

[2] Research physiologist, Jornada Experimental Range, Agricultural Research Service, USDA, Las Cruces, NM 88003

[3] Professor, Dept. of Anim. and Range Sci., New Mexico State University, Las Cruces, NM 88003-0003.

Introduction

Nutritive value of range forage can be inadequate for grazing livestock when forage is mature, during periods of drought or during critical livestock physiological stages. Supplementation has been a common practice to help correct nutritional deficiencies and improve livestock performance. Better productivity associated with supplementation of various classes of range livestock is well documented. Various studies concerning range livestock response to supplementation are reviewed by Allden (1981) and Holechek et al. (1989). Mechanisms by which supplementation improves livestock performance have been reviewed by Horn and McCollum (1987) and Petersen (1987). Diet selectivity can affect livestock nutritional status (Heady 1964). Holechek et al. (1989) reviewed various studies showing livestock vary their preference as the season progresses. Research evaluating the effects of protein supplementation on sheep diet, seasonal botanical composition and quality is unavailable for New Mexico rangelands.

Monitoring nutritional status of grazing animals has been complicated by animal selectivity. The use of fistulated animals has limited practical application because of high labor demand, high cost and low precision (Holloway et al. 1981, Holechek et al. 1982a, Kothmann and Hinnant 1987). Fecal indices have shown potential as indicators of both diet quality and performance (Holechek et al. 1982a, Kothmann and Hinnant 1987, Holechek et al. 1989). Fecal nitrogen may provide a cost-effective tool to monitor range livestock nutritional status. Information on effects of season and supplementation on sheep fecal chemical characteristics is lacking. The objective of our study was to evaluate the effects of protein supplementation and seasonal advance on sheep performance, diet selection and fecal chemical composition on southcentral New Mexico semi-desert grassland range in fall 1984, winter 1985 and spring 1985.

Study Area

Our study was conducted on the Jornada Experimental Range, on the Jornada de Muerte plain in Dona Ana Country, New Mexico. Elevation of the study area is 1300 m. Mean temperature ranges from a maximum of 36°C in June to a minimum of 13°C in January. The mean 80-year average annual precipitation is 230 mm with 52% of the annual rainfall occuring between July and September, which coincides with the growing season for perennial grasses. Precipation during the study is shown in table 1 and was 142% of the long-term average.

The study area consisted of three pastures (10B, 692 ha; 14, 486 ha; 7B, 421 ha) similar in terms of topography and vegetation. Major vegetation is dominated by tarbush *(Flourensia cernua)*, broom snakeweed *(Gutierrezia sarothrae)* and burrograss *(Scleropogon brevifolius)*. Major forage grasses include mesa dropseed *(Sporobolus flexuosus)*, red threeawn *(Aristida longiseta)*, black grama *(Bouteloua eriopoda)*, vine mesquite *(Panicum obtusum)* and tobosa grass *(Hilaria mutica)*. Important forbs include woolly paperflower *(Psilostrophe tagetina)*, leatherweed croton *(Croton corymbulosus)* and fendler bladderpod *(Lesquerella fendleri)*. Major shrub species are soaptree yucca *(Yucca elata)* and honey mesquite *(Prosopis glandulosa)*.

Table 1. Monthly precipitation (mm) at the Jornada Experimental Range during 1984-1985.

Month	Precipitation 1984-85	Precipitation Long-term average
July	45	45
August	113	46
September	6	37
October	75	24
November	21	12
December	57	15
January	29	12
February	4	9
March	12	8
April	10	5
May	2	10
June	10	13
Total	384	236

Table 2. Chemical composition of pinto beans (B) and alfala pellets (P) fed to ewes (dry matter basis)

Component	B	P
Dry Matter, %	92.9	93.4
Crude protein, %	24.6	17.4
Total nitrogen, %	3.9	2.8
Insoluble unavailable nitrogen, %	.3	.3
Available nitrogen, %	3.6	2.5
Acid detergent fiber, %	8.6	23.1
Gross energy, kcal/g	4.3	4.2

Materials and Methods

Fifteen ewes were allocated to each of three nutritional treatments: native range forage and no supplements, native range plus alfalfa pellets fed at 0.45 kg/head/day, and native range plus pinto beans at 0.33 kg/head/day. The two supplements (table 2) were fed on alternate days at levels providing comparable amounts of energy and protein. Treatment groups were rotated monthly among pastures to minimize pasture effects over season. Ewes were fed the supplement at a central corral and had free access to a salt: mineral mixture and water. Weights of all animals were recorded at monthly intervals. Beginning September 1984 and ending June 1985, fecal grab samples of 10 pellets each were collected from five ewes in each treatment group at 3-week intervals and dried at 50°C for 48 hours on the day of collection. Samples were ground through a 1-mm Wiley screen and seasonal composites (fall, winter, spring) were prepared for each ewe across sampling dates using equal proportions of samples. Samples of key forage plants were hand plucked twice per season, dried at 50°C, ground and stored to be used for diet simulation. Botanical composition of seasonal composites was determined by microhistological technique (Holechek and Valdez 1985a, Holechek and Valdez 1985b). Procedures for sample preparation and subsequent computation as described by Holechek (1982) and Holechek and Gross (1982b) were used. Five slides were prepared for each composite diet. Fecal material was soaked in bleach to remove plant pigments, rinsed and mounted on slides with Hoyer's solution. Observers were trained using Holechek and Gross (1982a) procedures. Observer accuracy was evaluated repeatedly for 10 hand-compounded diets until 90% accuracy was obtained. Twenty random fields were observed per slide at 200x magnification with a binocular microscope. Plant fragments were identified, recorded as frequencies and estimated as a percentage of the diet for each species. Dietary similarities between groups were calculated using Kulczynski's similarity index (Oosting 1956). Seasonal diet composites were simulated for each treatment group based on the microhistological analysis. Dry matter and ash content of supplements, fecal samples and simulated diets were determined by AOAC (1984) methods. Total nitrogen and fiber bound nitrogen were determined using Kjedahl procedures (AOAC 1984) and acid detergent fiber was determined according to procedures of Goering

Table 3. Percent by weight botanical composition of sheep diets supplemented with pinto beans (RB), alfalfa pellets (RP) or no supplement (R) on semi-desert rangeland during 1984-1985.

	Season												
	Fall 1984				Winter 1985				Spring 1985				
Forage	R	RB	RP	SE[j]	R	RB	RP	SE[j]	R	RB	RP	SE[j]	$\bar{X}$
Grasses:													
Black grama	5^{c}	8^{d}	8^{d}	0.4	10	10	11	1.0	7	6	10	0.6	8
Burrograss	4^{a}	5^{b}	6^{b}	0.4	5	4	4	0.6	2	4	2	0.3	4
Others[g]	5	5	4		7	3	4		5	5	4		5
Total grasses	14	18	18	0.8	22	17	19	1.6	14	15	16	0.9	17
Forbs:													
Woolly paper-flower	29^{b}	28^{b}	23^{a}	1.4	35^{a}	32^{b}	34^{ab}	1.0	20	22	18	1.1	27
Leatherweed croton	13^{a}	10^{b}	11^{ab}	0.9	12^{c}	12^{c}	9^{d}	0.8	12	13	12	0.7	12
Hymenopappus	17^{ac}	13^{bc}	10^{bd}	0.9	11^{e}	18^{f}	17^{f}	0.7	6^{a}	9^{b}	8^{b}	0.7	12
Bladderpod	6	8	8	1.1	7	7	8	0.7	3^{c}	4^{c}	9^{d}	0.8	7
Stickleaf	10	10	9	1.5	-	-	-	-	5^{f}	3^{f}	1^{e}	1.6	4
Roundleaf snakeweed	5^{e}	6^{e}	10^{f}	0.7	4	4	4	0.5	10^{ac}	8^{bc}	12^{bd}	0.8	7
Others[h]	5	5	4		10	4	4		27	22	20		11
Total forbs	86	80	77	1.5	78	77	76	1.3	84	82	80	1.3	80
Total Shrubs[i]	1^{c}	2^{c}	4^{d}	0.5	1^{e}	6^{f}	4^{f}	1.0	2	3	4	0.7	3

[ab] Means within seasons with different superscripts differ ($P < .05$).

[cd] Means within seasons with different superscripts differ ($P < .01$).

[ef] Means within seasons with different superscripts differ ($P < .0005$).

[g] Includes mesa dropseed (*Sporobolus flexuosus*), alkali sacaton (*Sporobolus airoides*).

[h] Includes globemallow (*Sphaeralcea varieties*), deers tongue (*Cryptantha crissisepala*), Tansyleaf aster (*Machaeronthera tanacetifolia*), purple scorpionhead (*Phacelia intermedia*), and flameflower (*Talinum argustissimum*).

[i] Includes mormon tea (*Ephedra trifurca*) and fourwing saltbush (*Atriplex canescens*).

[j] Standard error. n = 5.

and Van Soest (1970). Fecal samples were analyzed for acid pepsin disappearance (Wofford et al. 1985) using the second stage of the Tilley and Terry procedure (1963). Pepsin disappearnace may give an estimate of microbial matter in the feces (Wofford et al. 1985). Non-fiber bound nitrogen was computed as the difference between total nitrogen and fiber bound nitrogen.

Body weight change, botanical components of diets and fecal chemical components were analyzed using a split plot design with treatment as the main plot and season as the subplot. When significant F values were obtained, means were separated by least significant difference procedures (Steel and Torrie 1980). Relationships between performance (seasonal weight change) and fecal chemical components (seasonal mean) were analysed using correlation and simple linear regression analysis. A stepwise regression technique (Draper and Smith 1981) was used to obtain the best predictive models for weight change with weight change as the dependent variable and total fecal nitrogen, fecal non-fiber bound nitrogen, fecal acid detergent fiber and fecal acid pepsin disappearance as independent variables. Procedures of the Statistical Analysis System (SAS 1982) were used in all analyses.

Results and Discussion

Diet Botanical Composition

Key species in sheep diets during the study (table 3) were woolly paperflower *(Psilostrophe tagetinae)*, leatherweed croton *(Croton corymbulosus)*, hymenopappus *(Hymenopappus spp.)* and black grama *(Bouteloua eriopoda)*. Forbs dominated sheep diets in all seasons, comprising 80% of the diet when data were pooled across seasons and treatments. Diet similarities among the three

Table 4. Chemical composition of hand compounded diets (simulated from botanical composition) fecal samples of sheep supplemented with pinto beans (RB), alfalfa pellets (RP), or no supplement (R) on semi-desert rangeland during fall 1984, winter 1985 and spring 1985.

Diet chemical	Simulated diets[a]					
	Season			Treatment		
Component	Fall	Winter	Spring	R	RB	RP
Organic matter, %	85.32	81.29	84.93	83.63	83.70	84.30
Neutral detergent fiber, %	45.00	53.02	40.76	45.47	44.86	47.51
Acid detergent fiber, %	36.63	44.81	36.73	35.98	37.23	40.90
Crude protein, %	12.43	12.02	14.45	13.60	13.03	12.70
Total nitrogen, %	1.98	1.92	2.31	2.18	2.08	2.03
Fiber bound nitrogen, %	.19	.26	.20	.21	.20	.24
Non fiber bound nitrogen, %	1.79	1.66	2.11	1.97	1.88	1.79

Fecal chemical	Fecal samples[a]							
	Season				Treatment			
component	Fall	Winter	Spring	SE	R	RB	RP	SE
Acid detergent fiber, %	58.9^{d}	64.0^{e}	55.7^{d}	1.2	59.0^{bc}	57.8^{b}	61.9^{c}	1.2
Total nitrogen, %	2.6^{d}	2.3^{e}	2.5^{d}	.05	2.3^{d}	2.6^{e}	2.5^{e}	.06
Fiber bound nitrogen, %	.7	.7	.7	.02	.7	.7	.7	.02
Available nitrogen, %	1.8^{d}	1.5^{e}	1.8^{d}	.06	1.5^{d}	1.8^{e}	1.7^{e}	.06
Acid Pepsin disappearance, %	17.8^{d}	15.0^{d}	21.8^{e}	.70	17.2^{b}	19.2^{c}	18.2^{bc}	.70

[a] Expressed as a percentage of organic matter.

[bc] Means within rows within season or treatment with different superscripts differ ($P < .10$).

[de] Means within rows within season or treatment with different superscripts differ ($P < .05$).

treatments were 80, 90 and 88% for fall, winter and spring, respectively. Our data are consistent with Langlands and Bowles (1976) and Hatfield (1985) using sheep, and Judkins et al. (1985) using cattle, in showing protein supplementation does not influence diet botanical composition.

Our data agree with several other studies reviewed by Holechek et al. (1989) that reported sheep use forbs heavily when they are available. Studies by Beasom et al. (1982) and Holechek et al. (1986) show considerable change in forage selection by sheep with seasonal changes. In our study, little difference in diets occurred between the three seasons. We attribute this to the warm, wet winter in 1985, which resulted in considerable winter-spring forb growth. The atypical climatic conditions during our study prevent drawing definite conclusions about sheep forage selection, other than protein supplementation has small influence on diet selection.

Ewe Diet Quality

Chemical composition data for simulated diets show little difference among supplementation treatments in protein or fiber content (table 4). Judkins et al. (1985), working in a mountain foothill area of southern New Mexico, found the diet of protein supplemented and unsupplemented steers did not differ in protein or fiber content. Simulated diet data from our study indicate diet quality was lowest in winter, intermediate in fall and highest in spring. These trends in forage selection agree with trends reported for cattle on similar, nearby ranges (Hakkila et al. 1987). Crude protein concentrations in simulated diets were adequate for maintenance of gestating ewes (NRC 1985) during all periods of the study. However, we caution that protein deficiency may be a problem in years of average or below average precipitation because of lower forb availability. The forbs selected in our study, particularly woolly paperflower and leatherweed croton, have crude protein levels well over 10% during the fall-winter-spring period when grasses are dormant (Nelson et al. 1970). The availability of these forbs is closely associated with the amount of spring-summer precipitation (Pieper and Herbel 1982). In years of reduced precipitation, these forbs are low in availability.

Sheep Weight Changes

Supplementation increased ewe weight in the fall (table 5). In spring, ewes performed better on pinto beans than when unsupplemented. However, ewes supplemented with alfalfa pellets showed reduced weight compared with those receiving no supplementation. These findings may indicate that supplemented ewes were replacing some of their forage intake with the respective supplements. Substitutive effects of energy or protein supplementation on forage intake has been reported for high supplement allowances (Cook and Harris, 1968). In this same study supplementation had little influence on ewe ovulation rate (Hamadeh 1988). Because forage availability and forage quality were much higher than during an average year, it appears logical to conclude from our data that supplementation can increase ewe weight during forage dormancy. In most years, ewes probably respond much more positively to supplementation than in the atypical year of our study.

Table 5. Mean season weight changes (kg) for ewes receiving range forage (R), range forage plus pinto beans (RB) or alfalfa pellets (RP).

Season		Treatment[a]			
		R	RB	RP	SE
Fall[b]	1984	-0.1	4.8	6.4	.8
Winter[c]	1985	-3.3	-3.9	-4.7	.9
Spring[d]	1985	3.5	6.2	0.9	.8
$\overline{X}$		0.1	2.4	0.9	

[a] Least square means ± standard error, adjusted for initial weight.
[b] RB and RP ewes differed from R ewes (P< .01).
[c] Row means did not differ (P> .20).
[d] RB ewes differed from R ewes (P< .05) and RP ewes (P< .001) and R (P< .05) ewes differed from RP ewes.

Fecal Indicators

No season x treatment interactions (P>.10) were noted for any fecal component (table 3). All fecal chemical components were influenced by supplementation except fiber bound nitrogen. Fecal nitrogen concentrations were higher (P<.05) for supplemented than unsupplemented ewes. Supplemented ewes had higher (P<.10) fecal acid/pepsin disappearance than unsupplenented ewes. All fecal characteristics were highly influenced (P<.05) by season, except acid detergent insoluble nitrogen (P>.10). These results indicate fecal chemical components are sensitive to seasonal and dietary quality trends, and may reflect nutritional trends in animals. Fecal characteristics are metabolic end products of the integration of diet quality and digestibility (Squires and Siebert 1983). Erasmus et al. (1978) reported seasonal trends in fecal fiber components that may be associated with nutritional status of wild ungulates. Fecal nitrogen components (total and available) are, for the most part, associated with microbial activity in the rumen, and are thought to fluctuate with the quality of the diet (Mason 1969). Fecal nitrogen has been related to dietary nitrogen (Raymond 1948, Hinnant 1979, Holechek et al. 1982b), intake (Gallup and Briggs 1948, Arnold and Dudzinski 1963) and digestibility (Langlands 1967, Theurer 1970, Wallace and Van Dyne 1970). Fractioning fecal nitrogen into solubble and insoluble components, correcting it for acid detergent fiber insoluble nitrogen, or using fecal acid pepsin disarrearance may alleviate problems with fecal nitrogen caused by fiber bound indigestible nitrogen in diets high in browse and forbs (Mould and Robbins 1981, Kothmann and Hinnant 1987, Wofford et al. 1985).

Total fecal N and available N were poor indicators of trends in weight change (table 6). Wofford et al. (1985) reported total fecal nitrogen concentration is a poor predictor of ruminant nutritional status when dietary crude protein levels exceed 10%. Above this level, urinary nitrogen losses are not consistent relative to fecal nitrogen losses. Dietary crude protein levels (table 4) were well above 10% for all treatments and periods of study. Wofford et al. (1985) reported that fecal nitrogen concentrations above 2.0% indicate ruminants are consuming diets with more than 10% crude protein. Our data are consistent with their findings. Studies investigating relationships between performance and fecal chemical components are few. Gates and Hudson (1981) found fecal N to account for 85% of the variation in daily gain of elk. Squires and Siebert (1983) found liveweight gain of cattle on semi-desert range to be related to total fecal N (r = .82). They reported that liveweight change was zero when fecal N approached 1.37%. In the present study, a liveweight change of zero corresponds to a fecal nitrogen value of 2.49%. However, as previously stated, all our fecal nitrogen values exceed the threshold level of 2.0%, above which fecal nitrogen becomes unreliable (Wofford et al. 1985). Fecal acid pepsin disappearance was the best indicator of trends in weight of sheep. Other research relating fecal acid pepsin disappearance to weight changes in ruminants is unavailable.

Table 6. Linear regression equations using fecal indices (%) as independent variables and weight change (kg) as dependent variable (Y = AX + B) in sheep grazing semi-desert rangelands.

Fecal component[a]	A	B	r^2	syx
	Regression characteristics[a] (animal variation excluded, n = 9)			
Acid detergent fiber	-.70	42.10	.71	2.14
Total nitrogen	9.77	-24.41	.35	3.20
Available nitrogen	9.53	-16.40	.40	3.10
Acid pepsin disappearance	.94	-17.10	.65	2.35
	Regression characteristics (animal variation included, n = 44)			
Acid detergent fiber	-.28	16.86	.13	4.20
Total nitrogen	7.84	-19.65	.27	3.86
Available nitrogen	7.56	-13.07	.27	3.86
Acid pepsin disappearance	.89	-16.05	.51	3.15

[a] Data are on an organic matter basis.

Conclusions

Our study of ewe response to protein supplements in fall 1984, winter 1985 and spring 1985 on semi-desert range in New Mexico showed that both alfalfa pellets and pinto beans enhanced ewe performance. Superior forage growing conditions occurred before and during our study. We speculate that ewe weight responses to the protein supplements would be greater in years of average (or below) precipitation. Our study is consistent with other research in showing that protein supplementation has little to no influence on diet botanical composition and diet quality of range cattle and sheep. Fecal indicators (fecal nitrogen concentration, fecal acid pepsin disappearance) showed low associations with ewe weight changes. Throughout our study estimated ewe diet crude protein levels were more than 12% for all treatments. Other research shows fecal nitrogen concentration is unreliable as an indicator of ruminant nutritional status when diet crude protein levels exceed 10%.

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