Cattle and Sheep Diets Under Short-duration Grazing

M.H. RALPHS, M.M. KOTHMANN, AND L.B. MERRILL

Abstract

Studies have shown a negative relationship between stocking rate and animal performance in conventional grazing systems. However, short-duration grazing (SDG) proponents state that stocking rates can be increased and still maintain acceptable animal performance by reducing the length of stay on a pasture. The objective of this study was to determine if sheep and cattle diet quality could be maintained in SDG as stocking rates increased from the level recommended for moderate continuous grazing to 2.67 times the recommended level. Small pastures ranging from 1.68 ha to .47 ha were fenced to give the desired stocking rates. Pastures were grazed 3 days and rested 51 days. Diets were collected from esophageally cannulated sheep and cattle during the 3-day grazing periods. Botanical composition of diets was determined and crude protein and IVOMD were analyzed to estimate diet quality. As live green forage was depleted diet selection shifted to reserve forage resulting in a decline in diet quality as stocking rate increased in pastures where reserve forage was abundant during the cool season. There were few shifts in diet selection and diet quality where vegetation was more homogenous and lacked reserve forage. Grazing pressure declined during the warm season in all pastures due to above-average forage production. Only cattle diets showed a decline in digestibility as stocking rates increased and diet selection switched from mature warm-season grass to reserve forages. Diet quality declined within the short 3-day grazing periods and the decline was greater at the higher stocking rates.

Studies have shown that animals graze selectively; i.e., the proportion of species in a grazing animal's diet is frequently not the same proportion as in the vegetation community (Hardison et al. 1954, Weir and Torell 1959, Ridley et al. 1963, Lesperance et al. 1960, Cable and Shumway 1966). The selective removal of certain plant species, individual plants, and parts of plants to the exclusion of others alters the structure of the community as well as the quantity, quality, and subsequent utilization of the remaining forage (Arnold 1964). This generally results in a negative relationship between stocking rate and diet quality (Cook et al. 1953, 1962, 1965; Pieper et al. 1959) or animal performance (Hart 1972, Cowlishaw 1969, Denny and Barnes 1977).

Petersen et al. (1965) and Hart (1978) developed hypothetical livestock performance models which showed a plateau region at low stocking rates, in which animal performance was not responsive to stocking rate. As stocking rate increased, a critical point was reached, after which animal production declined linearly. Their hypotheses were supported by research results (Allison 1978, Johnson-Wallace and Kennedy 1944, Willoughby 1959, Arnold 1960, Duble et al. 1971).

Grazing intensity (defined as the number of livestock use-days per hectare per paddock per grazing cycle) was the major determinant of livestock performance under short-duration (SDG) in Rhodesia (Denny and Barnes 1977). Combinations of stocking rates, stocking densities, and periods of stay were altered to give specific grazing intensities. By maintaining low intensity per grazing period (i.e., reducing period of stay at higher stocking rates and densities), high animal gains, as well as high production per hectare, could be maintained at the higher stocking rates.

Short duration grazing utilizes multiple pastures, high stock densities, and short grazing periods to reduce grazing pressure in an effort to improve livestock performance. Taylor et al. (1980) reported that there were fewer changes in diet selection patterns of cattle during 7-day grazing periods of a SDG system compared to 21-day grazing periods in a high-intensity, low-frequency (HILF) system. The SDG system also maintained higher diet digestibility and crude protein levels; however, diet digestibility began to decline toward the end of the grazing periods. Based on Taylor et al.'s (1980) recommendation, the grazing periods in this study were shortened to 3 days in an attempt to reduce the changes in grazing pressure within the grazing periods. This study tested the hypothesis that diet quality could be maintained in SDG as stocking rate was increased from the level recommended for continuous grazing to 2.67 times this level.

Study Area

The study was conducted at the Texas Agricultural Experiment Station near Sonora, Texas, (101° W, 30° N). Soils were Tarrant stony clays, 8 to 15 cm deep, and Tarrant silty clays, 15 to 25 cm deep (members of the clayey-skeletal, montmorillonitic, thermic family of Lithic Haplustalls). The range site classification was Low Stony Hill. Vegetation was a mixed-grass community dominated by common curlymesquite [*Hilaria belangeri* (Steud.) Nash], 3-awn species (*Aristida* Spp.), and sideoats grama [*Bouteloua curtipendula* (Michx) Torr.] with scattered motts of live oak (*Quercus virginiana* Mill.). Sacahuista (*Nolina texana* S. Watt.), a large grass-like plant of the Liliaceae family was prominant on the shallow Tarrant stony clay soil and pricklypear (*Opuntia machrorhiza* Engelm) was scattered throughout the pastures. Western

Authors are former research assistant, presently range scientist, USDA-ARS Poisonous Plant Research Lab, Logan, Utah 84321; professor, Department of Range Science, Texas A&M University, College Station, Texas; and former professor in charge, Sonora Experiment Station, Texas Agricultural Experiment Station.

The assistance of C.A. Taylor, Jr. and R.T. Hinnant in conducting the experiment and Rex Hurst in analyzing portions of the data is gratefully acknowledged. Approved by the Director, Texas Agricultural Experiment Station as TA-19135.
Manuscript accepted 26 September 1985.

bitterweed (*Hymonoxys odorata* DC.), an annual poisonous species which germinated during the moist fall, was abundant during the spring and early summer.

The study began at the end of the 1980 drought and continued through one of the wettest years on record. The 30-year average annual precipitation for the area was 610 mm, but during the study, precipitation was 30% above average and fairly evenly distributed throughout the year. Data were interpreted in light of the above-normal precipitation and very favorable growing conditions.

Methods

An 8.5-ha pasture was divided into 2 blocks roughly along the soil boundary, and 4 stocking rate treatments were randomly applied to each block. Grazing herds consisted of two 317-kg heifers and twelve 40-kg yearling ewes which combined were equivalent to 3 animal units. Six additional ewes were added to the grazing herds in April to increase grazing pressure due to the above-average standing crop. Pasture sizes were varied to obtain the desired stocking rates. Pastures were alternately grazed 3 days and rested 51 days to simulate an 18 pasture SDG system. Grazing animals and esophageally cannulated diet collection animals were held in a pasture having similar vegetation adjacent to the study pasture between grazing and collection periods.

To facilitate sampling and labor involved with diet collections during the grazing periods, the cycles of the 2 blocks were staggered. The cycle of block 1 began grazing on 24 September 1980. The cycle of block 2 began on 21 October. The study continued through September 1981. Stocking rates in block 1 ranged from 1.19 to 3.46 AUM/ha (Table 1). Stocking rates in block 2 were set 20% higher than those in block 1 because the deeper soils were believed to be more productive than those in block 1.

Standing crop before and after each grazing period was determined by clipping herbaceous forage at ground level from 25, 1 × 0.25-m plots systematically located along transects running the length of the pastures. Species were grouped into forage classes: warm-season grasses, cool-season grasses, forbs, and poisonous forbs. Clipped samples were oven dried at 60° C for 48–72 hours and then weighed to estimate air dry standing crop. Utilization of herbaceous forage was expressed as the difference in standing crop before and after grazing. Utilization was compared to the estimated livestock demand for forage. Forage demand was estimated from dry matter intake requirements (NRC 1970, 1975) based on the grazing animals' weight and rate of gain. Standing crop of reserve forages (sacahuista, pricklypear, and shrubs) was sampled seasonally and the mean for the study is presented. Standing crop of herbaceous forage was summarized for 2 seasons. Cool season included grazing periods from October 1980 through April 1981, and warm season included grazing periods from May through September 1981 and the first grazing period in September 1980.

Diet samples were collected from 2 mature esophageally fistulated steers (668 kg) and 4 mature esophageally fistulated ewes (42 kg). The fistulated animals were fitted with screen-bottom bags and allowed to graze for 30 to 40 minutes in the early morning on each of the 3 days the pasture was grazed. Diet samples were frozen and later freeze-dried prior to analysis.

Individual plant species and/or forage classes in diets were identified and quantified by the fragment density technique (Kothmann 1968). A subsample of plant fragments was spread evenly over a 20 × 60-cm grid containing 20 permanently marked 1-cm² plots located at random. Fragments falling within these plots were identified and counted. Diet composition was based on percent of fragments in each forage category. An attempt was made to adjust the composition estimate by a weight factor for the different forage classes, but the variability of fragment sizes within forage classes was as great as between forage classes and thus precluded development of an accurate and reliable correction factor.

The nutrient content of the diets was determined by standard procedures. Total nitrogen (N) was determined by the Kjeldahl procedure (A.O.A.C. 1970) and reported as crude protein. In vitro organic matter digestibility (IVOMD) was determined by a 48-hour fermentation in rumen liquor followed by NDF extraction (Goering and Van Soest 1970). Rumen inoculum was taken from a rumen fistulated Angus cow grazing mature bermudagrass pasture. In vitro digestibility of samples was corrected for batch variability by including forage samples of a known in vivo digestibility. All diet samples were adjusted by the ratio of in vitro to in vivo digestibility of the standard forage.

Diet botanical composition and nutrients were analyzed by analysis of variance (ANOVA) in a split-split plot design (Helwig and Council 1979). The statistical model and mean squares are contained in Table 2. There was a significant interaction between stocking rate treatment and block for the major forage classes in cattle diets and nutrients in both cattle and sheep diets. Furthermore, grazing periods consistently accounted for the greatest amount of variation in the model. There were also significant block by period and block by stocking rate by period interactions for most of the diet components. There was a distinct shift in forage availability and diet selection and resulting diet quality between the cool winter/spring season and the warm rapid growth period. Therefore, the model was reduced and the data analyzed separately for blocks and season using grazing periods within seasons as replications in time to evaluate differences between stocking rate treatments. Where significant differences ($P \leq .10$) occurred between stocking rate treatments, linear and quadratic orthogonal polynomials were used to describe the response of diet components to increasing stocking rates (Ostle and Mensing, 1975).

The analysis of nutrients was carried one step further by using simple linear regression to describe the response of diet quality components to increasing grazing pressures as stocking rates increased. Grazing pressure is the ratio of forage demand to forage available at an instant in time. Grazing pressure index (GPI) was calculated as the total forage demand for the 3-day grazing period divided by the forage standing crop at the beginning of the period (Scarnecchia and Kothmann 1982), and was used as the independent variable in the simple linear regression. Animal demand for forage of the 3-day grazing periods was estimated from dry matter intake requirements (NRC 1970, 1975) based on the grazing animal's weight and rate of gain.

The changes in diet selection and nutrients within the 3-day grazing periods were evaluated in a partially reduced model. The day by period interactions for important forage classes and nutrients in the full model were significant but the period by block interaction was not (Table 2). Therefore, the main effects of day and the day by stocking rate interaction were analyzed separately for seasons but with blocks pooled.

Results and Discussion

Standing Crop and Utilization

Mean standing crop of forage in each pasture during the warm season was double the standing crop during the cool season (Table 3). Above-average precipitation and favorable growing conditions in late spring and early summer resulted in higher than average forage production. Sacahuista was abundant in block 1, but comprised only a minor proportion of the total standing crop in block 2. Pricklypear was fairly evenly distributed throughout all pastures.

Availability of herbaceous forage declined in direct proportion to the decreasing pasture size as stocking rates increased (Table 3). During the cool season, utilization of herbaceous forage exceeded estimated forage demand in the lightest stocking rate of both blocks, but was less than the estimated demand in the other stocking rate treatments. Actual consumption may have declined as stocking rates increased. The switch in cattle diets to reserve forages could also have accounted for the low disappearance of herbaceous forage at the higher stocking rates.

During the warm season, utilization in all treatments in block 1

Table 1. Stocking rates and area of pastures. Pasture sizes in block 2 were reduced 20% to increase stocking rates due to soil differences.

Block 1				Block 2			
		Stocking rates				Stocking rates	
Treatment	Area (ha)	AUM/ha	AUY/Sec	Treatment	Area (ha)	AUM/ha	AUY/Sec
1	1.68	1.19	26	1	1.20	1.67	36
2	0.98	2.05	44	2	0.79	2.52	54
3	0.75	2.64	57	3	0.62	3.23	70
4	0.58	3.46	75	4	0.47	4.21	91

Table 2. Statistical model and mean squares of forage classes and nutrients in sheep and cattle diets.

		% forage class in diets								% nutrients in diets			
		Sheep			Cattle					Sheep		Cattle	
Statistical model	df	Warm-season grass	Cool-season grass	Forb	Warm-season grass	Cool-season grass	Forb	Sacah-uista	Prickly-pear	CP	IVOMD	CP	IVOMD
Block	1	3900**[1]	28	4850*	12526^T	122	1154	15403	3367**	64	116	149	392
Stocking Rate (SR)	3	1433*	391	2421*	646	321	1221	1608	1008*	17	128	112	69
Block × SR (error a)	3	104	140	215	1449*	187^T	472	5103**	97	17*	48.6^T	92^T	317*
Period	6	11655**	3219**	6951**	1957**	405**	4286**	7277**	3074**	184**	377**	205**	486**
Block × Period	6	1382**	165	1202**	2420**	286*	796*	2303**	1590**	65**	128**	61	287**
SR × Period	18	307	213	378	396	138	327	877	364	7	20	36	109*
Block × SR × Period (error b)	18	263*	157*	276*	360*	77^T	265**	491	329^T	5**	20**	31**	50
Day	2	112	14	990**	4666**	424**	16	7751**	199	10**	116**	61**	245**
SR × Day	6	268*	368**	380**	116	168*	104	162	187	3	28**	4	25
Period × Day	12	237*	105	292*	396*	49	154	261	421*	4^T	15*	13**	46
Pooled non-significant interactions (error c)	92	121	104	160	198	49	119	372	159	2.4	6	4	35

[1]Significance probabilities from F-test (** $P \leq .01$), (* $P \leq .05$), (T $P \leq .10$).

Table 3. Mean standing crop (Kg/pasture) before and after grazing periods for seasons, blocks and stocking rate treatment.

			Herbaceous Forage										Reserve Forage			
		Stocking rate	Warm-season grass		Cool-season grass		Forb		Total		Utili-[1]	De-[2]	Poison-ous	Sacah-[3]	Prickly	
Season	Block	treatment	Before	After	Before	After	Before	After	Before	After	zation	mand	forb	uista	pear	Shrubs
Cool	1	1	540	432	78	56	148	111	765	600	165	95	49	800	218	430
		2	289	237	56	34	108	137	453	408	45		41	1171	219	416
		3	221	144	29	28	38	44	288	216	72		16	497	229	45
		4	143	117	17	16	25	12	185	144	41		7	890	78	102
	2	1	328	266	79	45	69	44	475	355	120		41	54	253	228
		2	169	156	27	28	70	45	266	229	37		25	51	149	37
		3	164	107	26	22	50	30	240	159	81		17	203	203	101
		4	135	93	24	10	25	12	184	114	20		12	16	135	48
Warm	1	1	713	698	178	166	477	444	1368	1308	60	115	125			
		2	376	327	86	95	293	267	754	690	64		49			
		3	245	206	63	59	193	152	500	419	81		45			
		4	174	149	35	21	113	98	340	268	72		29			
	2	1	735	725	166	156	277	180	1179	1062	117		58			
		2	315	213	82	63	267	159	664	436	228		46			
		3	222	167	50	36	128	84	400	287	113		33			
		4	268	203	51	31	81	46	400	279	121		25			

[1]Utilization is the difference in total herbaceous forage standing crop before and after grazing.
[2]Mean livestock demand for forage (kg) for 3-day grazing periods during cool and warm seasons. Calculated from NRC tables (1970, 1975) based on livestock weight and rate of gain.
[3]Standing crop of sacahuista, prickly pear and shrubs is the mean standing crop for the study.

was less than estimated demand. Two grazing periods during this season followed substantial rains and thus occurred during periods of rapid forage growth. Forage growth actually exceeded utilization resulting in higher standing crop at the end of these grazing periods. Grazing periods in block 2 occurred during periods of uniform growth and utilization was fairly close to estimated demand.

Diet Selection and Quality

Cool Season

Cool-season grass declined in sheep diets in block 1 as stocking rates increased (Table 4). This was offset by an increase in the dry dormant warm-season grass. There were no changes in grass in sheep diets in block 2; however, forbs declined in the heaviest stocking rate. Cool-season grass and forbs declined in cattle diets in block 1 with a compensatory increase in the reserve forages, sacahuista and pricklypear, as stocking rate increased. Allison (1978) also found that forbs and grass leaves declined in cattle diets as available forage declined from 50 to 10 kg/AUD in a series of grazing pressure trials.

Forbs comprised a large percentage of both sheep and cattle diets in both blocks of stocking rate treatment 2. However, this was probably due more to the relative availability of forbs (Table 3) than to stocking rate treatment. Forbs were alive and growing slowly throughout the cool season, yet there was probably little competition for forbs between cattle and sheep. Forbs growing upright were readily available to both sheep and cattle. However, most forbs were in the rosette stage for much of the cool season and were readily available to sheep but below the effective grazing height for cattle.

Standing crop of cool-season grasses was somewhat less than forbs but was readily available to both cattle and sheep. Selection pressure reduced availability of cool-season grasses as stocking rates increased and contributed to their decline in both cattle and sheep diets.

Pricklypear and sacahuista are evergreen species, but are very coarse and are considered low quality forage (Huston et al. 1981). Pricklypear was scattered fairly uniformly throughout all pastures but sacahuista was abundant only in block 1 (Table 3). As stocking rate increased in block 1, cattle switched from cool-season grass and forbs to the reserve forages, sacahuista and pricklypear.

There were no significant shifts in diet selection in block 2. Dry dormant warm-season grass was only a minor component of cattle diets but served as reserve forage for sheep in block 1 as the availability of cool-season grasses declined. The more homogenous vegetation in block 2 presented fewer opportunities for cattle to shift their diet as stocking rate increased.

The nutrient content of both sheep and cattle diets in block 1 reflected the switch to less palatable, lower quality forage as stocking rate increased. Crude protein in sheep diets declined 3.2% and IVOMD declined 5% (Table 4). Crude protein in cattle diets declined 8.8% but the decline in IVOMD was not significant. Pricklypear in cattle diets in treatments 3 and 4 may have increased the overall digestibility of diets. Taylor et al. (1980) also reported that high levels of pricklypear in cattle diets increased nutrient digestibility in spring and fall.

The lack of changes in diet selection in block 2 resulted in few significant differences in diet quality as stocking rate increased. Only IVOMD in sheep diets declined as stocking rates increased. CP and IVOMD in both sheep and cattle diets were uniformly lower than in block 1.

Table 4. Mean percentage of major forage classes and nutrients in sheep and cattle diets for cool and warm seasons.

			Block 1						Block 2					
			Stocking rate					Orthogonal[2]	Stocking rate					Orthogonal[2]
Animal	Season	Diet component	1	2	3	4	P[1]	polynomial	1	2	3	4	P[1]	polynomial
% Forage Class														
Sheep	Cool	Warm-season grass	12	12	27	28	.01	+L	25	36	29	40	.34	
		Cool-season grass	39	24	26	13	.02	–L	24	8	19	17	.32	
		Forb	47	61	35	52	.10		42	50	42	30	.03	Q
	Warm	Warm-season grass	42	43	44	53	.63		53	58	64	68	.09	+L
		Forb	55	50	45	31	.08	–L	36	32	30	20	.01	–L
Cattle	Cool	Warm-season grass	12	11	10	4	.28		14	18	13	20	.57	
		Cool-season grass	26	14	4	1	.03	–L	7	6	7	3	.69	
		Forb	28	35	10	1	.09	–L	10	19	13	8	.10	Q
		Sacahuista	29	34	53	74	.05	+L	52	31	43	29	.26	
		Pricklypear	1	4	17	21	.15	+L						
	Warm	Warm-season grass	56	37	40	25	.11	–L	82	79	76	85	.70	
		Forb	16	14	15	8	.63		7	8	7	6	.85	
		Sacahuista	23	43	37	59	.02	+L	5	2	9	3	.09	
% Nutrients														
Sheep	Cool	CP	18.5	19.9	16.2	15.3	.006	–L	15.4	15.9	15.0	15.5	.84	
		IVOMD	74	74	65	69	.005	–L	69	69	68	66	.10	–L
	Warm	CP	12.8	12.5	12.4	11.9	.73		10.8	10.6	10.8	11.1	.86	
		IVOMD	66	66	63	64	.40		62	64	63	62	.02	
Cattle	Cool	CP	14.5	12.8	8.3	5.7	.08	–L	8.5	8.9	8.1	7.9	.78	
		IVOMD	65	63	61	57	.37		56	65	62	66	.13	
	Warm	CP	9.7	9.2	8.4	7.5	.15	–L	8.3	7.8	7.9	8.4	.54	
		IVOMD	55	56	55	51	.44		60	59	60	61	.88	
Grazing pressure index														
	Cool		.12	.20	.31	.57			.20	.35	.40	.51		
	Warm		.09	.17	.26	.46			.11	.18	.31	.32		

[1]Probability of Type I error or α.
[2]Linear or quadratic orthogonal polynomial response of diet component to increasing stocking rate. Significance probability of orthogonal polynomial $\alpha < .05$.

Table 5. Change in forage class and nutrients in sheep and cattle diets within 3-day grazing periods.

	Sheep Diets								Cattle Diets							
	Cool Season				Warm Season				Cool Season				Warm Season			
	Day				Day				Day				Day			
Diet component	1	2	3	P[1]	1	2	3	P	1	2	3	P	1	2	3	P
% Forage Class																
Warm-season grass	24	24	25	.90	55	58	61	.31	24	13	10	.01	74	64	47	.002
Cool-season grass	18	18	18	.87	1	2	3	.08	13	8	3	.16	1	3	1	.90
Forb	54	53	48	.67	39	32	25	.008	18	18	16	.81	6	6	8	.19
Sacahuista	2	3	6	.07	2	2	5	.10	26	40	54	.002	17	25	34	.01
Pricklypear	—	—	—	—	—	—	—		17	19	13	.16	1	5	7	.07
% Nutrients																
CP	17.0	16.0	15.6	.04	11.3	10.9	10.7	.35	9.6	8.8	8.4	.08	8.5	7.9	7.0	.01
IVOMD	71	69	68	.07	64	62	61	.15	64	61	57	.0004	57	57	57	.93

[1]Probability of Type I error or α.

Table 6. Regressions, describing the relationship between grazing pressure index (GPI) (x) and nutrients (y) in sheep and cattle diets in block 1.

Animal	Season	Nutrient	P[1]	R^2	Equation
Sheep	Cool	CP	.008	.51	$y = 20.49 - 10.65x$
		IVOMD	.09	.25	$y = 75.44 - 16.97x$
Steer	Cool	CP	.009	.50	$y = 17.33 - 26.31x$
		IVOMD	.15	.19	$y = 67.06 - 20.48x$
	Warm	IVOMD	.02	.33	$y = 60.59 - 26.92x$

[1]Probability of Type I error or α.

Warm Season

Botanical composition of sheep diets was sensitive to stocking rate in both blocks. Forbs declined and warm-season grass increased in block 2. Sacahuista replaced warm-season grass in cattle diets in block 1 as stocking rate increased. Warm-season grass in cattle diets declined 31% while sacahuista increased 36%. In block 2, warm-season grasses dominated cattle diets but stocking rate did not affect diet selection.

Although there were distinct shifts in selection by sheep, changes in diet quality during the warm season were not significant. However, there was a negative trend of CP in cattle diets in block 1, reflecting the switch from warm-season grass to sacahuista as stocking rate increased.

IVOMD of cattle diets in block 2 was markedly higher than in block 1. Warm-season grasses dominated cattle diets in block 2 and were more digestible than the sacahuista-dominated diets in block 1.

Diet Changes within Grazing Periods

There were changes in diet selection and quality among days within the 3-day grazing periods (Table 5). Although the main effects of day for forage classes in sheep diets in the cool season were not significant, there was a significant day by stocking rate interaction for forbs. Forbs declined only 3% in treatment 1 compared to 21% in treatment 4 within the 3-day grazing periods. Cool and warm season grasses fluctuated in the diets without apparent response to stocking rate. There was a significant decline of forbs in sheep diets within the 3-day grazing period during the warm season. This was offset by nonsignificant increases of both cool and warm season grasses.

Warm season grass declined significantly in cattle diets with a compensating increase in sacahuista within the 3-day grazing period during both the cool and warm seasons (Table 5). Cool season grass showed a day by stocking rate interaction during the cool season declining from 26% to 8% of the diet in treatment 2 while diets in treatment 4 contained less than 5%.

Nutrients in both cattle and sheep diets declined slightly within the 3-day grazing period during the cool season (Table 5). However, there was a significant day by stocking rate interaction for IVOMD in sheep diets. IVOMD declined only 1% in treatment 1 compared to 5% in treatment 4 during the cool season and increased 2% in treatment 1 but decreased 7% in the warm season. During the warm season, CP in cattle diets decreased during the grazing period.

Other grazing trials have shown a switch from preferred to less preferred forage and resulting decline in diet quality with progressive utilization of forage during the trials (Pieper et al. 1959, Cook et al. 1962, Anderson 1977, Pfister et al. 1984, Taylor et al. 1980). Our data demonstrate that even within short grazing periods, there were shifts to less preferred and lower quality forages, and the shifts were more dramatic at the higher stocking rates.

Diet Quality in Relation to Grazing Pressure

Grazing pressure index is a quantative expression of the relationship between animal demand and available supply of forage, and thus is a more sensitive parameter of animal-forage relations than stocking rate. Significant negative regressions generally occurred between GPI and diet quality components in both sheep and cattle diets in block 1 during the cool season (Table 6). Crude protein showed a fairly strong negative relationship to GPI in both sheep and cattle diets. IVOMD was not as strongly correlated. The increasing amounts of the highly digestible pricklypear in cattle diets as stocking rates increased probably mitigated the negative influence of increasing GPI on IVOMD. Due to the lack of shifts in diet selection in block 2, there was no relationship between GPI and diet quality.

Forage was probably not limiting to sheep in any of the stocking rate treatments during the warm season. As a result, sheep diet quality showed no response to GPI during the warm season. Denny and Barnes (1977) stated that grazing intensity had no effect on animal production during the dormant season; indicating little difference in nutritive quality of available forage. Where forage is uniform in quality and in sufficient quantity that it does not limit intake, grazing pressure would not be expected to influence diet quality or production. This corresponds to the plateau region of Hart's (1978) theoretical stocking rate model.

Cattle switched from dry warm season grass to sacahuista in the latter part of the summer as GPI increased, creating a significant negative regression between GPI and IVOMD in block 1.

Summary and Conclusions

Diet quality is only one component of livestock gains. Intake is also important but was not measured in this study. Olson and Stuth (1984) reported a significant reduction of intake at heavy stocking rates under SDG, in addition to a decline in nutrients in cattle diets. Intake could also have declined as stocking rates increased in our study; especially in block 2 where there was less opportunity to shift diets to reserve forage when live green forage was limited.

There were significant changes in diet selection within the short 3-day grazing periods of this simulated SDG system and the magnitude of these changes was greater at the higher stocking rates. Both cattle and sheep shifted to less preferred reserve forage with a resulting decline in nutrient quality of diets in block 1 during the cool season. These results support the hypothesis of diet sensitivity to grazing pressure: "Sensitivity of nutrient intake to grazing pressure is a function of the degree of variation in forage quality within the standing crop" (Kothmann, 1980). Live green forage was limited during the cool season. In block 1, reserve forage was abundant and cattle switched from forbs and cool season grass to reserve forages with a decrease in diet quality as grazing pressure increased at the higher stocking rates. There was also a shift in sheep diets from cool-season grass to mature warm-season grass which resulted in a significant decrease in diet quality.

The selection patterns observed in block 1 were obscured in block 2. The differences between blocks are not entirely explained by differences in available forage (Table 3). However, block 2 had a more homogenous vegetation community that provided limited opportunity for shifts in diets.

The high amount of precipitation during the spring and early summer allowed for excellent regrowth of forage and maintained a fairly high standing crop. Mean grazing pressure was reduced by 25% and 46% from cool-season levels in block 1 and 2, respectively. There were shifts in sheep diet selection in both blocks during the warm season, but the light grazing pressure provided sufficient selectivity within the short 3-day grazing period that diet quality was not affected. During the latter part of the summer the warm-season vegetation entered dormancy. Cattle shifted from warm season-grass to sacahuista in block 1 as stocking rates increased with a resulting decline in diet quality.

Sheep diet quality was substantially higher than cattle diet quality but the proportional reduction in quality was greater for cattle than for sheep as stocking rates increased. Sheep appeared to be less affected by the increasing stocking rates in this simulated SDG than were cattle.

Heitschmidt et al. (1983) speculated that SDG may be able to extend the critical stocking rate of Hart's (1978) model and maintain livestock performance at higher stocking rates. The short 3-day grazing periods did not prevent a decline in diet quality within the grazing period but may have moderated the magnitude of decline. SDG may reduce grazing pressure and prevent a decline in nutrient intake until forage becomes limiting. But, the key to maintaining individual animal performance in SDG or any other grazing system is the availability of live green forage (Kothmann 1980). GPI on live green forage may serve as a useful tool in monitoring relative availability of forage and predicting livestock performance.

Literature Cited

A.O.A.C. 1970. Official methods of analysis. (11th ed.). Ass. Off. Agr. Chem. Washington, D.C.

Allison, C.D. 1978. Forage intake of cattle as affected by stocking pressure. Ph.D. Diss. Texas A&M Univ., College Station.

Anderson, D.M. 1977. Standing crop, diets, travel and weight changes under short-duration and continuous grazing. Ph.D. Diss., Texas A&M Univ., College Station.

Arnold, G.W. 1960. The effect of the quantity and quality of pasture available to sheep on their grazing behavior. Australian J. Agr. Res. 11:1034-1043.

Arnold, G.W. 1964. Factors within plant associations affecting the behavior and performance of grazing animals. *In:* D.J. Crisp (Ed.). Grazing in Terrestrial and Marine Environments. Symposium of the British Ecological Society. Banger 1962. Blackwell Scientific Publications, Oxford.

Cable, D.R., and R.P. Shumway. 1966. Crude protein in rumen contents and in forage. J. Range Manage. 19:124-128.

Cook, C.W., M.M. Kothmann, and L.E. Harris. 1965. Effect of range condition and utilization on nutritive intake of sheep on summer range. J. Range Manage. 18:69-73.

Cook, C.W., L.A. Stoddart, and L.E. Harris. 1953. Effects of grazing intensity upon the nutritive value of range forage. J. Range Manage. 6:51-54.

Cook, C.W., K. Taylor, and L.E. Harris. 1962. The effect of range condition and intensity of grazing upon daily intake and nutritive value of the diet on desert range. J. Range Manage. 15:1-6.

Cowlishaw, S.J. 1969. The carrying capacity of pastures. J. British Grassl. 24:207-214.

Denny, R.P., and D.L. Barnes. 1977. Trials of multipaddock grazing systems on veld. (3) A comparison of six grazing procedures on two stocking rates. Rhodesia J. Agr. Res. 15:129-142.

Duble, R.L., J.A. Lancaster, and E.C. Holt. 1971. Forage characteristics limiting animal performance on warm-season perennial grasses. Agronomy J. 63:795-798.

Duble, R.L., J.A. Lancaster, and E.C. Holt. 1971. Forage characteristics limiting animal performance on warm-season perennial grasses. Agronomy J. 63:795-798.

Goering, H.K., and P.J. Van Soest. 1970. Forage fiber analysis (apparatus, reagents, procedures and some applications). USDA Agr. Handbook 379.

Hardison, W.A., J.T. Reid, C.M. Martin, and P.G. Woolfolk. 1954. Degree of herbage selection of grazing cattle. J. Dairy Sci. 37:89-102.

Hart, R.H. 1972. Forage yield, stocking rate, and beef gains on pasture. Herbage Abstracts 42:345-352.

Hart, R.H. 1978. Stocking rate theory and its application to grazing on rangelands. *In:* H.A. Heady (Ed.). Proc. First Internat. Rangeland Congr. Soc. for Range Managet. Denver, Colo. Aug. 14-18. 1978.

Heitschmidt, R.K., H.B. Johnson, J.R. Frasure, and D.L. Price. 1983. Cow-calf and vegetation response to heavy rates of stocking at the Texas Experimental Ranch. Texas Agr. Exp. Sta. Bull. 1427.

Helwig, J.J., and K.A. Council (ed). 1979. SAS User's Guide, 1979 edition. SAS Institute Inc. Cary, N.C.

Huston, J.E., B.S. Rector, L.B. Merrill, and B.S. Engdahl. 1981. Nutritional value of range plants in the Edwards Plateau region of Texas. Texas Agr. Exp. Sta. Bull. 1357.

Johnstone-Wallace, E.B., and K. Kennedy. 1944. Grazing management practices and their relationship to the behavior and grazing habits of cattle. J. Agr. Sci. 34:190-197.

Kothmann, M.M. 1968. The botanical composition and nutrient content of the diet of sheep grazing on poor condition pasture compared to good condition pasture. Ph.D. Diss. Texas A&M Univ., College Station.

Kothmann, M.M. 1980. Nutrition of livestock grazing on range and pasture lands. p. 56-78. *In:* D.C. Church (Ed.). Digestive Physiology and Nutrition of Ruminants. (Vol. 3) Practical Nutrition. 2nd ed. O&B Books Inc., Corvallis, Ore.

Lesperance, A.L., E.H. Jensen, V.R. Bohman, and R.A. Madsen. 1960. Measuring selective grazing with fistulated steers. J. Dairy Sci. 43:1615-1622.

NRC. 1970. Nutrient requirements of domestic animals. No. 4. Nutrient requirements of beef cattle. 4th revised edition. Nat. Acad. Sci. Washington, D.C.

NRC. 1975. Nutrient requirements of domestic animals. No. 5. Nutrient requirements of sheep. 5th revised edition. Nat. Acad. Sci. Washington, D.C.

Olson, P.D., and J.W. Stuth. 1984. Nutrient intake of cattle in a short-duration grazing system as influenced by stocking rate. Abstracts, 37th Annual Meeting, Soc. for Range Manage. Rapid City, S.Dak.

Ostle, B., and R.W. Mensing. 1975. Statistics in research. 3rd ed. Iowa State Univ. Press. Ames.

Petersen, R.G., H.L. Lucas, and G.O. Mott. 1965. Relationship between rate of stocking and per animal and per acre performance on pasture. Agron. J. 57:27-30.

Pfister, J.A., G.B. Donart, R.D. Pieper, J.D. Wallace, and E.E. Parker. 1984. Cattle diets under continuous and four-pasture, one-herd grazing systems in south central New Mexico. J. Range Manage. 37:50-54.

Pieper, R., C.W. Cook, and L.E. Harris. 1959. Effect of intensity of grazing upon nutritive content of the diet. J. Animal Sci. 18:1031-1037.

Ridley, J.R., A.L. Lesperance, E.H. Jensen, and V.R. Bohman. 1963. Relationship of animal preference to botanical composition of irrigated pastures. J. Dairy Sci. 46:128-130.

Scarnecchia, D.L., and M.M. Kothmann. 1982. A dynamic approach to grazing management terminology. J. Range Manage. 35:262-264.

Taylor, C.A., M.M. Kothmann, L.B. Merrill, and D. Elledge. 1980. Diet selection by cattle under high-intensity, low-frequency, short-duration, and Merrill grazing systems. J. Range Manage. 33:428-434.

Weir, W.C., and D.T. Torell. 1959. Selective grazing by sheep as shown by a comparison of the chemical composition of range and pasture forage obtained by hand clipping and that collected by esophageal-fistulated sheep. J. Animal Sci. 18:641-649.

Willoughby, W.M. 1959. Limitations to animal production imposed by seasonal fluctuations in pasture and by management procedures. Australia J. Agr. Res. 10:248-268.