Some effects of a rotational grazing treatment on cattle grazing behavior

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Abstract

Research was conducted on the effects of rotational grazing (RG) compared to continuous grazing (CG) on the behavior of cattle grazing on rangelands. Different livestock densities in the RG treatments were created by varying the size of paddocks in a 465-ha, 16-paddock, cell designed RG treatment stocked at a rate of 3.6 ha/cow/yr. Paddock sizes of 30 and 10-ha were used to simulate RG with 14 (RG-14) and 42-paddocks (RG-42), respectively. The CG treatment consisted of a 248-ha pasture stocked at 5.9 ha/cow/yr. Data were collected using vibracorders, pedometers and observation to estimate time (min/day) spent: intense grazing, search grazing, trailing, or sleeping; distance walked (km/day), and individual animal space (m²/animal) in grazing subherds. Total grazing time did not vary among grazing treatments, but the components of total grazing (i.e., intense and search grazing) did vary among treatments. Cattle in the RG-14 paddocks spent less time search grazing compared to the ones in the other treatments presumably because the rotational grazed paddocks were more uniform because of less mixing of live and dead forage. Search grazing was highest in the RG-42 paddocks which may be due to the high stock density in this treatment coupled with an attempt to maintain individual animal space. Grazing time tended to be longer the first day in a RG-14 paddock than the last. Time spent trailing and the distance walked increased as the frequency of rotation increased among the different treatments. Sleeping was similar among grazing treatments. Individual animal space within a grazing subherd decreased as the stock density increased because of the grazing treatment.

Key Words: cell grazing, continuous grazing, vibracorders, pedometers

Grazing management affects plant and animal production through the effect that it has on critical parameters at the plant animal interface. The animal's proximal response to management-induced changes at this interface is a behavioral response. Restricted nutrient intake is probably the major factor limiting production from grazing animals (Hodgson 1982). However, behavior variables may be more sensitive to grazing management than nutrient intake because intake may be buffered by adaptive behavior. Understanding how livestock adjust their grazing behavior to variation in herbage standing crop and grazing management systems is essential to the development of a theoretical framework of the factors controlling intake of grazing animals (Demment et al. 1986).

Cattle respond to grazing management and variations in herbage standing crop and structure by varying the time spent grazing, rate of biting, bite size, time spent at a feeding station, and time spent selecting bites or feeding stations (Stobbs 1973; Jamieson and Hodgson 1979a, 1979b; Gammon and Roberts 1980; Ruyle and Dwyer 1985). Grazing behavior has been studied most extensively on relatively small improved pastures with little botanical diversity. The interest in grazing behavior on improved pastures occurred presumably because the need for such knowledge was first apparent under the increased intensity of management associated with these highly productive systems. With the advent of intensive rotational grazing systems on rangelands it is necessary to determine if the behavioral responses of cattle to intensive grazing systems are equivalent in complex and simple ecosystems.

Interest in rotational grazing systems has increased dramatically in the U.S. during the past 10 years because of the claim that proper implementation of a multi-paddock RG system will increase livestock carrying capacity on rangelands (Savory and Parsons 1980). This claim was made, however, in the absence of any supportive scientific data. Thus, in 1981 we designed a series of studies to compare the effects of rotational grazing (RG) to continuous grazing (CG) on quantity and quality of herbage produced and consumed, harvest efficiency, animal behavior, watershed condition, livestock performance (cow/calf), and economic profits. Seven previous papers have quantified the effects of 2 livestock densities in a RG treatment on quantity and quality of forage produced (Heitschmidt et al. 1987a, 1987b, 1987c), watershed condition (Pluhar et al. 1987), preference for plant communities (Walker et al. 1988a), quality and botanical composition of cattle diets (Walker et al. 1988b), and density of cattle trails (Walker and Heitschmidt 1986). Our objective in this paper is to quantify the effects of these same RG treatments on cattle behavior. We measured the amount of time spent in various activities, the distance cattle walked and density of animals within subgroups.

Materials and Methods

Study Area and Treatments

The study was conducted at the Texas Experimental Ranch located (99°14'W, 33°20'N) on the eastern edge of the Rolling Plains resource region. The climate is continental, semiarid, and highly variable. Annual precipitation is bimodally distributed and averages 682 mm. Peak precipitation months are May (96 mm) and September (118 mm). Average maximum daily temperatures range from 11.4° C in January to 35.8° C in July. Average minimum daily temperatures range from -2.4° C in January to 22.0° C in July.

The 465-ha, cell-designed (paddocks radiating from a common center) RG treatment was initiated in March 1981. Initially the treatment consisted of 14 paddocks that averaged 33 ha in size. The treatment was stocked with 125 Angus × Hereford crossbred cows at a heavy rate of 3.7 ha/cow/year. Stocking rate was constant until June 1984 when it was reduced to 5.2 ha/cow/year because of drought. Rate of rotation was flexible and varied according to vegetation growth rates and nutrient requirements of the cows. Days of rest between grazing periods ranged from about 30 to 65. In March 1982 a 30-ha paddock was divided twice creating three 10-ha paddocks for a total of 16 paddocks in the RG treatment.

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Appreciation is expressed to the Swen R. Swenson Cattle Co. for providing the land, livestock, and facilities for this study; the Texas Experimental Ranch Committee for providing financial assistance; and Steve Dowhower and David McKown for assistance in data collection.

Report is published with approval of the Director, Texas Agr. Exp. Sta. as TA 23938.

Manuscript accepted 17 November 1988.

Data on cattle behavior were collected on 5 adjacent paddocks including three 10-ha paddocks and two 27-ha paddocks. Stocking rate on the different size study paddocks was kept constant by varying the length of graze. Based on desired rest periods, length of graze in the 5 paddocks ranged from 18 hours to 2 days in the 10-ha paddocks and from 2 to 5 days in the 27-ha paddocks. Paddocks were arranged so that cattle grazed one 27-ha paddock, then the three 10-ha paddocks, and finally the other 27-ha paddock. The radial length of all RG paddocks was about 1.3 km. These treatments were designed to simulate 14- and 42-paddock RG systems. Hereafter, the 10-ha paddocks are referred to as the RG-42 treatment and the 27-ha paddocks as the RG-14 treatment.

The CG treatment was a single, 248-ha pasture that had been stocked at a moderate rate since 1960 and was stocked at 5.9 ha/cow/year throughout this study. The longest dimension of this pasture was 2.7 km and the farthest distance to the centrally located water was 1.4 km. Range condition in all pastures was good. For a more detailed description of the study area and study design, see Heitschmidt et al. (1985, 1987c).

Cattle Behavior

Cattle grazing behavior was monitored simultaneously in the CG and RG treatments during 8 seasonal trials conducted between October 1982 and August 1984. Trial duration ranged from 6 days in the spring to 15 days in the winter. Data were collected using vibracorder's (Stobbs 1970) to estimate the amount of time spent in various activities, pedometers to estimate the distance traveled (Walker et al. 1985), and observation to estimate animal dispersion. Ten cows were randomly selected from each herd and equipped with the instruments. The same cows were used for the first 4 trials and a different set of randomly selected cows were used for the last four trials.

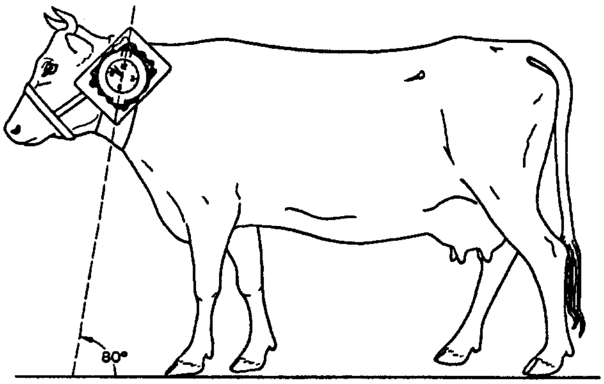

Fig. 1. *Diagram of a cow with a vibracorder oriented at an 80° angle with the horizon.*

Vibracorders were attached to the animals by placing them in a neoprene bag that was fastened around the animal's neck and counter weighted opposite the vibracorder. The vibracorders were oriented so that when a cow was standing with her head up, a line passing through the 12 and 6 o'clock positions on the clock face intersected the horizon at approximately an 80° angle (Fig. 1). With vibracorder mounted in this manner, the pendulum and the attached stylus that scribes the chart are sensitive to the position (raised or lowered) of the animal's head and to somatic activity. The mark caused by the movement of the pendulum is at the top (i.e., centrifugal position) of its stroke when the animal's head is up and the bottom (i.e., centripetal position) of its stroke when the head is down. Furthermore, when the animal's head is up pendulum movement is sensitive to somatic activity, while when the head

Table 1. The effect of grazing treatments and seasonal trials on the time spent in various activities (min/day).

Grazing Treatment	1982 Oct	1983 Jan	1983 Jun	1983 Sep	1984 Jan	1984 Mar	1984 May	1984 Aug	Treatment Average
Total Grazing									
CG	614	589	692	648a	578	744	750	607	653
RG-14	576	549	662	523b	533	633	681	575	591
RG-42	565	538	616	531b	513	637	660	527	573
Trial Average	585a	559a	657b	567a	542a	671b	697b	570a	
Intense Grazing									
CG	268	370	319	402a	390	345a	292	212a	325a
RG-14	367	408	298	249b	382	379a	299	177a	320a
RG-42	354	368	216	107c	339	222b	262	43b	239b
Trial Average	330ab	382b	278ac	252dc	371ab	315ab	284a	144d	
Search Grazing									
CG	346	219a	373	247a	188	399	458	395	328ab
RG-14	209	141b	364	274a	151	254	382	398	272a
RG-42	211	171c	400	424b	174	415	397	484	334b
Trial Average	255a	177a	379b	315b	171a	356b	412b	426b	
Trailing									
CG	24	6	3a	14a	5	1	2	7	8a
RG-14	39	15	11a	9a	12	15	13	9	16a
RG-42	64	18	62b	22b	12	18	24	32	31b
Trial Average	42a	13b	25a	15b	10b	11b	13b	16b	
Sleeping									
CG	61	57	40	49	56	37	29	41a	46
RG-14	59	64	48	60	60	48	32	48a	52
RG-42	61	65	38	39	63	44	34	34b	47
Trial Average	60a	62a	42bc	49b	60a	43bc	32c	41bc	

[a,b,c]Means in the same activity and column or within the same trial average followed by different letters were different ($P<0.10$).

Table 2. Simple means ± standard deviation of individual animals for daily travel distance (km/day) measured with pedometers.

Grazing Treatment	TRIAL 1982 Oct	1983 Jan	1983 Jun	1983 Sep	1984 Jan	1984 Mar	1984 May	1984 Aug	Treatment Average
					km/day				
CG	6.1 ± 0.8	4.2 ± 0.8	5.0 ± 1.9	6.4 ± 0.9	4.1 ± 0.4	5.7 ± 1.0	9.2 ± 2.3	5.7 ± 1.5	5.8 ± 2.0
RG-14	6.5 ± 1.7	5.8 ± 1.2	5.7 ± 1.8	5.6 ± 0.6	4.7 ± 0.6	6.6 ± 1.7	8.5 ± 1.6	8.9 ± 2.2	6.5 ± 2.0
RG-42	8.1 ± 1.5	6.8 ± 1.6	8.6 ± 2.2	6.9 ± 0.9	4.7 ± 0.9	8.6 ± 2.2	9.4 ± 1.3	12.6 ± 2.4	8.2 ± 2.7
Trial Average	6.9 ± 1.6	5.6 ± 1.6	6.4 ± 2.5	6.3 ± 1.0	4.5 ± 0.7	7.0 ± 2.1	9.0 ± 1.8	8.8 ± 3.5	6.8 ± 2.4

is down the pendulum is insensitive to somatic activity. By mounting vibracorders in this position we were able to distinguish 5 activities, viz., 2 types of grazing, uninterrupted walking bouts (e.g., trailing to water), sleeping, and loafing (Fig. 2).

The 2 types of grazing were termed intense and search grazing. Intense grazing was indicated on the chart by a single concentric arc (caused by the rotation of the clock) positioned at the bottom of the stroke with occasional centrifugal lines perpendicular to this arc that represent head raising (Fig. 2). The frequency of the

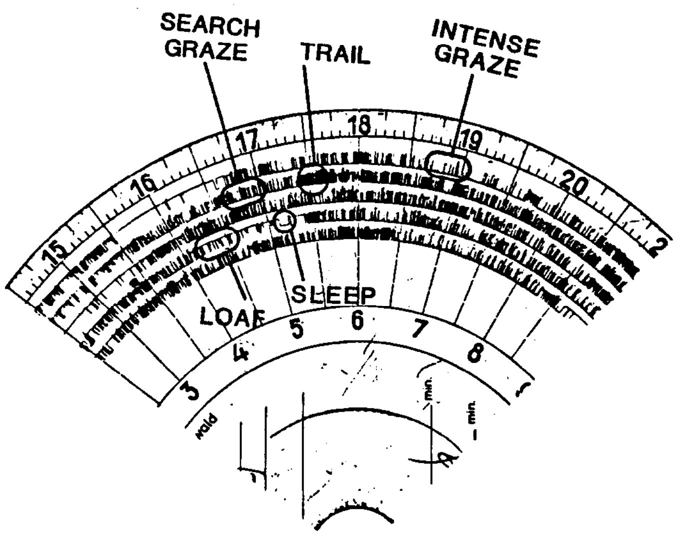

Fig. 2. *Vibracorder chart showing the different patterns that were created by various activities when the vibracorder was mounted as shown in Figure 1.*

centrifugal lines on the chart was proportional to the amount of time during a grazing bout that the animal's head was up. When the frequency of centrifugal lines increased to more than about 1 per minute, the activity was classified as search grazing (Fig. 2). When the cattle were very active as in episodes of uninterrupted travel the vibracorder pendulum swung freely, creating a dark band that extended past the normal centrifugal and centripetal limits of the stroke when it was at rest in either of these positions. These dark bands of coalesced arcs with no discernable orientation (i.e., centrifugal or centripetal) were classified as trailing (Fig. 2). When cattle are recumbent with their head either resting on the ground or turned back on their flank (i.e., milk fever position) they are generally considered to be engaged in deep sleep (Ruckebusch et al. 1974). When cattle were in this posture the scribe on the chart was in the head down position. Such events lasted about 5 min and resulted in a "U" shaped scribe on the chart which was classified as sleep (Fig. 2). Loafing (i.e., idle or ruminating) was indicated on the vibracorder chart by a single, centrifugally located, arc with perpendicular centripetal lines caused by somatic movement (Fig. 2).

Distance traveled was estimated using 2 pedometers per animal with 1 attached to each foreleg. Attachment and calibration were as described by Walker et al. (1985). Pedometers were read when vibracorder charts were changed, cattle were rotated between RG treatments, and at the end of each trial. The time of each reading was recorded and travel distance was expressed as a daily average for each treatment.

Cattle Dispersion

Cattle were observed simultaneously in the CG and RG treatments. Observations were made using scan sampling (Altmann 1974) at hourly intervals between daylight and dark for a total of 75 observation days in each treatment. The location, peripheral boundary, activity, and number of cows in each herd or subherd was recorded on topographical maps. Activities were classified as grazing, loafing, or mixed. Subherds were classified as grazing or loafing when 90% or more of the animals within the subherd were engaged in the specified activity. When less than 90% of the animals within a subherd were engaged in the same activity, subherd activity was classified as mixed. Individual animal space (m^2/animal) was calculated from the recorded areas of occupation of each subherd.

Data Analyses

Vibracorder data were summarized as daily duration (i.e., min/-day) spent in each activity averaged across animals and days within a trial and paddock. Likewise, dispersion data were summarized as average individual animal space for each trial and paddock. These paddock averages were analyzed separately for each activity using repeated measurements least squares analysis of variance with grazing treatment (i.e., RG-42, RG-14, and CG) as the main plot and trial as a repeated measurement. These data were also analyzed for each trial separately using a one-way analysis of variance with grazing treatment as the main effect. Data from the RG-14 treatment were further analyzed to determine if the average duration of the different activities differed among the days in a paddock using a within paddock split-plot analysis. For this analysis the data were split into 3 subsets based on the length of the graze period in the RG-14 paddocks and the day effect was analyzed using linear contrast of orthogonal polynomials. If the covariance matrix of the repeated measures analysis did not satisfy the Huynh-Feldt condition, the probability level of the associated F-ratio was based on the Box correction for degrees of freedom (Huynh and Feldt 1976). Protected least significant differences were used for mean separation. These analyses used the variation among the 2 paddocks in the RG-14 treatment and the 3 paddocks in the RG-42 treatment to estimate experimental error in this grazing treatment case study.

General linear models were used to evaluate the relationship between grazing time and forage (Heitschmidt et al. 1987c) or diet (Walker et al. 1988b) variables that were collected in companion studies to this investigation.

Data from pedometers represents cumulative travel between readings and can not indicate temporal distribution. Therefore, average values for each animal and treatment were the only information available for this variable, and travel distance was interpreted using sample means and standard deviations.

Results

Variation among paddocks was great and the effect of trial was the major factor affecting time spent by cattle in the different activities (Table 1). The interaction of grazing treatment and trial was not significant.

Grazing Treatments

Total grazing time across all trials was similar among treatments ($P>0.30$), averaging 653, 591, and 573 min/day in the CG, RG-14, and RG-42 treatments, respectively (Table 1). Analysis of individual trials indicated that total grazing time was affected by grazing treatment in September 1983 when the cattle in the CG treatment grazed longer than the ones in the RG treatments ($P<0.10$).

Intense grazing varied among grazing treatments ($P<0.01$) and cattle in the CG and RG-14 treatments spent more time engaged in intense grazing than the ones in the RG-42 treatment (325, 320, and 242 min/day, respectively). Analysis of the individual trials indicated that this difference was significant in September 1983, March 1984, and August 1984 (Table 1). Time spent search grazing was greater ($P<0.05$) for RG-42 cattle than RG-14 cattle, while the CG cattle were intermediate (334, 272, and 328 min/day, respectively).

Time spent trailing increased as the frequency of rotation increased from the CG to the RG-42 treatment (Table 1). This increase was consistent with distance travelled (Table 2). However, the increase was proportionally greater when measured with vibracorders (time) than with pedometers (distance). Movement between paddocks partially accounted for the difference among grazing treatments in the distance traveled (km/day). Observation data indicated that cattle travelled about 1.5 km each time they were rotated. Thus, travel due to rotation averaged 0.5 and 1.5 km/day in the RG-14 and RG-42 treatments, respectively based on a modal duration of a 3-day/1-day graze period in the RG-14 and RG-42 treatments, respectively.

The amount of time spent in deep sleep was not affected by grazing treatment. The average value across all treatments of 49 min/day is in close agreement with the data of Ruckebusch (1975) and Ruckebusch and Bueno (1978).

Day of Rotation

In the RG-14 treatment the day of grazing in a paddock affected the amount of time spent in the different activities only during trials with a 3-day graze period. Total grazing time declined linearly ($P<0.13$) between the first and third day in a paddock (Table 3). This decline in total grazing time was due to approximately equal declines in both intense ($P<0.14$) and search grazing ($P<0.30$). There was a trend toward a decrease in grazing time because of day in a paddock for the 2-day and 4-day trials but it was not significant. Time spent trailing or sleeping was not affected by day ($P>0.40$).

Trial

There were large seasonal differences in the amount of time spent in the different activities. Total grazing time appeared to be positively related to seasonal variation in forage quality, reaching a maximum of 697 min/day in the spring and a minimum of 542 min/day in the winter. These trends were consistent between years, except for the August 1984 trial. The amount of time spent in intense grazing was generally inversely related to forage and diet quality, while search grazing appeared positively related to forage and diet quality. These variations in intense and search grazing resulted in the animals spending over half of their total grazing time intensely grazing during the fall and winter and less than half in the spring and summer.

General linear models were used to examine more fully the effect of herbage or diet characteristics on grazing time (Table 4). Herbage variables used were total standing crop (kg/ha) and percent of the standing crop that was live. Diet components considered were percentage in vitro digestible organic matter (IVDOM) and crude protein (CP). However, IVDOM is the diet component presented in this paper because it was a better predictor than CP.

Analyses of both vegetation and diet parameters indicated that the intercept (i.e., main effects), but not the slope was affected by grazing treatment. All categories of grazing time (i.e., total, intense, and search) showed a significant relationship to the models, but models that used standing crop parameters had larger coefficients of variation and smaller standard errors of prediction than models that used diet parameters (Table 4). Total and search grazing time increased as the quality of the standing crop or diet increased, but search grazing was about 3 times more sensitive to changes in quality compared to total grazing. Intense grazing was negatively related to forage quality. The coefficients for total standing crop were not significant in these models.

The data from the RG paddocks during the September 1983 trial appeared to be outliers in models that included standing crop

Table 3. The effect of day of stay on the time (min/day) spent grazing in the RG-14 paddocks during trials with a 3-day grazing period.

Day of Graze	1982 Oct	1983 Sep	1984 Mar	1984 Aug	Treatment Average
	Total Grazing				
1	627a	574a	645	610a	614
2	595a	505b	628	568ab	574
3	506b	491b	628	556b	543
	Intense Grazing				
1	389	267	364	198	304
2	400	245	376	192	303
3	314	236	398	140	272
	Search Grazing				
1	239	307	281	412	310
2	195	260	253	376	271
3	192	255	229	407	271

[a,b]Means in the same activity and column followed by different letters were different ($P<0.10$).

Table 4. The effect of grazing treatment and variation in standing crop (Stcr) or diet in vitro digestible organic matter (IVDOM) on grazing time.

Dependent Variable	Independent Variables: Class	Continuous: Total Stcr	Continuous: % Live Stcr	Model: P>F	R^2	$S_{y/x}$
Graze Time		Coefficients				
Total	TRT**	0.001	0.076*	0.0151	0.30	70
Intense	TRT***	0.002	−0.204***	0.0002	0.47	80
Search	TRT**	−0.001	0.281***	0.0001	0.52	80
		Diet IVDOM				
Total	TRT**	0.539**		0.0057	0.26	70
Intense	TRT**	−1.157***		0.0007	0.33	90
Search	TRT	1.696***		0.0001	0.41	10

*,**,***$P<0.10$, $P<0.05$, $P<0.01$, respectively.
TRT is the test for the effect of grazing treatment on the model intercept with 2 degrees of freedom.

Table 5. The effect of grazing treatments and seasonal trials on the individual animal space (m²/animal) in subherds that were grazing.

Grazing Treatment	1982 Oct	1983 Jan	1983 Jun	1983 Sep	1984 Jan	1984 Mar	1984 May	1984 Aug	Treatment Average
CG	714a	1136a	1347a	1428a	1495a	2442a	2857a	1982a	1675a
RG-14	583a	418b	772ab	600b	491b	761b	958b	834b	677b
RG-42	309b	229b	369b	284c	329b	394b	537c	513b	370c
Trial Average	536a	594a	829b	771b	772b	1199c	1450d	1110c	

[a,b,c,d]*Means in the same activity and column or within the same trial average followed by different letters were different* ($P<0.05$).

variables. If these data were removed (i.e., 4 observations), the coefficient of determination for intense and search graze increased to 0.72 and 0.67, respectively. However, we were unable to discern a reason to explain the cause of these data being outliers.

Cattle Dispersion

Grazing treatments affected the individual animal space of cattle in all activities (Table 5). As stock density increased because of the imposed treatments the individual animal space decreased ($P<0.05$). The effect of trial was not significant for individual animal space.

Discussion and Conclusions

The effect of grazing treatments indicated several general trends which we hypothesize were caused by a combination of vegetation and social factors that influenced behavior in different ways depending on the grazing treatment. The trend towards shorter total grazing time in the RG compared to CG treatment (Table 1) is consistent with previous studies (Hancock 1953, Castle et al. 1975, Gammon and Roberts 1980). We believe that these differences among treatments were at least a partial result of more uniform herbage due to less mixing of live and dead tissue in the RG paddocks (Heitschmidt et al. 1987c). This may have resulted in cattle spending less time searching for and selecting bites in the RG paddocks. This hypothesis is supported by the fact that longer total grazing time in the CG compared to the RG-14 treatment was caused by primarily by more time spent search grazing (Table 1). However, this relationship did not hold for the RG-42 treatment, which had the greatest amount of search grazing time relative to the other treatments. We hypothesize that this discrepancy may have been caused by greater social interaction at the high stock density in this treatment. The increased movement associated with grazing in the RG-42 treatment (i.e., greater search grazing time) may have been associated with movement to avoid social conflicts and maintain individual animal space (Leyhausen 1971) rather than because the animals were spending more time searching for bites. This hypothesis is supported by the low individual animal space found in the RG-42 treatment (Table 5) which presumably would increase competition for space, and by the greater proportion of time cattle spent grazing preferred plant communities which we reported previously (Walker et al. 1988a). In that study the proportion of the time that cattle were observed on preferred plant communities relative to the availability of that community in a paddock increased as stock density increased from the CG to the RG-42 treatment. This may indicate that cattle spent less time searching among plant communities and that movement while grazing may have been an effort to maintain individual animal space rather than searching activity.

The decrease in grazing time as the RG-14 paddocks were progressively defoliated between the first and last day of grazing in a paddock (Table 3) conflicts with the concept that reduction in available forage results in longer grazing times because less forage is consumed per bite (Arnold and Dudzinski 1978). However, behavioral response to changes in available forage appear to be affected by grazing management systems (Jamieson and Hodgson 1979b). Grazing time usually increases with progressive defoliation under continuous grazing (Chacon and Stobbs 1976, Jamieson and Hodgson 1979b, Stuth et al. 1986). However, grazing time decreased in response to lower levels of herbage allowance under strip grazing with a back fence (Jamieson and Hodgson 1979a, Le Du et al. 1979, Baker et al. 1981). Jamieson and Hodgson (1979a) suggested that the association of reduced grazing time with lower herbage allowance under strip grazing may be a conditional behavior whereby the animals were balancing the difficulty of prehension of herbage with the anticipation of an imminent fence move. However, in the present study we believe that shorter grazing times associated with progressive defoliation of the RG paddock may have been caused by a different behavioral response. Grazing time may increase the first day in a paddock because of exploratory activity in the new paddock (Arnold and Dudzinski 1978, Gluesing and Balph 1980, Anderson and Urquhart 1985). Exploration in the new paddock could be associated with search grazing resulting in longer grazing time during the first 1 or 2 days in a paddock. This hypothesis is supported by a nonsignificant trend in longer search times on the first day in a paddock (Table 3) and coincides with other data that indicated that nutrient content of the diet did not vary between the first and last day in these same RG paddocks (Walker et al. 1988b). When longer grazing times have been associated with progressive defoliation there has been a concomitant change in diet quality (Chacon and Stobbs 1976, Jamieson and Hodgson 1979b).

As stock density increased because of the imposed grazing treatments the observed individual animal space declined (Table 5). Had the cattle in the RG-42 treatment distributed themselves uniformly across the entire paddock, they would still have had less space per animal than that observed for grazing subherds in the CG treatment. If it is assumed that CG represents an unconstrained individual animal space representative of the equilibrium between cohesive and dispersive forces of cattle, then the decreased individual animal space observed in the RG treatments may indicate that these treatments did not provide adequate space for animals to maintain their preferred amount of individual distance. These results should be viewed with caution because in this study the effect of treatment on individual animal space was confounded with herd size. However, Arnold and Maller (1985) found that individual animal space increased as the number size of sheep in a flock increased.

Factors that determine the circadian sleep profile include: difficulty in foraging, availability of food, digestive processes such as rumination, predator susceptibility, and other social and environmental pressure (Ruckebusch 1975). The absence of any differences in time spent sleeping indicated that despite alterations in other activities the cattle may have adapted to the RG treatment.

The results of this study help explain our previous findings from this series of studies on the effect of rotational grazing at a heavy rate of stocking on the producer and consumer components of this rangeland ecosystem. Compared to continuous grazing the RG treatment did affect the standing forage (Heitschmidt et al. 1987c), grazing pressure (Walker et al. 1988b), and stock density. However, cattle selected diets of similar botanical and nutrient composition (Walker et al. 1988b). These results provide evidence of a change in food searching strategies as a behavioral response that may aid cattle in maintaining an adequate diet despite high grazing pressures. These behavioral adaptations may also influence energy requirements by animals on different grazing treatments. While the shorter grazing times of cattle on RG-treatments could indicate a reduction of energy expenditure for harvesting forage, this potential advantage could be negated by greater travel distance in the same treatments. With high numbers of paddocks the energy cost of walking due to the movement between paddocks and the increase in search grazing upon entering a new paddock or because of high stock densities would soon outweigh any advantages due to shorter grazing times. We believe these data provide evidence based on behavior responses that there is little justification for using large numbers of paddocks in rotational grazing systems on rangelands. This also supports similar conclusions that were based on the fact that increasing the number of paddocks to more than about 8 results in only slight increases in the length of the rest period (Barnes 1978).

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