due to the plants going into winter dormancy and the movement or storing of more nutrient reserves into the root system. Having a lower soluble carbohydrate content, the forages would have more fiber.

Digestibility data (Table 4) show a substantial reduction in digestibility for dead *vs* live plant material during all warm months. This was true for both caged (ungrazed) and grazed (access to grazing permitted) samples. As expected, digestibility of the standing vegetation was much lower during the period from November to March. In general, digestibility differences were often on the order of two-fold; between the live *vs* dead forages, and between growing *vs* non-growing months of the year. As fiber increases over any particular time, digestibility decreases.

Effect of Forage Density on Grazing Behavior, Forage Intake and Animal Performance

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Story in Brief

Sorghum sudan hybrid (Sx-17) was planted at three seeding rates (A, 16.8; B, 33.6 and C, 50.4 kg/ha) to determine the effect of different forage densities on grazing behavior, forage intake and animal performance of beef heifers. Two 1.2 ha pastures were used for each seeding rate. All pastures received 57 kg/ha of actual nitrogen at planting time. Four animals grazed each pasture from July 1 to September 29, 1977. An intake trial was conducted from July 26 to August 8, 1977, using chromic oxide as an external marker. During this time, one animal in each pasture was fitted with an 8-day recorder to continuously monitor grazing behavior.

There was a high correlation between grazing time measured by visual observation and that estimated when the vibration recorder was used (r=.92). Further, the activity of one animal in each pasture represented the activity of about 75 percent of the other animals in the pasture within a given five minute interval. This indicates the animals behave primarily as a group rather than as individuals.

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Forage density for seeding rates A, B and C respectively was 715, 815, and 950 kg/ha ($P<.10$) on August 1 and 1220, 1155 and 1400 kg/ha on August 8. The fast growth rate of the forage reduced differences in density as the trial period progressed. Forage samples contained 56 percent neutral detergent fiber and 73 percent *in vitro* dry matter digestibility. Leaves accounted for 52.5 percent; stems 13 percent; extraneous material (dry material, weeds, etc.) 34.6 percent of the sample dry weight. There were no differences in either chemical or physical composition due to seeding rate. The amount of time spent grazing was 8.7, 12.0 and 9.4 ($P<.1$) hr/day and time spent grazing within each grazing period was .6, 1.02 and .8 hr for seeding rates A, B and C respectively. Dry matter intake was 8.6, 8.6 and 7.6 kg/day and gains were .52, .34 and .45 kg/animal/day and 208, 150, 217 kg/ha for the 90 day grazing period for seeding rates A, B and C, respectively.

The accuracy and utility of the vibration recorder demonstrate that this device can be used to monitor grazing behavior and will greatly reduce the labor requirements for such experiments.

Introduction

In contrast to feedlot type rations, high or total forage rations are not very well characterized for their nutrient value or production potential. Much forage is harvested by the grazing animal, and one of the most perplexing problems encountered by animal scientists is measuring voluntary forage intake. Methods used to estimate voluntary intake at the present time give only rough estimates. Many factors influence voluntary intake such as behavior of grazing, time spent grazing and search rate of the animal. These problems and factors, and the interactions of the soil-plant-animal system will need to be defined if we are to predict production in terms of output per animal, output per unit of land area or per unit of input (dollars, feed, etc.) for any given set of conditions. The objectives of this study were to determine the effect of forage density on grazing behavior, forage intake and animal performance.

Materials and Methods

Six 1.2 ha pastures of sorghum sudan (Sx-17) were seeded in duplicate at three rates: A, 16.8; B, 33.6 and C, 50.4 kg/hectare. Pastures were fertilized at the time of planting with 56 kg/ha of actual nitrogen. Soil type was Dale siltloam with 0-1 percent slope, moderately permeable on a wide terrace in a "second river bottom". Four Hereford x Angus heifers grazed each pasture from July 1 to September 29, 1977. Initial weights were approximately 275 kg each. Beginning July 26, and continuing for 14 days, three animals in each pasture were dosed with shredded paper imbedded with chromic oxide and pressed into pellets. Three such pellets weighing a total of about 30 grams were given to each animal each day at 8 am. During the last seven days, fecal samples were collected at the time of chromium administration. On the last day, a partial diurnal curve was established from 6 am to 8 pm to determine if there were interactions between time of sampling and seeding rate. Hand plucked samples of forage were taken three times during the collection period. These samples were analyzed for *in vitro* dry matter digestibility (Tilley and Terry, 1963). Also, at the beginning and at the end of the collection period, yield samples were hand clipped at 2.5 cm from a ½ M^2 circle at two locations within each pasture and dried at 65 C. This value is shown as forage density. The yield samples were separated into (1) leaf, (2) stem and (3) weeds or other extraneous material. One animal in each pasture was fitted with an 8-day recorder to allow continuous monitoring of grazing behavior (Stobbs, 1970).

Of primary importance in this trial was to determine the feasibility of using the vibration recorder to monitor grazing time and thereby eliminate the need for constant observation of the animals. During one day (daylight hours only) the animals in each pasture were observed and their activity was recorded at five minute intervals. This was correlated with results from the recorder to determine its accuracy.

Results and Discussion

The correlation coefficient between "*actual*" and "*recorded*" for starting time of a grazing period was .999 and for the end of a grazing period was .997 (Table 1). The regression coefficient (slope) was .99 in both cases. Grazing time in hours, however, was not as closely related. It resulted in a correlation coefficient of .92 and regression coefficient of .89. One possible explanation for this is probably the lack of variation in the length of the grazing period. The average period of grazing was about .8 hr.

Another point of interest is how closely animals behave as a group. During the one day observation period, activity of all animals was recorded as well as that of the animals wearing recorders. Analysis of these data indicate that in any five minute period, 73 percent of the animals were doing the same thing (Table 2). Further, 75 percent of the animals were grazing if any one animal was grazing during any given five minute interval. Therefore it was concluded that the vibration recorder was satisfactory as a method of recording grazing time and that one animal per group may represent the majority of the group. This has been previously shown by other researchers (Stobbs, 1970; Castle *et al.*, 1975).

Cr_2O_3 ratio was not influenced by the interaction between seeding rate and sample time. A graphic illustration is presented in Figure 1. Excretion was significantly ($P<.05$) affected by time with a peak appearing 6-9 hr after dosing.

Forage density at the beginning of the intake trial significantly ($P<.1$) increased with increasing seeding rate (Table 3). However, by the end of the

Table 1. Accuracy of vibration recorder

Variable	Intercept	b[a]	r[b]
Start grazing, hr	2.92	.987	.999
Stop grazing, hr	7.49	.991	.997
Grazing time, hr	.11	.896	.925

[a]Regression coefficient.
[b]Correlation coefficient.

Table 2. Group behavior of heifers

	Seeding Rate, kg/ha		
Item	16.8	33.6	50.4
Animals engaged in similar activity, %[a]	77.7	68.5	72.6
Animals grazing, %[b]	86.0	66.6	71.8

[a]Within a given five minute interval, the percentage of animals engaged in similar activity.
[b]Within a given five minute interval, the percentage of animals grazing when the animal with the recorder was grazing.

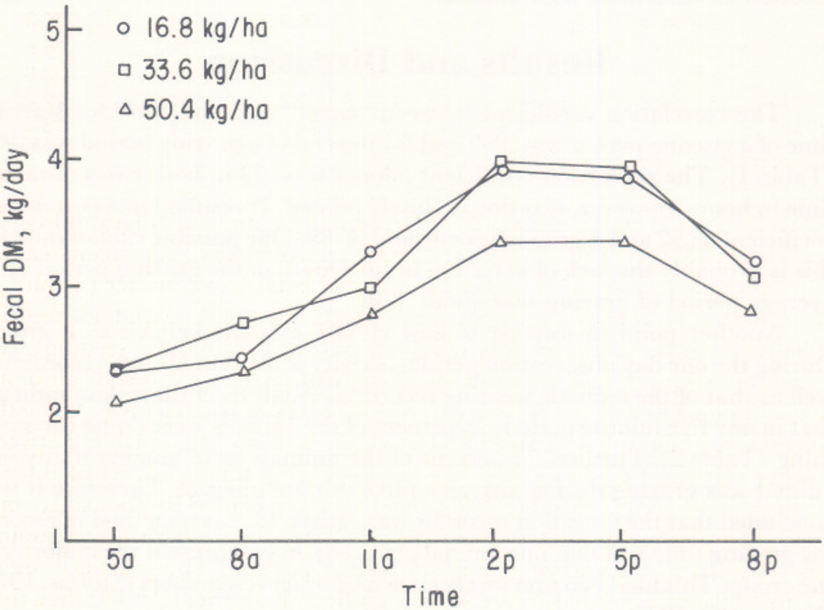

Figure 1. Diurnal effects on fecal dry matter excretion as determined by Cr_2O_3 ratio

trial, growth rate of the forage had been so rapid that average differences were obscured.

Composition of the hand plucked forage is shown in Table 4. Quality was high as expected since leaves were selected. This is illustrated by relatively low

Table 3. Pasture characteristics

Item	Seeding rate, kg/ha		
	16.8	33.6	50.4
Forage density, start, kg/ha	715[a]	815[a]	950[b]
Forage density, end, kg/ha	1220	1155	1400
Forage density, average, kg/ha	967	985	1175
Leaf, %	50.1	50.9	56.5
Stem, %	11.9	13.9	13.2
Extraneous, %	37.9	35.2	30.3
Leaf:stem, start[d]	5.8	6.2	6.8
Leaf:stem, end[d]	4.2	2.7	3.0
Leaf:stem, average	5.0	4.5	4.9

[a, b]Means in same row not followed by common superscript are significantly different.

[c]Percentage of stem was significantly ($P<.05$) lower at the beginning of the trial than at the end.

[d]Leaf:stem ratio was significantly ($P<.05$) lower at the end of the trial than at the beginning.

Table 4. Forage composition (hand plucked samples)

Item	Seeding rate, kg/ha		
	16.8	33.6	50.4
Neutral detergent fiber, %	55.9	54.8	56.3
Acid detergent fiber, %	28.5	28.3	28.8
Lignin, %	3.5	3.5	3.6
Cellulose, %	22.3	21.8	22.2
IVDMD, %[a]	74.6	74.5	73.4

[a]*In vitro* dry matter disappearance (Tilley and Terry, 1963).

cell wall content (56 percent neutral detergent fiber) and high digestibility (74 percent IVDMD). Yield samples contained approximately 52 percent leaves, 13 percent stems, and 34.5 percent weeds and extraneous matter (Table 3). Much of the extraneous matter was dead plants in pastures with high seeding rates whereas the majority was weeds in pastures of the low seeding rate. Using these figures, leaf:stem ratio was approximately the same for all treatments, ranging from 4.5 to 5. There were differences in grazing time among the different seeding rates (Table 5), but there was no relationship between seeding rates and grazing time. Maximum grazing time was recorded for a seeding rate of 33.6 kg/hectare. This may have been caused by poor soil in one of the replicates of this treatment in which the forage density was quite low and was reflected in the carrying capacity of that pasture. The grazing time of heifers on pastures seeded at rate A was significantly shorter ($P=.07$) than that of heifers grazing pastures seeded at rate B. Grazing time on seeding rate C was intermediate between the other two. Hours per grazing period followed the same trend as that of grazing time per day. There were approximately the same number of grazing periods per day for all of the treatments. This indicated a very "ordered" behavior among animals. This phenomenon can also be noted in day to day periods of grazing which occurred at approximately the same time and by all animals.

Table 5. Animal behavior, consumption and performance

Item	Seeding rate, kg/ha		
	16.8	33.6	50.4
Grazing time, hrs			
Daily	8.7[b]	11.9[c]	9.4[b, c]
Per grazing period	.60[b]	1.02[c]	.78[b]
Dry matter intake, kg/day	8.6	8.6	7.6
Daily gain, kg	.52	.34	.45
Animal days	159	153	169
Gain, kg/ha[a]	208[b]	150[c]	218[b]

[a]91 days grazing.

[b, c]Means in same row not followed by same superscript are significantly different ($P<.05$).

Animal response data included dry matter intake, gain per animal and gain per hectare (Table 5). Dry matter intake and gain per animal was not significantly affected by treatment; however, there were numerical differences especially in gains per animals. This was inversely proportional to grazing hours spent each day. Dry matter intake was about 7.5 to 8.5 kg/day which is reasonable for animals this size, but gains were low for that level of TDN intake. This may suggest that intake was either slightly overestimated or that TDN intake over the entire period was not as high as during the trial. Gains ranged from .34 to .52 kg/day. Gain per hectare for the 90 day grazing season followed similar to animal daily gains. Pastures seeded at rate B produced lowest gains and were significantly different from the other two.

These preliminary trials indicate that to monitor effects of forage density on behavior and intake of grazing animals, a forage likely to respond less in terms of growth for a short period of time would be better suited than sorghum sudan hybrids. Permanent pastures would not only be more suitable experimentally, but would provide information of more use to cattlemen. Several stocking rates or grazing pressures might be used to achieve the various plant or forage densities. Further, as plants become shorter, animals may have a more difficult time prehending the forage and intake may be limited by bite size (Stobbs, 1975). This parameter should also be incorporated into future studies of this type.

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