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Grazing steer fecal output dynamics on south Texas shrubland

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Abstract

Combined with other information, fecal output appears to have potential use in models to predict forage intake. Better understanding of fecal output dynamics relative to forage availability could improve model estimates of animal performance. Field trials were conducted during 4 different periods to investigate the relationship between 1) declining forage mass or forage component availability and beef steer fecal output and between 2) browse consumption and available forage mass. Fecal output was estimated using the rare-earth marker ytterbium. Initial fecal output as a percentage of body weight was greatest in March (1.24%) and least in August (0.96%). Regression slopes were negatively correlated (–0.73) with initial forage mass. As indicated by regression slopes, fecal output declined most rapidly in March (slope = 0.57) and slowest in August (slope = 0.13). Expression of available forage mass as either daily grass allowance or daily grass leaf allowance, both as g dry matter/kg live weight, produced similar regression equation statistics. Development of regressions for individual pastures within trials did, however, improve equation statistics in all trials except August. Browse consumption was <10% until daily grass allowance fell below 50 g/kg live weight then increased to between 53 and 64% below 25 g/kg live weight, but was not adequate to maintain fecal output. Apparent seasonal differences in fecal output suggest lower forage intake (29%) in August compared to March. Fecal output was not affected by daily grass allowance above 100 g. Fecal output declined to below 0.6% of body weight below 100 g daily grass allowance. Data are interpreted to suggest that different fecal output curves and/or adjustment factors may be needed to account for season and initial forage mass.

Key Words: herbage allowance, beef cattle, browse consumption

Resumen

Combinada con otra información, La producción fecal parece tener un uso potencial en los modelos para predecir el consumo de forraje. Un mejor entendimiento de la dinámica de producción fecal relativa a la disponibilidad de forraje podría mejorar las estimaciones de los modelos acerca del comportamiento productivo animal. Se condujeron estudios de campo durante 4 diferentes períodos con el objetivo de investigar la relación entre 1) la disminución de la masa de forraje o la disponibilidad del componente de forraje y el rendimiento fecal de novillos para carne y 2) el consumo de forraje de arbustos y la masa disponible de forraje. La producción fecal fue estimada usando como marcador el Iterbio. La mayor producción fecal inicial, expresada como porcentaje del peso corporal, se obtuvo en marzo (1.24%) y la menor en agosto (0.96%). Las pendientes de regresión fueron negativamente correlacionadas (-0.73) con la masa inicial de forraje. Como indicaron las pendientes de regresión, la producción fecal disminuyó más rápidamente en marzo (pendiente = 0.57) y más despacio en agosto (pendiente = 0.13). La expresión de la masa de forraje disponible ya sea como la asignación diaria de zacate o la asignación diaria del material foliar de zacate, ambas expresadas como g de materia seca/kg de peso vivo, produjeron ecuaciones de regresión similares. El desarrollo de regresiones para potreros individuales dentro de los ensayos mejoró la ecuación estadística en todos los ensayos excepto en agosto. El consumo de forraje de arbustos fue <10% hasta que la asignación diaria de zacate cayó abajo de 50 g/kg de peso vivo, entonces, abajo de los 25 g/kg de peso vivo, se incrementó entre 53 a 64% pero no fue adecuada para mantener la producción fecal. Las aparente diferencias estacionales en la producción fecal sugieren un bajo consumo de forraje (29%) en agosto comparado con marzo. El rendimiento fecal no fue afectado cuando la asignación de forraje fue arriba de los 100 g. Cuando la asignación diaria de zacate fue menos de 100 g, la producción fecal disminuyó a menos del 0.6% del peso corporal. Los datos son interpretados para sugerir que diferentes curvas de producción fecal y/o factores de ajuste pueden ser necesitados cuando para reportar por estación y masa de forraje inicial.

Grazing animal forage intake is routinely estimated using fecal output-forage indigestibility ratios (Langlands 1975, Cordova et al. 1978). Fecal output can be relatively stable within a physiological stage (McCollum and Gaylean 1985, Ellis et al. 1988) or across a wide range of digestibility (Ellis et al. 1988) but can change with physiological stage (Sprinkle et al. 1992), gut capacity or forage type (McCollum and Gaylean 1985), and forage availability (McCollum and Gaylean 1985, McKown et al. 1991). Although fecal output and body weight have been used to predict feed or roughage

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intake (Conrad et al. 1964, Forbes 1983), fecal output dynamics with regard to forage availability need further clarification for use in grazing animal models. Rayburn (1986) reported rapidly declining intake for cattle below 2,250 kg/ha forage availability; however, this threshold may vary from <3,000 kg/ha (Allden and Whittaker 1970) to <135 kg/ha (Handl and Rittenhouse 1972). Vegetation characteristics, e.g., leaf and stem proportions, may be more highly correlated to forage intake and fecal output than gross forage mass. In shrublands, these relationships may be affected by a large, diverse supply of browse.

This research was conducted 1) to examine relationships between available forage mass and fecal output and between forage components and fecal output and 2) to determine how browse consumption relates to available forage mass.

Methods

This study was conducted on the La Copita Research Area (27° 40'N, 98° 12'W) in northeastern Tamaulipan Province, about 80 km W of Corpus Christi, Tex. To establish contrasting forage conditions, four 0.4-ha pastures were established on a gray sandy loam site that had been chained 7 years earlier. Two of the 4 pastures (A and B) were chained only while the other 2 (C and D) were also sprayed 3 years before the study with picloram at a rate of 1.0 kg active ingredient/ha to create grazing conditions with high grass production and low available browse.

Four grazing trials were conducted during seasons representing different phenological stages. Trials were conducted in 1) March,1985; 2) May, 1985; 3) August, 1985; and 4) January, 1986. Two pastures (1 chained only and 1 chained and sprayed) were grazed by 6 Beefmaster steers each for 21 days or until utilization of the grass standing crop was judged to be 90% during each trial. Pastures A (chained only) and C (chained and sprayed) were grazed in March and August while pastures B (chained only) and D (chained and sprayed) were grazed in May and January, allowing 150 to 210 days between trials. Three sets of steers were used during this study. One set was used in the March and May trials, a second set in August, and a third set in January. Within each trial, each group of steers was 9 to 14 months old and weighed 240 to 340 kg.

Dominant grasses in pastures included purple threeawn (*Aristida purpurea* Nutt.), plains bristlegrass [*Setaria leucopila* (Scribn. & Merr.) K.Schum.] and Texas bristlegrass (*Setaria texana* W.H.P. Emery), Texas tridens [*Tridens texanus* (S. Wats.) Nash], hooded windmillgrass (*Chloris cucullata* Bisch), buffelgrass (*Cenchrus ciliaris* L.), fall witchgrass [*Leptoloma cognatum* (Schult.) Chase var. *cognatum*], Kleberg bluestem (*Dichanthium annulatum* Stapf) and Hall panicum (*Panicum hallii* Vasey var. *hallii*). Common woody plants occurring in pastures were mesquite (*Prosopis glandulosa* Torr.), spiny hackberry (*Celtis pallida*), lime pricklyash (*Zanthoxylum fagara* (L.) Sarg.), coyotillo [*Karwinskia humboldtiana* (R.& S.) Zucc], desert yaupon (*Schaefferia cuneifolia* Gray), shrubby blue sage (*Salvia ballotaeflora* Benth.), and whitebrush [*Aloysia gratissima* (Gill. & Hook.) Troncoso]. Plant growth initiates in late March with a bimodal peak of grass standing crop in June and October depending on rainfall patterns. Browse standing crop peaks in July and remains stable for most species through early November.

Five sample collections were conducted during each trial except in January when only 4 were possible. Sample collections occurred at the beginning and end of each trial and at 5-day intervals during the trial. Twelve, 1 x 30 m belt transects were established in each paddock to characterize available forage throughout each trial. Available browse standing crop was measured in each belt transect using the browse volume-weight method (Lopes and Stuth 1984). Two, 0.5 x 1 m quadrats were randomly located in each of the 12 belt transects and herbage composition by weight visually estimated and all herbaceous aboveground biomass subsequently clipped to ground level. Standing crop (kg/ha) was determined by species by multiplying estimated species composition by total clipped herbage for each sample collection within each trial.

Four, esophageal fistulated steers (270 kg, 9 months of age) per pasture were allowed to graze for approximately 30 min at the beginning of each sample collection in each trial. Ten total esophageal fistulated steers were available for sampling. Sample collections were staggered by one day for the 2 pastures used within each trial. Between each collection event, collector steers were grazed in pastures adjacent to and with the same vegetation as trial pastures. Collector steers and their mothers were experienced with the vegetation in the region before weaning. Collected extrusa was dried 48 hours at 60°C and subjected to macrohistological analysis to determine steer diet composition by plant group and plant part (Araujo 1985). Diet samples were analyzed for crude protein (CP) content on a dry matter basis by micro-Kjeldahl procedure (AOAC 1960). Digestible organic matter (DOM) was determined by in vitro procedures using a 48-hour fermentation (Tilley and Terry 1963) followed by neutral detergent fiber procedure (Van Soest and Wine 1967).

Grass standing crop components (live leaf, dead leaf, live stem, and dead stem) were estimated using extrusa grass component composition, grass standing crop disappearance, and initial grass standing crop mass. Grass component mass was estimated by multiplying percent grass component in extrusa obtained at each sample collection by the amount of grass disappearance occurring during the interval between that sample collection and the next and summing interval values for each component over the entire trial. These totals were used to calculate initial mass and initial percentage of each grass component and grass component composition of the residual grass throughout the trial. Herbage disappearance between clipping dates was assumed to be equal to consumption. Little or no growth occurred during the 5 days intervals between sampling dates within each trial. Because available grass was so low during the last interval of each trial, composition of the grass standing crop was assumed to be proportional to extrusa sample grass component composition at the beginning of this interval.

To estimate fecal output, non-cannulated steers used to graze pastures were dosed daily with the rare-earth element ytterbium in powdered acetate form via gelatin capsules. Steers were dosed daily beginning 9 days before each trial. During this pre-trial period, these steers

Table 1. Mean and standard error for initial and end of trial forage crude protein (CP, dry matter basis) and digestible organic matter (DOM) for March, May, August, and January trials by pasture.

Trial	CP, Pasture A or B[1] Initial	CP, Pasture A or B[1] Ending	CP, Pasture C or D[2] Initial	CP, Pasture C or D[2] Ending	DOM, % Pasture A or B Initial	DOM, % Pasture A or B Ending	DOM, % Pasture C or D Initial	DOM, % Pasture C or D Ending
	(%)				(%)			
Mar.	16.6±0.2	12.1±0.5	17.0±0.3	10.5±0.2	65.2±1.2	34.0±1.3	67.5±1.2	36.0±3.0
May	12.1±0.2	12.4±0.4	11.5±0.2	9.9±0.3	74.8±0.5	46.0±1.2	71.8±0.5	45.0±2.5
Aug.	9.8±0.2	9.2±0.4	9.3±0.2	7.6±0.3	74.8±0.5	44.0±1.2	71.4±1.1	46.0±2.5
Jan.	11.6±0.2	10.2±0.8	11.5±0.3	8.9±0.1	70.6±2.5	38.0±5.0	69.7±0.5	34.0±2.0

[1]Pastures A & B were chained 7 years before this study.
[2]Pastures C & D were chained and then sprayed with picloram at 7 and 3 years, respectively, before this study.
n=4

were grazed in pastures adjacent to and with the same vegetation as trial pastures. Because vegetation was the same in these adjacent pre-trial and trial pastures, fecal output estimates should not have been affected. Each trial pasture was grazed by 6 steers. Fecal samples were collected from each steer 24 hours after each diet collection and analyzed for ytterbium concentration using atomic absorption spectroscopy (Ellis et al. 1982). Galyeanet et al. (1986) reported that over a variety of experimental conditions, average continuous-dose marker estimates of fecal output using ytterbium were 104% of total fecal collection with a range of 86 to 144%. Musimba et al. (1987) suggested that this technique is most useful for relative comparisons. Because marker recovery was not determined, results are valuable because they may indicate general relationships and areas for future investigation. Steers were weighed at the beginning of each trial at 0600 hours after penning at 2000 hours the previous evening to determine fecal output on a percent body weight basis.

Regression and correlation analyses (SAS 1988) were performed across and within trials to determine the relationship between available forage, diet composition, and dietary browse consumption and fecal output on a dry matter basis as a percentage of body weight. Non-log functions were tested first in regressions. Log functions were then used in regressions because of the apparent visual trends in the data.

Results and Discussion

Diet Quality

In general both CP and DOM declined during each trial as quantity of forage decreased. Highest CP levels occurred in March and lowest levels in August (Table 1). Initial CP levels were similar between pastures within trials. Ending CP levels tended to be higher in pastures A and B (chained only) with more available brush. Initial and ending DOM levels were relatively similar between pastures within trials, but varied among trials. Generally, DOM levels declined more drastically than CP levels. These dietary trends reflect a shift toward browse as available grass declined.

Daily Grass or Grass Leaf Allowance and Fecal Output

Initial fecal output was associated with a range of ungrazed grass standing crop of 1500 to 3000 kg/ha with lowest herbage mass in March and highest in August (Table 2). Initial fecal output as a percent of body weight differed among trials ($P<0.10$) from a high in March (1.24%), to a low in August (0.96%), with May (1.09%) and January (1.08%) between these extremes. Initial fecal output in May, January, and August was 88, 87, and 77% of initial March fecal output, respectively.

Using stepwise regression, the log function of grass standing crop explained 74 to 94% of the variation in fecal output for individual trials (Table 3). Except for January, the log of grass standing crop was the only variable

Table 2. Initial standing crop (kg/ha ± standard error) of grass, forbs, and browse and initial percent grass standing crop component by trial and pastures.

Trial	Pasture	Grass	Forbs	Browse	Pasture	Grass	Forbs	Browse
	Initial Standing Crop (kg/ha[-1])							
Mar.	A[1]	1040±87	163±22	1976±28	C[2]	1850±114	101±15	632±15
May	B[1]	1512±183	700±107	2200±36	D[2]	2788±395	164±20	1305±29
Aug.	A	1256±113	664±131	2986±46	C	3005±413	356±149	1808±38
Jan.	B	765±100	239±43	839±16	D	1578±179	71±27	769±19

Trial	Live leaf A/B	Live leaf C/D	Dead leaf A/B	Dead leaf C/D	Live stem A/B	Live stem C/D	Dead stem A/B	Dead stem C/D
	Initial Grass Standing Crop Component (%)							
Mar.	68	34	13	15	7	8	12	43
May	43	53	15	9	16	18	26	20
Aug.	31	28	24	27	25	9	20	36
Jan.	9	10	47	26	6	26	38	38

[1]Pastures A & B were chained 7 years before this study.
[2]Pastures C & D were chained and then sprayed with picloram at 7 and 3 years, respectively, before this study.

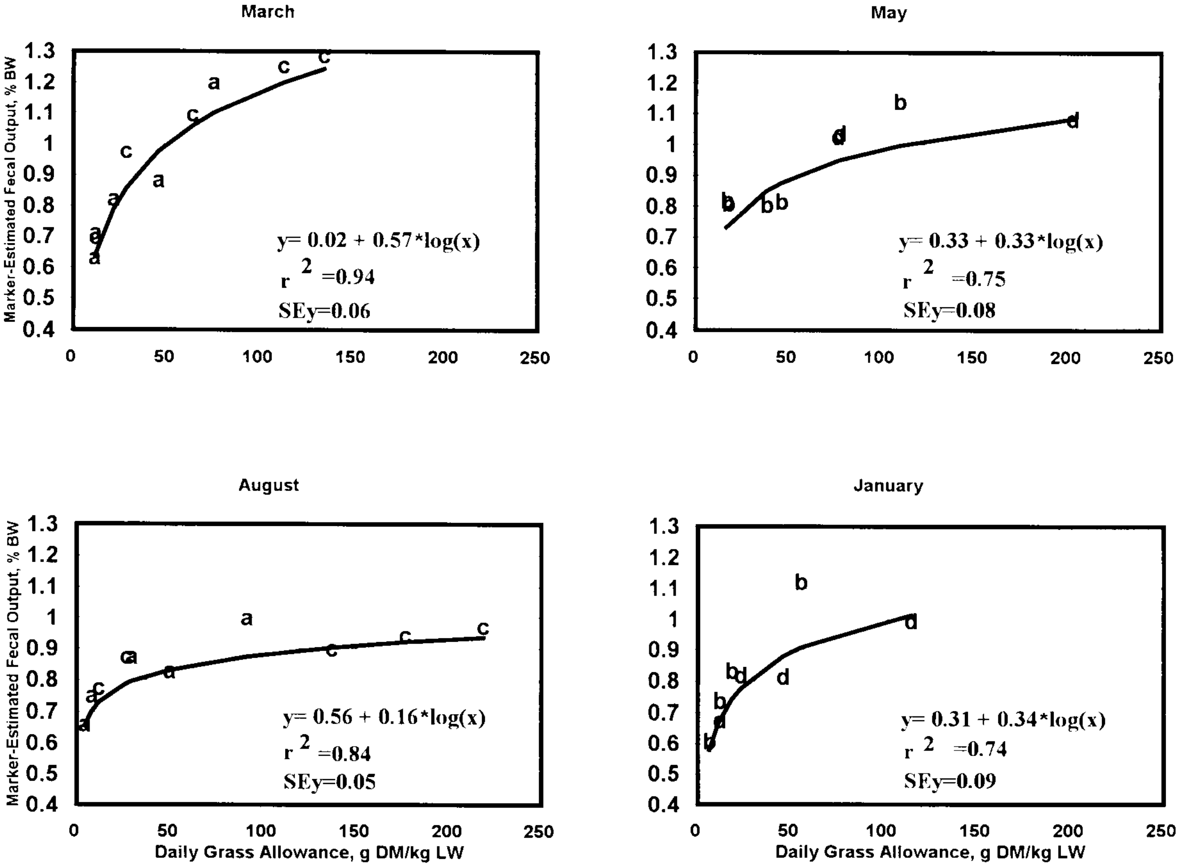

Fig. 1. Influence of daily grass allowance, g dry matter (DM)/kg live weight (LW) on marker-estimated fecal output of steers. Predictive equations are based on the log of daily grass allowance with pastures A and C or B and D combined for March, May, August, and January. Pastures A & B were chained 7 years before this study. Pastures C & D were chained and then sprayed with picloram at 7 and 3 years, respectively, before this study. Endpoints of lines for each trial indicate the grass allowance range.

selected. The strongest regression relationships between grass standing crop and fecal output occurred in March and August (Table 3).

The relationship between grass standing crop and fecal output does not integrate pasture size, animal number, and animal size; therefore, the relationship between fecal output and daily grass allowance, g dry matter/kg live weight, was examined for each trial using the log function of grass allowance. Across trials, initial fecal output corresponded to daily grass allowances of 100 to 200 g/kg live weight (Fig. 1) with lower levels occurring in January and accompanied by a fecal output decline in pasture B (chained only) almost twice that in pasture D (chained and sprayed, Table 4). As indicated by slopes of the regression functions (Fig. 1), daily grass allowance had the least impact on fecal output in August and the greatest impact in March. Perhaps this difference in regression slopes indicates either differences in marker recovery, diet quality differences or an unwillingness of animals to shift from highly desirable but minimally occurring and rapidly declining forage components, e.g., live leaf in March. August live:dead leaf ratio was about 1:1 compared to >2:1 in March and May, and < 1:2 in January. Mnene et al. (1996) noted reduced fecal output when cattle diets predominated by dead leaf shifted to diets predominated by live leaf available at low levels.

Pastures C and D (chaining plus picloram) had a higher initial grass standing crop and daily grass allowance than pastures A and B (chained only) in all trials (Table 2, Fig. 1). In all trials except August, analysis of daily grass allowance-fecal output relationships by individual pastures improved regression equation statistics for one or both pastures (Table 4). Initial daily grass allowance was negatively correlated (–0.73) with regression equation slopes. In all trials except March, regression equation slopes for pastures A and B were greater than those for pastures C and D indicating a more rapid decline in

Table 3. Stepwise regression analysis of log functions of kg grass (LGKG), forb (LFKG), and browse (LBKG) standing crops and fecal output as a percent of body weight.

Trial	Variable	Partial R^2	Model R^2	Probability
Mar.	LGKG	0.94	0.94	0.0001
May	LGKG	0.75	0.75	0.0055
Aug.	LGKG	0.84	0.84	0.0002
Jan.	LGKG	0.74	0.74	0.0060
	LFKG	0.16	0.90	0.0391
	LBKG	0.06	0.96	0.0640

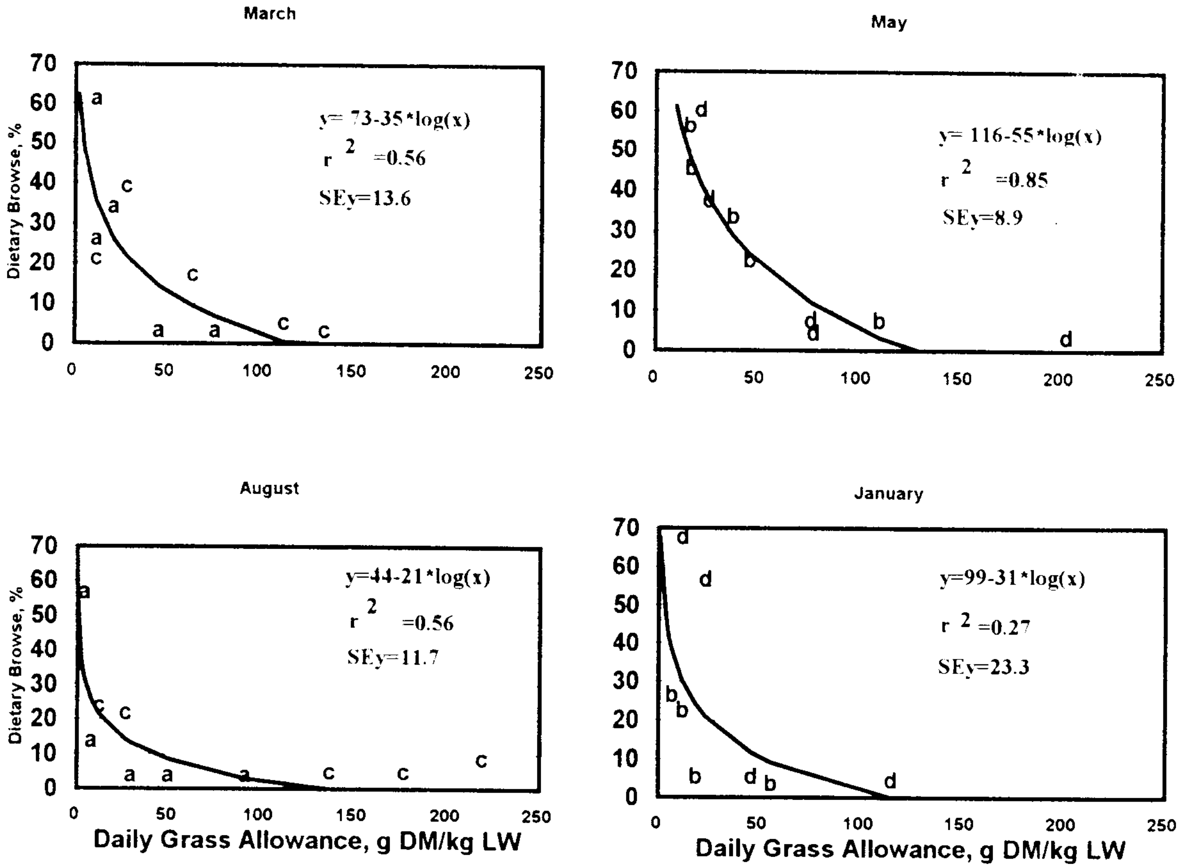

Fig. 2. Effect of daily grass allowance, g dry matter (DM)/kg live weight (LW) on dietary browse content. Predictive equations are based on the log of daily grass allowance with pastures A and C or B and D combined. Pastures A & B were chained 7 years before this study. Pastures C & D were chained and then sprayed with picloram at 7 and 3 years, respectively, before this study.

fecal output in pastures A and B with lower initial grass allowances. These lower initial grass allowances probably resulted in an inability to maintain rumen fill. Although not consistent across trials, McCollum and Galyean (1985) reported greater fecal output in conjunction with increased undigested fill, which was attributed to either expanded gut capacity or the forb component of the diet.

In the present study, the greatest decline in fecal output appears to have occurred below 100 g of daily grass allowance. Ellis et al. (1984) reported that a progressive reduction in daily herbage allowance of ryegrass from 700 to 100 g dry matter/kg body weight had no significant effect on daily fecal output. The NRC (1987) intake function suggests that 100% forage intake is achieved above 200 g daily dry matter forage allowance/kg body weight. On wheat pastures, steers have exhibited increased gain with increasing daily forage allowance up to 250 g (Pinchak unpublished data). Redmon et al. (1995) suggested similar plateau levels for daily forage allowance on wheat.

Regression of the log of daily grass leaf allowance, g dry matter/kg live weight and fecal output by trial and by pasture within trials resulted in little or no improvement in equation statistics over grass allowance equations (Table 4). Initial fecal output was associated with daily grass leaf allowances of 30 to 120 g.

One potential explanation for lower initial fecal output in August is the influence of high environmental temperatures. Average maximum temperature was 26°C in March, 32°C in May, 38°C in August, and 22°C in January. Depressions in forage intake have been associated with high environmental temperatures (NRC 1987). It seems logical that, like depressed fecal output associated with low forage availability (McCollum and Galyean 1985, McKown et al. 1991), depressed fecal output could be expected if forage intake were depressed by high environmental temperatures. Apparent lower initial fecal output in May could also be related to high environmental temperatures. Because animals were in the thermoneutral zone during the January trial, fecal output values were affected by factors other than temperature.

Differential preferences among forages with contrasting phenologies may also account for the apparent lower initial fecal output levels in May, August, and January. If steers consumed less forage and less indigestible fill, fecal output could be depressed. Estimated dead leaf in the initial forage mass increased almost 2 to 3 fold in August and January, respectively, compared to March and May (Table 2).

Diet quality, specifically with regard to protein, is also a potential explanation for some of the apparent differences in fecal output observed in this study. Milford and Minson (1965) reported depressed intake in relation to CP levels below 7%. In the present study, no CP levels were below this threshold (Table

Table 4. Regression comparisons for fecal output as a percent of body weight and daily grass allowance (GA, g dry matter/kg live weight), daily grass leaf allowance (GL, g dry mattter/kg live weight) and most highly correlated single grass species across pastures and by pastures.

Trial	Across Pastures GL	GA A/B[1]	GA C/D[2]	GL A/B	GL C/D	Species A/B	Species C/D
Mar.							
r^2	0.71	0.84	0.99	0.87	0.96	0.97	0.99
SEy	0.13	0.10	0.03	0.09	0.05	0.05	0.004
Slope	0.46	0.54	0.54	0.61	0.46	0.74	0.60
Int[3]	0.32	0.006	0.11	0.004	0.41	0.19	0.42
RT[4]	log	log	log	log	log	log	log
May							
r^2	0.76	0.65	0.98	0.71	0.98	0.91	0.99
SEy	0.07	0.10	0.007	0.09	0.007	0.05	0.0005
Slope	0.27	0.35	0.13	0.28	0.09	0.33	0.01
Int	0.52	0.29	0.75	0.50	0.85	0.69	0.98
RT	log	log	log	log	log	log	linear
Aug.							
r^2	0.86	0.88	0.87	0.89	0.85	0.86	0.90
SEy	0.04	0.05	0.03	0.05	0.03	0.06	0.03
Slope	0.15	0.21	0.13	0.18	0.12	0.20	0.12
Int	0.63	0.50	0.62	0.61	0.66	0.67	0.75
RT	log	log	log	log	log	log	log
Jan.							
r^2	0.80	0.99	0.91	0.99	0.80	0.99	0.99
SEy	0.08	0.02	0.05	0.02	0.07	0.03	0.002
Slope	0.25	0.54	0.30	0.35	0.17	0.06	0.40
Int	0.61	0.12	0.32	0.59	0.67	0.58	0.95
RT	log	log	log	log	log	linear	log

[1]Pastures A & B were chained 7 years before this study.
[2]Pastures C & D were chained and then sprayed with picloram at 7 and 3 years, respectively, before this study.
[3]Int = intercept
[4]RT = regression type

1). McCollum (1995) suggested that forages below 10% CP may be deficient in ruminally degradable protein. Improved intake has been reported in relation to ruminally degradable protein (Hannah et al. 1991, Lintzenich et al. 1995, Köster et al. 1996). Initial dietary CP was below 10% in the August trial. It is conceivable that a lack of ruminally degradable protein may have contributed to a depressed intake and the apparent depression in initial fecal output in August. Escape protein (Donaldson et al. 1991) and amino acid profile (Hill and Ellis 1991) have also been reported to function in intake control. The potential influence of these factors should not be overlooked. Although ending dietary CP was above 10% in all trials except August, these values were influenced by dietary browse (Fig. 2). South Texas browse species CP levels are reported in the 10 to 30% range (Taylor et al. 1997). However, recent evidence suggests (Barnes et al. 1991) that crude protein values overestimate the nutritional value of these species. Therefore, it is possible that crude protein, ruminally degradable protein, escape protein, and/or amino acids were deficient toward the end of the trials.

Individual Grass Species and Fecal Output

Within each trial and pasture, correlations were calculated between grass standing crop of each species and fecal output. Standing crop of the single grass species most highly correlated with fecal output was used to develop log or linear regression equations. Except for August, where no improvement was observed, single species equation standard error of estimate was reduced by half to an order of magnitude compared to equations using grass allowance or grass leaf allowance (Table 4). Only in the March chained pasture did the single species used in these regressions rank first in standing crop. In most cases, these species ranked second or third in standing crop and in 2 instances they were minor components of the standing crop. Although these observations may not have general application, we believe they indicate that partitioning the total grass standing crop can provide greater understanding of fecal output and intake dynamics. The tradeoff between diet selection and acquisition of dry matter can be seen from these analyses.

Dietary Components and Fecal Output

Correlation analysis of fecal output and dietary components indicated differences among trials (Table 5). During March, fecal output was positively correlated (0.67) with live grass stem and negatively correlated (–0.60) with live browse stem. May fecal output was positively correlated with live grass leaf (0.87) and negatively correlated with live forb leaf (–0.76), live forb stem (–0.91), and live browse leaf (–0.63). August fecal output was correlated (0.78) with live grass leaf. In January, dead grass leaf was the only dietary component correlated (0.89) with fecal output. Penning et al. (1994) reported that bite mass was more highly correlated (0.82) with green leaf mass than any other sward measurement. Only in the March trial was grass leaf, live or dead, not correlated with fecal output. In this trial, dietary live leaf content tended to remain high despite declining forage availability. This relatively high level of live leaf is probably an indication of animal drive to consume leaf over stem and live over dead tissue relative to quantity of leaf available per tiller.

For the 3 trials in which grass leaf, live or dead, was correlated with fecal output, maximum observed fecal output was achieved when leaf made up 50 to 70% or more of the diet. However, when grass leaf fell below 10% in the diet, fecal output was depressed by 25 to 40%. In all trials, maximum observed fecal output was attained only when total dietary grass content (leaf and stem) was near 100%.

Table 5. Correlation of diet composition (%) of total grass (TG); live leaf (GLL), dead leaf (GDL) and live stem (GLS); forb live leaf (FLL) and live stem (FLS); and browse live leaf (BLL) and live stem (BLS) to fecal output as a percent of body weight.

Trial	TG	GLL	GDL	GLS	FLL	FLS	BLL	BLS
Mar.	0.68	0.10	0.50	0.67	0.06	0.25	-0.45	-0.60
May	0.94	0.87	0.48	0.24	-0.76	-0.91	-0.63	-0.58
Aug.	0.64	0.78	0.34	0.16	-0.36	-0.21	-0.22	-0.22
Jan.	0.74	0.17	0.89	0.48	-0.26	-0.54	-0.55	-0.27

Table 6. Correlation of grass standing crop (GSC; kg/ha) and fecal output as a percent of body weight (FO) or dietary browse content (DBC; %) by trial.

Relationship	Correlation (r) by Trial Mar.	May	Aug.	Jan.
GSC vs FO	0.91	0.81	0.79	0.84
GSC vs DBC	-0.71	-0.76	-0.50	-0.51
FO vs DBC	-0.70	-0.92	-0.75	-0.43

Dietary Browse, Fecal Output, and Daily Grass Allowance

Both grass standing crop and fecal output were negatively correlated with dietary browse content (Table 6). Daily grass allowance levels at which dietary browse levels increased corresponded to where declining fecal output was observed (Fig. 1 and Fig. 2). These relationships indicate that 1) cattle selected browse in significant amounts only when grass standing crop became limiting and 2) browse consumption was not adequate to maintain fecal output. Seasonal differences in the correlations between grass standing crop and fecal output suggest that forage characteristics other than simply grass standing crop warrant study to gain a clearer understanding of factors influencing fecal output.

To better understand these relationships in shrubland situations, daily grass allowance was compared to dietary browse content (Fig. 2) using the log of daily grass allowance. Browse comprised less than 10% of steer diets until daily grass allowance fell below about 50 g/kg live weight. Prediction equations showed an exponential increase in browse consumption rising to nearly 60% of steer diets as daily grass allowance dropped below 25 g/kg live weight. Highest actual browse consumption was 64% in January, followed by 58, 57, and 53% in March, May, and August, respectively. These browse levels occurred at actual daily grass allowance levels less than 25 g/kg live weight and mostly in pastures A and B (chained only). When contrasted by trial, browse consumption had the strongest relationship with daily grass allowance in May followed by March, January and August in that order (Fig. 2). The shift to browse occurred earliest in May and latest in August, probably because May browse offered a reasonable alternative food, but August offered less alternative forage because of leaf drop.

Conclusions

Whether due to environmental conditions, differential forage quality, or differential forage preferences, apparent differences in fecal output among seasons found in this study could reflect important differences in forage intake. Assuming equal dry matter digestibility and using March and August fecal outputs, forage intake for a 300 kg steer would be 29%, 29%, and 16% lower in August than March at 1) initial fecal output levels, 2) 100 g, and 3) 50 g daily grass allowance/kg live weight, respectively. In reality, forage quality would be expected to decline with rapidly declining forage availability, further diminishing forage intake and animal nutritional status. Although potentially important, the rapid declines in fecal output that occurred below 100 g daily grass allowance would most likely only be observed under extremely high stock densities. Rapid declines in fecal output associated with lower initial daily grass allowance emphasize the need for lower stock densities under these conditions. It appears that, if stock density is maintained so that daily grass allowances are above 100 g dry matter/kg live weight, forage availability will have minimal effect on fecal output and on forage intake. Using the dry matter digestibility assumptions above, estimated forage intake depressions at about 100 g daily grass allowance were 3 to 8% below that calculated using initial fecal output. We interpret the data to indicate that different fecal output curves or adjustment factors may be needed to characterize fecal output relative to 1) seasonal differences and 2) different initial grass standing crops and grazing pressure.

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