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METABOLIC COMPONENTS OF CATTLE UNDER LIGHT AND HEAVY RATES OF STOCKING IN 1970

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TABLE OF CONTENTS

ABSTRACT

The work on metabolic components of cattle was conducted on pastures which were stocked lightly (23W) and heavily (23E) in 1970. Animal liveweights and animal days of grazing were monitored throughout the six months of warm-season grazing. After the completion of facilities, drinking water containing tritium, lithium, and chromium-EDTA was metered individually to fistulated animals and collectively to herd animals. Samples of urine and feces were collected daily and composited by weeks for determinations of tracer concentrations and various chemical components. Forage intake was estimated in three different ways, and dry matter digestibility was estimated by a fecal-nitrogen index equation. Under light stocking there were 20.8 animal days of grazing per hectare, during which about 130 kg/ha of forage dry matter was harvested. Under heavy grazing there were 40.9 animal days of grazing per hectare, during which about 257 kg/ha of forage dry matter was harvested.

INTRODUCTION

The primary objective in 1970 was to estimate fecal and urine output by the herds of yearling Hereford heifers on lightly stocked pastures (Pasture 23W) and heavily stocked pastures (Pasture 23E). Secondary objectives included comparisons among methods and further evaluation of water-soluble-tracer techniques for determining metabolic components of cattle on pasture.

Total amounts of energy and nutrients moving through the livestock were to be obtained from data of complementary projects. However, inadequate methodology prevented the direct estimation of some metabolic components. To compensate for these deficiencies, several methods were used to estimate forage intake, dry matter digestibility, and fecal output.

This report includes three parts as follows: (i) livestock biomass and metabolic components, (ii) water kinetics, and (iii) preliminary experiments using chromium-EDTA as an indicator of fecal output by grazing cattle. A fourth part, "estimating urine output by lithium dilution," will be added when the chemical analyses are completed. Part I includes observed and calculated data needed in subsequent evaluations of the livestock component. Parts II and III include details of tracer techniques.

SECTION I: LIVESTOCK BIOMASS AND METABOLIC COMPONENTS

METHODS

Facilities

A livestock-watering system and set of pens were built to serve the cattle on Pastures 23E and 23W, each of which have grazeable areas of 122 ha. The pen setup included an entry lane, weighing chute, two large pens for herd animals, and eight individual animal pens for fistulated heifers used in the project conducted by Rice and Vavra (1971). Each pen was supplied with metered drinking water from a common source. The drinking water, obtained from a well equipped with a windmill, was mixed with tracers in reinforced Butyl rubber tanks and piped by gravity flow through an underground plastic pipe to the pens. Since the facilities were not completed until mid-June, the data record is incomplete through the first two months (May and June) of grazing.

Livestock

Rancher-owned yearling Hereford heifers were obtained as herd animals. Esophageal-fistulated yearling heifers were brought in from the University of Wyoming by Rice and Vavra (1971). Pasture 23E was stocked with 35 head of herd animals and four head of fistulated animals. Pasture 23W was stocked with 12 head of herd animals and four head of fistulated animals. All heifers were weighed biweekly after an overnight shrink. Herd animals were placed on the pastures on May 1. Those on Pasture 23W remained on pasture until October 30, but those on 23E ran out of feed and were given another pasture on September 9. Fistulated animals were placed on the pastures about May 22, and were removed and taken back to Wyoming an August 27.

Water Intake

On Monday through Friday each week after completion of the facilities, the cattle were admitted to assigned pens from about 9 AM to 12 noon for drinking and sample collection. The water meters were read before and after the animals drank to determine water intake exclusive of leakage and evaporation losses through the remainder of the day. Both herd and fistulated animals drank water at will from assigned herd pens on Saturday and Sunday. Thus, the mean daily water drunk by fistulated animals is based on five days per week and that of herd animals on seven days per week, so the amounts of water drunk are essentially parameter measurements.

Water-Soluble Tracers

Tritiated water was added to the drinking water at a concentration of 90×10^{-5} μc/ml to permit the estimation of water turnover by the animals. A total of about 170 mc of tritium was used through the season.

To estimate total body water content (tritium space) of the 12 herd animals on Pasture 23W, tritiated water was injected intravenously at a rate of about 220 μc per animal five separate times spaced four weeks apart and scheduled at routine animal weighing times.

Lithium chloride was added to the drinking water at a concentration of 20 ppm of Li. Since lithium at low concentrations is excreted predominantly in the urine, this element was used as an index of urine volume.

Due to the high cost of material, ^{14}C-labelled polyethylene glycol could not be used on the pastures as an index of fecal output. Therefore, a substitute tracer (chromium EDTA) was added to the drinking water for preliminary development and evaluation of assay procedures, tracer recovery, and diurnal excretion patterns. Since individual-animal data would be available for the fistulated heifers, chromium recovery rates might be determined and applied to the herd animals for estimating fecal output.

Urine Samples

Urine samples were collected daily Monday through Friday and composited among days for weekly determinations of tritium, lithium, gross energy, dry matter, and nitrogen. The fistulated animals were sampled individually by palpating with a hand-held vibrator. Samples from herd animals were collected in a bucket fastened to the end of a conduit pipe. Equal aliquots then were composited among animals to obtain daily samples, and among daily samples to obtain weekly samples. A minimum of five animals were sampled daily from the small herd on Pasture 23W and a minimum of seven were sampled daily from the herd on Pasture 23E. In addition to the weekly composite samples, daily samples collected from the herd animals on Pasture 23W were retained for 10 days after each tritium injection to permit the determination of total body water at five weighing times. All urine samples were refrigerated at 3°C until delivered for analyses.

Fecal Samples

Fecal samples also were collected daily Monday through Friday and composited in the manner described for urine samples. Fecal samples were dried in a forced-air electric oven at 50°C, ground in a Wiley mill, and retained in plastic vials for subsequent determinations of chromium, gross energy, nitrogen, ash, acid detergent fiber, and lignin.

Chemical Analyses

Tritium and lithium determinations (Knox et al. 1970) were done in the Animal Science Metabolic Laboratory by Knox. All other determinations were done in the Grasslands Laboratory by Streeter.

Hand-Plucked Samples of Herbage

Hand-plucked samples of herbage were collected Monday through Friday in a manner that approximated the herbage being grazed. Moisture percentages of herbage samples were used to estimate forage intake by the water-intake method, which is described in previous papers (Hyder, Bement, and Norris 1968).

RESULTS

Observed Data

Tables 1 through 5 include observed data on stocking rates, animal liveweights, dates of grazing, and metabolic components monitored in this project. Since the sampling was structured on a weekly basis, the data are reported accordingly. A great many comparisons between light and heavy stocking rates and between herd and fistulated animals can be made with the data.

Forage Intake

Estimates of fecal output for herd animals by chromium dilution were unsatisfactory (see Part III). Therefore, the estimation of

Table 1. Observed data, Pasutre 23W, stocked lightly with 12 head of herd animals (yearling Hereford heifers) plus 4 head of fistulated yearling Angus heifers, pasture area = 122 ha.

Dates of Grazing		Herd Animals						
		Mean Air Temperature[a] (°C)	Precip.[a] (mm)	Mean Liveweight (kg)	Mean Daily Gain (kg)	Animal Days of Grazing	Water Drunk (liters/head/day)	Moisture in Hand-Plucked Herbage (%)
May	1- 7	10.0	0	213[b]	-0.43	84		
	8-14	10.0	0		-0.43	84		
	15-21	13.3	0	207	0.93	84		
	22-28	13.9	11		0.93	84		
	29- 4	10.6	10	220	0.93	84		
June	5-11	12.8	11		0.93	84		
	12-18	16.7	18	233	0.50	84	12.9	60
	19-25	20.0	0		0.50	84	23.5	65
	26- 2	21.7	2	240	0.64	84	24.2	56
July	3- 9	20.6	1		0.64	84	26.1	47
	10-16	20.6	9	249	0.28	84	23.8	48
	17-23	21.1	17		0.28	84	20.8	50
	24-30	20.6	10	253	1.21	84	22.7	52
	31- 6	22.8	7		1.21	84	27.6	48
Aug.	7-13	20.6	0	270	1.14	84	26.5	38
	14-20	20.0	0		1.14	84	37.5	40
	21-27	19.5	0	286	0.21	84	25.4	40
	28- 3	18.9	5		0.21	84	25.4	30
Sept.	4-10	15.0	0	289	0.21	84	21.6	34
	11-17	9.5	7		0.21	84	18.2	34
	18-24	11.1	19	292	0.71	84	15.1	32
	25- 1	12.8	7		0.71	84	15.5	39
Oct.	2- 8	6.7	10	302	-0.21	84	14.0	39
	9-15	3.3	4		-0.21	84	4.5	36
	16-22	3.3	0	299	0.14	84	20.4	35
	23-29	3.3	16		0.14	84	14.4	40
	30			301				
						2,184		

Table 1, Part II.

Dates of Grazing		Herd Animals							
		Feces						Urine	
		Dry Matter (%)	Gross Energy (kcal/g D.M.)	N (% D.M.)	Ash (% D.M.)	Acid Detergent Fiber (% D.M.)	Lignin (% D.M.)	Gross Energy (kcal/ml)	N (mg/ml)
May	1- 7								
	8-14								
	15-21								
	22-28								
	29- 4								
June	5-11								
	12-18	16.2	4.10	2.05	23.6	46.2	10.5	0.22	8.55
	19-25	16.2	4.08	1.97	22.0	44.7	10.3	0.19	7.76
	26- 2	17.7	4.18	1.96	22.2	46.5	12.5	0.15	7.19
July	3- 9	17.0	4.18	1.91	21.9	45.2	11.6	0.20	6.99
	10-16	16.1	4.21	1.72	21.1	46.5	11.5	0.20	7.29
	17-23	17.0	4.18	1.72	22.3	45.4	10.1	0.25	8.86
	24-30	17.5	4.21	1.68	21.5	45.8	10.6	0.22	8.88
	31- 6	17.0	4.23	2.16	20.7	43.2	8.8	0.28	8.68
Aug.	7-13	18.6	4.22	1.50	19.2	43.6	9.9	0.30	9.11
	14-20	18.5	4.26	1.48	19.5	43.3	8.1	0.28	8.44
	21-27	19.8	4.26	1.50	20.4	43.8	9.9	0.30	9.47
	28- 3	18.0	4.20	1.62	21.9	43.4	8.6	0.35	8.67
Sept.	4-10	21.2	4.14	1.61	25.0	45.5	8.9	0.34	9.47
	11-17	19.6	4.17	1.57	23.2	44.2	9.4	0.44	11.40
	18-24	18.6	4.32	1.58	21.0	43.5	9.8	0.32	9.45
	25- 1	18.4	4.28	1.50	22.4	44.0	10.0	0.40	9.87
Oct.	2- 8	19.2	4.47	1.53	18.9	43.3	9.7		
	9-15	20.6	4.37	1.50	19.4	43.7	9.9		
	16-22	19.4	4.41	1.57	19.1	42.4	10.0		
	23-29								
	30								

Table 1, Part III.

Dates of Grazing		Mean Live-weight (kg)	Mean Daily Gain (kg)	Animal Days of Grazing	Water Drunk (liters/ head/day)	Fistulated Animals c/ — Feces: Dry Matter (%)	Gross Energy (kcal/g D.M.)	N (% D.M.)	Ash (% D.M.)	ADF (% D.M.)	Lignin (% D.M.)
May	1- 7										
	8-14										
	15-21										
	22-28			12							
	29- 4	223	0.65	28							
June	5-11		0.65	28							
	12-18	232	-0.50	28	9.5						
	19-25		-0.50	28	12.9						
	26- 2	225	-0.21	28	13.6						
July	3- 9		-0.21	28	14.4						
	10-16	222	0.14	28	9.8	19.2	4.03	1.69	24.4	46.7	10.4
	17-23		0.14	28	11.4	19.7	3.99	1.62	25.6	47.4	9.6
	24-30	224	0.86	28	14.4	21.3	4.07	1.63	24.3	47.2	10.0
	31- 6		0.86	28	14.4	19.3	4.10	2.04	21.8	43.4	8.2
Aug.	7-13	236	0.00	26 d/	16.7	20.8	4.41	1.52	19.7	44.6	8.4
	14-20		0.00	21	17.8	21.3	4.13	1.50	22.3	43.5	7.4
	21-27	236		18 e/	20.8	20.8	4.15	1.71	23.0	43.8	9.0
	28- 3										
Sept.	4-10										
	11-17										
	18-24										
	25- 1										
Oct.	2- 8										
	9-15										
	16-22										
	23-29										
	30										
				358							

a/ Air temperature and precipitation as recorded at CPER headquarters.

b/ Animals were weighed individually after an overnight shrink on the first day of alternate weeks, except no shrink on initial weight.

c/ Individual animal data in Tables 3 and 4.

d/ One animal removed Aug. 12.

e/ Three animals removed Aug. 27.

Table 2. Observed data, Pasture 23E, stocked heavily with 35 head of herd animals (yearling Hereford heifers) plus 4 head of fistulated yearling Hereford heifers, pasture area = 122 ha.

Dates of Grazing		Herd Animals				
		Mean Liveweight (kg)	Mean Daily Gain (kg)	Animal Days of Grazing	Water Drunk (liters/head/day)	Moisture in Hand-Plucked Herbage (%)
May	1- 7	209[a/]	-0.50	245		
	8-14		-0.50	245		
	15-21	202	0.64	245		
	22-28		0.64	245		
	29- 4	211	0.65	245		
June	5-11		0.65	245		
	12-18	220	1.07	245	14.0	58
	19-25		1.07	245	23.1	57
	26- 2	235	0.43	245	19.7	55
July	3- 9		0.43	245	24.6	56
	10-16	241	0.21	245	20.8	47
	17-23		0.21	245	18.5	62
	24-30	244	0.43	245	20.4	53
	31- 6		0.43	245	21.6	46
Aug.	7-13	250	0.93	245	22.7	44
	14-20		0.93	245	26.9	34
	21-27	263	0.07	245	25.4	39
	28- 3		0.07	245	21.2	35
Sept.	4-10	264		210[b/]		
	11-17			out		
	18-24					
	25- 1					
Oct.	2- 8					
	9-15					
	16-22					
	23-29			4,620		
	30					

Table 2, Part II.

Dates of Grazing		Herd Animals: Feces: Dry Matter (%)	Feces: Gross Energy (kcal/g D.M.)	Feces: N (% D.M.)	Feces: Ash (% D.M.)	Feces: ADF (% D.M.)	Feces: Lignin (% D.M.)	Urine: Gross Energy (kcal/ml)	Urine: N (mg/ml)
May	1- 7								
	8-14								
	15-21								
	22-28								
	29- 4								
June	5-11								
	12-18	17.4	3.85	1.83	27.5	46.9	10.2	0.24	9.11
	19-25	17.1	3.84	1.84	27.7	50.6	12.1	0.20	8.10
	26- 2	19.0	3.94	1.67	25.0	50.2	11.7	0.21	7.19
July	3- 9	19.3	3.95	1.76	25.4	49.4	12.6	0.24	7.31
	10-16	19.5	4.04	1.72	25.0	49.4	12.0	0.25	7.03
	17-23	19.1	4.06	1.61	25.3	47.6	11.0	0.29	11.62
	24-30	19.6	3.94	1.51	25.8	50.4	10.8	0.28	10.11
	31- 6	18.9	3.98	2.04	23.5	47.9	10.4	0.30	10.06
Aug.	7-13	19.3	4.06	1.59	23.5	46.7	10.1	0.30	10.15
	14-20	20.0	4.06	1.49	23.3	45.9	11.1	0.36	9.48
	21-27	20.1	4.08	1.55	24.0	45.5	10.4	0.30	8.46
	28- 3	20.3	4.00	1.53	25.2	47.8	11.4	0.45	9.74
Sept.	4-10								
	11-17								
	18-24								
	25- 1								
Oct.	2- 8								
	9-15								
	16-22								
	23-29								
	30								

Table 2, Part III.

Dates of Grazing		Fistulated Animals[c/] Mean Live-weight (kg)	Mean Daily Gain (kg)	Animal Days of Grazing	Water Drunk (liters/ head/day)	Feces Dry Matter (%)	Gross Energy (kcal/g D.M.)	N (% D.M.)	Ash (% D.M.)	ADF (% D.M.)	Lignin (% D.M.)
May	1- 7										
	8-14										
	15-21										
	22-28			12							
	29- 4	244	0.00	28							
June	5-11		0.00	28							
	12-18	244	-0.43	28	14.8						
	19-25		-0.43	28	13.6						
	26- 2	238	0.14	28	11.7						
July	3- 9		0.14	28	15.5						
	10-16	240	-0.14	28	11.0	18.9	4.07	1.62	22.4	49.4	12.6
	17-23		-0.14	28	11.7	19.9	4.02	1.61	24.1	48.2	10.7
	24-30	238	0.43	28	12.9	20.0	4.07	1.62	23.1	48.8	11.0
	31- 6		0.43	28	15.1	20.8	3.96	1.53	24.3	47.0	9.0
Aug.	7-13	244	0.21[d/]	28	14.4	23.4	3.99	1.51	23.7	47.8	8.6
	14-20		0.21[d/]	25[e/]	19.3	22.3	4.14	1.58	22.2	45.1	9.6
	21-27	252		18[f/]	19.3	23.8	4.10	1.80	23.0	45.5	10.4
	28- 3										
Sept.	4-10										
	11-17										
	18-24										
	25- 1										
Oct.	2- 8										
	9-15										
	16-22										
	23-29										
	30										
				363							

a/ Animals were weighed individually after an overnight shrink on the first day of alternate weeks, except no shrink on initial weight.

b/ Pasture 23E was grazed very closely; and the cattle were given another pasture September 9.

c/ Individual animal data in Tables 3 and 5.

d/ Calculated for three head remaining.

e/ One animal removed August 18.

f/ Three animals removed August 27.

Table 3. Water drunk (liters/head/day) by fistulated animals.

Date of Grazing		Pasture 23W				Pasture 23E			
	Tag No.:	9027	9010	684	9031	9073	9098	9078	9088
	Lot No.:	W1	W2	W3	W4	E1	E2	E3	E4
June 12-18		9.8	9.1	7.6	11.0	14.0	10.6	19.7	14.4
19-25		14.0	11.7	12.1	14.0	10.2	15.5	13.6	16.0
26- 2		14.8	11.0	13.2	15.5	9.1	-	10.2	16.3
July 3- 9		18.2	11.4	13.2	-[a/]	14.4	-	16.3	16.0
10-16		12.5	7.6	7.9	11.4	10.6	10.6	11.7	10.6
17-23		14.0	8.3	10.2	12.1	9.8	11.0	14.0	-
24-30		13.2	9.8	12.9	21.2	9.5	17.4	11.0	13.6
31- 6		16.3	7.2	14.0	20.4	16.3	15.1	14.8	14.0
Aug. 7-13		16.7	x[b/]	17.8	15.5	10.6	16.7	17.0	14.0
14-20		19.7	x	17.4	15.9	16.3	25.7	x	15.5
21-27		21.2	x	20.1	20.8	16.3	23.8	x	18.2

a/ Plug was lost from esophageal fistula or otherwise leaking badly.

b/ Animal was removed from pasture.

Table 4. Individual fistulated animal data, Pasture 23W, light grazing, fecal samples.

Week	Animal[a/]	Dry Matter (%)	Gross Energy (kcal/g)	N (% D.M.)	Ash (% D.M.)	ADF (% D.M.)	Lignin (% D.M.)
July 10-16	W1	18.6	4.154	1.72	22.1	45.2	9.9
	W2	19.3	4.032	1.64	23.6	46.8	9.6
	W3	19.8	3.913	1.70	27.6	48.1	11.8
	W4	No sample					
July 17-23	W1	20.3	3.909	1.61	28.0	47.9	9.0
	W2	19.7	4.169	1.60	21.3	46.1	10.0
	W3	19.2	3.887	1.64	27.5	48.2	9.7
	W4	No sample					
July 24-30	W1	21.8	4.244	1.69	19.9	45.1	9.8
	W2	20.1	4.249	1.64	21.7	44.8	9.6
	W3	23.5	3.715	1.43	30.6	53.4	10.0
	W4	19.7	4.061	1.77	24.9	45.6	10.8
July 31- 6	W1	19.7	4.029	2.00	22.9	43.8	7.8
	W2	No sample					
	W3	18.9	4.177	2.09	20.7	43.1	8.5
	W4	No sample					
Aug. 7-13	W1	21.5	4.637	1.58	20.5	44.6	8.7
	W2	No sample					
	W3	20.2	4.184	1.45	19.3	44.7	8.2
	W4	No sample					
Aug. 14-20	W1	22.7	4.158	1.54	22.0	43.5	7.8
	W2	No sample					
	W3	21.6	4.066	1.46	23.8	45.0	7.5
	W4	19.5	4.169	1.50	21.1	41.9	6.9
Aug. 21-27	W1	20.9	4.218	1.74	21.5	44.3	9.5
	W2	No sample					
	W3	20.8	4.245	1.76	22.0	41.8	8.6
	W4	20.7	3.979	1.63	25.4	45.3	8.9

[a/] Ear tag numbers are included in Table 3.

Table 5. Individual fistulated animal data, Pasture 23E, heavy grazing, fecal samples.

Week	Animal[a/]	Dry Matter (%)	Gross Energy (kcal/g)	N (% D.M.)	Ash (% D.M.)	ADF (% D.M.)	Lignin (% D.M.)
July 10-16	E1	21.5	3.951	1.59	24.6	50.4	14.2
	E2	19.1	4.058	1.63	23.9	51.2	13.4
	E3	17.2	4.183	1.54	19.9	48.7	11.2
	E4	17.9	4.099	1.70	21.4	47.5	11.7
July 17-23	E1	22.6	4.099	1.58	22.9	49.2	11.0
	E2	No sample					
	E3	18.5	3.771	1.48	27.8	49.7	10.7
	E4	18.6	4.202	1.77	21.7	45.8	10.5
July 24-30	E1	21.7	4.078	1.60	23.4	50.9	12.3
	E2	21.3	3.962	1.55	25.9	49.3	10.2
	E3	17.7	4.196	1.63	19.6	46.9	10.8
	E4	19.2	4.043	1.68	23.5	48.0	10.6
July 31- 6	E1	22.4	3.981	1.66	24.2	46.6	9.4
	E2	21.4	3.813	1.52	27.2	47.8	8.4
	E3	18.6	4.077	1.42	21.6	46.7	9.2
	E4	No sample					
Aug. 7-13	E1	27.7	3.836	1.56	25.7	50.7	9.3
	E2	22.3	3.986	1.54	24.1	47.7	7.8
	E3	20.2	4.194	1.36	19.1	45.0	8.2
	E4	23.3	3.929	1.59	26.0	48.0	9.1
Aug. 14-20	E1	22.4	4.174	1.68	22.3	45.4	9.6
	E2	22.8	4.098	1.51	22.3	43.3	8.4
	E3	No sample					
	E4	21.7	4.138	1.54	21.9	46.6	10.8
Aug. 21-27	E1	23.8	4.048	1.69	22.9	46.3	10.5
	E2	23.9	4.099		23.3	43.0	8.4
	E3	No sample					
	E4	23.6	4.147	1.91	22.8	47.3	12.4

[a/] Ear tag numbers are included in Table 3.

forage intake of herd animals as a quotient of fecal output divided by dry matter indigestibility (as estimated for fistulated animals by Rice and Vavra, 1971) was impossible. However, forage intake by herd animals was estimated by water-intake (Hyder et al. 1966), tritium dilution, and the California Net Energy System (see Part II). By any method, herd animals consumed more forage than fistulated animals, and animals on Pasture 23W consumed more than those on 23E (Table 6). For fistulated animals, forage intake, as estimated by the water-intake method, was greater than that estimated by the quotient method used by Rice and Vavra. For herd animals, forage intake, as estimated by the water-intake method, was less than that estimated by the net energy method and greater than that estimated by water turnover. Environmental conditions sometimes exceed the limits imposed by the water-intake method (Hyder et al. 1968), but were continuously within those limits in 1970. Consequently, there is no reason to suspect serious error in the estimates of forage intake based on the water-intake method.

Dry Matter Digestibility

The fecal-nitrogen index method of estimating dry matter digestibility appears reliable when the regression equation is derived from conventional trials on the forage of interest. We lack conventional trials on the forage at the Pawnee Site; however, Wallace (1969) derived a nitrogen-index equation for range forage in eastern Colorado. His equation was used to estimate dry matter digestibilities to compare with the in vitro estimations of digestibility reported by Rice and Vavra (1971). The nitrogen-index equation estimated digestibilities at values

Table 6. Calculated data -- forage dry matter intake.

Dates of Grazing		Pasture 23E -- Heavy					Pasture 23W -- Light			
		Herd Animals			Fistulated		Herd		Fistulated	
		By Water Intake[a/]	By Tritium Dilution[b/]	By Net Energy[b/]	By Water Intake[a/]	By Fistula[c/]	By Water Intake[a/]	By Net Energy[b/]	By Water Intake[a/]	By Fistula[c/]
		(kg/head/day)								
May	1- 7									
	8-14									
	15-21									
	22-28									
	29- 4									
June	5-11									
	12-18	5.4	2.0	8.3	5.8	2.8	5.3	8.6	3.9	2.5
	19-25	7.7	7.1	10.8	4.5	2.8	9.4	9.7	5.2	2.5
	26- 2	5.9	5.5	7.3	3.5	2.8	7.3	7.7	4.1	2.5
July	3- 9	7.8	6.3	6.9	4.9	2.8	7.1	6.4	3.9	4.0
	10-16	5.9	5.7	6.4	3.1	2.8	6.8	5.5	2.8	4.0
	17-23	6.5	5.0	5.3	4.1	2.8	6.0	5.1	3.3	4.0
	24-30	6.3	5.7	6.3	3.9	2.8	6.8	6.1	4.3	4.0
	31- 6	5.6	4.9	7.0	3.9	3.3	7.3	7.1	3.8	4.6
Aug.	7-13	6.3	6.5	9.6	3.9	3.3	7.0	8.6	4.4	4.6
	14-20	7.0	9.6	10.2	5.0	3.3	10.2	10.1	4.9	4.6
	21-27	7.0	5.1	5.4	5.3	3.3	7.0	6.4	5.8	4.6
	28- 3	5.8	2.9	4.6			6.7	4.5		
Sept.	4-10						6.6	7.9		
	11-17						6.5	10.0		
	18-24						5.1	6.6		
	25- 1						5.5	5.2		
Oct.	2- 8						5.0	5.2		
	9-15						1.8[d/]	5.2		
	16-22						8.1	6.8		
	23-29						5.9	7.3		
MEAN		6.4	5.5	7.3	4.4	3.0	6.6	7.0	4.2	3.8

a/ Calculated by the water-intake method (Hyder, et al. 1968).

b/ Calculated by Knox (1970), as described in another section of this report).

c/ As reported by Rice and Vavra (1971). These values are adjusted to an animal liveweight of 225 kg, which is near the observed weight of the fistulated animals.

d/ Low intake shows effect of snow storm and cold weather.

nearly identical to those reported by Rice and Vavra (1971), except for fistulated animals on Pasture 23E in the month of August (Table 7).

Energy and Nitrogen Components

Total amounts of energy and nitrogen consumed, and of energy and nitrogen excreted in feces, on each pasture were estimated as follows:

Component	Pasture	
	23W	23E
Animal days of grazing per ha	20.8	40.9
Dry matter consumed (kg/ha)	129.8	256.7
Gross energy consumed (Mcal/ha)	515.5	983.2
Nitrogen consumed (kg/ha)	2.4	4.4
Dry matter in feces (kg/ha)	48.6	96.8
Gross energy in feces (Mcal/ha)	205.6	385.6
Nitrogen in feces (kg/ha)	0.8	1.6

These estimates are based on forage intake by the water-intake method, dry matter digestibility by the nitrogen-index method, and observed data in Tables 1 and 2. Mean values across all dates were used in the calculations, and applied to the entire grazing season. Energy and nitrogen in urine can be added, if estimates of urine output by lithium dilution appear satisfactory.

Table 7. Calculated data -- dry matter digestibility.

Date of Grazing		Pasture 23E -- Heavy			Pasture 23W -- Light		
		Herd[a]	Fistulated[a]	Fistulated[b]	Herd[a]	Fistulated[a]	Fistulated[b]
		%					
May	1- 7						
	8-14						
	15-21						
	22-28						
	29- 4						
June	5-11			65			64
	12-18	65		65	69		64
	19-25	66		65	68		64
	26- 2	62		65	68		64
July	3- 9	64		58	67		65
	10-16	63	61	58	63	63	65
	17-23	61	61	58	63	61	65
	24-30	59	61	58	62	62	65
	31- 6	69	60	58	71	69	65
Aug.	7-13	61	59	52	59	60	61
	14-20	59	61	52	59	59	61
	21-27	60	65	52	59	63	61
	28- 3	60		52	61		61
Sept.	4-10				61		
	11-17				60		
	18-24				61		
	25- 1				59		
Oct.	2- 8				60		
	9-15				59		
	16-22				60		
	23-29						
	30						

a/ As calculated by the fecal nitrogen index equation ($Y = 18.6X + 31.3$) derived by J. D. Wallace (1969).

b/ As reported by Rice and Vavra (1971)--in nitro determinations.

SECTION II: WATER KINETICS

PURPOSE

This segment of the project was devoted to determining three parameters in range cattle; total body water, dry matter intake by dilution kinetics with ^3H_2O, and urine water excretion by using lithium as a tracer.

METHODS

Total Body Water Flux

Twelve head of heifers in Pasture 23W were periodically injected intravenously with approximately 1 mc ^3H_2O. Composite urine samples were collected, treated with activated charcoal, and assayed for ^3H_2O by scintillation spectrometry. Procedures used have previously been described (Knox et al. 1970).

Dry Matter Intake

Dry matter intake was estimated in 35 head of heifers in Pasture 23E. These animals drank water containing low concentrations of ^3H_2O. Composite urine samples were collected and assayed for ^3H_2O. By using the ^3H_2O entry rate and the concentration of body ^3H_2O, the dry matter intake was estimated. Additionally, the California Net Energy System (CNE) was used to estimate dry matter intakes based upon body weight gains.

Urine Water Excretion

Urine excretion was estimated using lithium dilution kinetics and dry matter content of urine.

RESULTS

In Table 8 water flux data is shown for the various times of the experimental season. The turnover rate gradually fell from the first to the last test period. Also, there appeared to be a strong positive correlation between water flux and body weight (Fig. 1). In most cases, daily water flux was less than measured water intake. This suggests a lack of equilibrium between gut water and body water, especially when food water content was greater than 50%. The percents of body water generally declined through the season, suggesting that liveweight gains contained increasing amounts of fat (Table 8).

Estimates of dry matter intake by tritium dilution varied from 2 to 9.5 kg of dry matter/day (Table 9). Additional values calculated by the CNE estimated forage intake at a higher level (4.5 to 10.7 kg) than by tritium dilution (Table 10). However, the two sets of intake estimates agree rather well, except during the first two weeks (June 12 to 26). The seasonal trends in intake are similar, even though the two techniques are completely unrelated.

DISCUSSION

The theoretical basis of tritium dilution is well established, and previous data (see 1970 report) show excellent accuracy. However, there is one serious problem. When the forage consumed contains large amounts of water (probably 50% or more) it is likely that there is not complete equilibrium between gastrointestinal water and that in the body. This was not the case when dry feed was fed (D.M. = 85 to 90%), because less than 5% of the total water intake was derived from the feed. In these studies, up to 20% of the total water flux was derived from feed water.

Table 8. Water kinetics of heifers on pasture 23W, light grazing.

Dates of Determinations	Weight[a/] (kg)	Intercept[b/] (μc/ml x 10^{-5})	Turnover Rate[b/] (fraction/hr)	Total[c/]	Body Water[d/] (% of body weight)	Water Flux[e/] (liters/ day)	Water Intake[f/] (liters/ day)
May 15-26	221	425	.0079	135.6	61.3	25.2	--
June 15-26	238	456	.0071	136.5	57.4	23.3	20.8
July 10-24	251	465	.0060	137.6	54.8	19.8	22.3
Aug. 7-21	283	447	.0051	148.4	52.4	18.2	31.6
Sept. 4-16	290	422	.0042	158.1	54.5	15.9	19.9

a/ Weight estimated to middle of period by extrapolation of actual values.

b/ Kinetic data obtained were based upon the formula $Y_t = Y_o e^{-\lambda t}$. $Y_t = {}^3H_2O/H_2O$ at any time, $Y_o = {}^3H_2O/H_2O$ at zero time (extrapolated from semilog base e plot of dilution data). λ = fraction of H_2O turning over per unit time t; also, λ is the slope of the semilog plot calculated by method of least squares.

c/ Total body water was calculated by dividing the amount of ${}^3H_2O$ injected by the correction for endogenous activity.

d/ Body water as a percent of body weight = (total body water/animal weight) x 100.

e/ Water flux = total body water x turnover rate.

f/ Water intake = that actually measured.

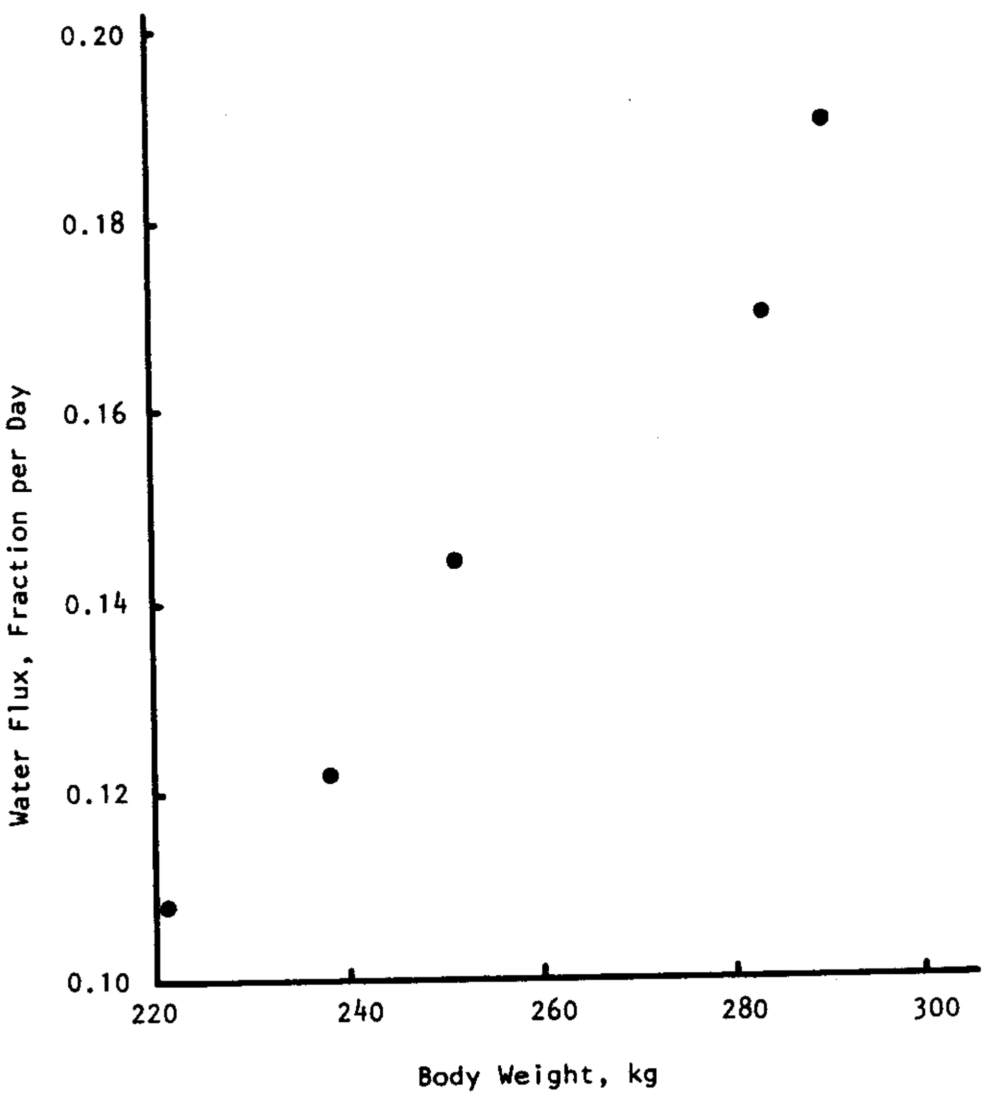

Fig. 1. Relationship between daily water flux and body weight.

Table 9. Water intake, partitioning, and dry matter consumption of heifers in Pasture 23E, heavy grazing.

Experimental Date	Specific Activity ($\mu c \times 10^{-5}$)		Water Partitioning (kg/day)				Water in Forage %	Estimated Forage Intake[e] (kg/day)
	Urine	Drinking H_2O	Total Intake[a]	= Drunk[b]	+ Metabolic[c]	+ Feed[d]		
June 12-18	51.4	95.3	21.3	14.0	4.6	2.7	57	2.0
19-25	53.4	96.6	35.5	23.1	4.8	7.6	52	7.0
26- 2	52.7	97.2	30.4	19.7	4.8	5.9	52	5.4
July 3- 9	53.0	94.2	36.8	24.6	4.8	7.4	52	6.8
10-16	56.2	94.2	31.2	20.8	4.9	5.5	52	6.4
17-23	58.4	96.3	28.3	18.5	5.0	4.8	49	5.0
24-30	63.4	95.8	30.8	20.4	5.0	5.4	49	5.6
31- 6	63.4	92.0	31.3	21.6	5.1	4.6	49	4.8
Aug. 7-13	61.0	85.8	31.9	22.7	5.1	4.1	39	6.4
14-20	61.0	85.4	37.7	26.9	5.2	5.6	37	9.5
21-27	63.1	83.6	33.7	25.4	5.3	3.0	37	5.1
28- 3	65.7	88.4	28.5	21.2	5.3	2.0	41	2.9

a/ Total intake = (specific activity in drinking water x water drunk) ÷ mean specific activity in urine, which is 62.3 $\mu c/ml$.

b/ Water drunk = that actually measured.

c/ Metabolic water = 80.8 g $H_2O \times W_{kg}^{3/4}$.

d/ Feed water = total intake - (water drunk + metabolic water).

e/ Estimated forage intake = (feed water ÷ percent of water in forage)100 - feed water.

Table 10. Estimate of dry matter intake by the California Net Energy System, Pasture 23E, heavy grazing.

Experimental Date	Animal Weight (kg)	Avg. Daily gain[a] (kg)	Net Energy Required		Feed Required		Estimated Forage Intake (kg D.M./day)
			Maint.[b] (Mcal)	Gain[c] (Mcal/lb)	Maint.[d] (kg/day)	Gain[e] (kg/day)	
June 12-18	222	0.78	4.47	3.84	3.5	4.7	8.2
19-25	229.5	1.14	4.60	3.95	3.6	7.1	10.7
26- 2	236	0.57	4.68	4.01	3.7	3.6	7.3
July 3-19	239	0.43	4.73	4.06	3.7	2.7	6.4
10-16	241.5	0.29	4.75	4.08	3.7	1.8	5.6
17-23	243	0.23	4.79	4.10	3.8	1.5	5.3
24-30	245	0.37	4.82	4.12	3.8	2.4	6.2
31- 6	248	0.49	4.86	4.17	3.8	3.2	7.0
Aug. 7-13	252.5	0.83	4.93	4.21	3.8	5.5	9.3
14-20	259	0.92	5.03	4.30	3.9	6.2	10.1
21-27	263	0.21	5.07	4.34	4.0	1.5	5.5
28- 3	264	0.08	5.10	4.37	4.0	0.5	4.5

a/ Average daily gain calculated from extrapolated values of actual weights.

b/ Maintenance energy required = 43 kcal/day × $W_{lb.}^{3/4}$ (Lofgreen and Garrett 1968).

c/ Energy required per kg of gain = (16.7 kcal/day × $W_{lb.}^{3/4}$) 2.205.

d/ Feed required for maintenance = (43 kcal·$W_{lb.}^{3/4}$/0.58 Mcal NE_M/lb.) 0.4536 (Lofgreen and Garrett 1967).

e/ Feed required for gain = [(16.7 kcal·$W_{lb.}^{3/4}$ × ADG) ÷ (0.29 Mcal NE_p/100 lb.)] 0.4536 were determined from the feed protein, dry matter, and estimated crude fiber.

Data presented in Table 10 suggest that the CNE provides a good index of dry matter intake and has a great deal of utility in the field. The data required for these calculations is obtained from animal weights and the crude fiber and crude protein concentrations of forages consumed. The method also avoids the problem of ^3H_2O residues. Furthermore, in pastures where the terrain is not drastic, the energy lost in locomotion is not greatly different from that expended under conditions involved in developing the CNE data.

SECTION III: PRELIMINARY EXPERIMENTS USING CHROMIUM-EDTA AS AN INDICATOR OF FECAL OUTPUT BY GRAZING CATTLE

INTRODUCTION

One phase of the Grassland Biome Program is to estimate the energy flow through various compartments of the ecosystem. To be able to measure this energy flow, the estimation or measurement of the amount of biomass of various components within the system is required, as well as the proportion of this biomass that is transferred from one organism to another. The quantity of forage consumed by grazing cattle can be computed from the ratio of the quantity of feces excreted to the indigestibility of forage consumed. Measurement of the quantity of feces excreted by grazing cattle can be made directly with total collection harnesses and bags. However, this method cannot be easily applied to large numbers of animals because the equipment is relatively costly, sampling is time consuming, and the apparatus can induce an added stress to the animal.

Fecal excretion can be estimated indirectly by the "tracer" technique. Experimental animals receive a known quantity of tracer for a period of time of sufficient length to insure stabilization of its concentration in the feces. The quantity of feces produced in a unit of time is equivalent to the weight of a tracer administered during that time divided by the weight of the tracer per unit of fecal material. The validity of the method is based on the assumption that the tracer is completely indigestible, does not influence the response of the animal, and passes through the animal uniformly. One of the most common materials used for this purpose is chromic oxide (Cr_2O_3). However, many studies have shown that Cr_2O_3 has variable recovery in the feces, and large errors are involved in predicting intake based on this data. To reduce the problem of uneven distribution of the indicator in the gastrointestinal tract of ruminants, Hogan (1964) used a soluble tracer, radioactive chromium complexed with ethylene diamine tetra acetic acid (Cr^{51}EDTA). Approximately 95% of the amount of the tracer that was administered was recovered in the fecal material.

METHODS

Individual Studies

This phase of the study was designed to evaluate the fecal recovery of chromium administered in the form of Cr-EDTA. Four yearling heifers with esophageal fistulas were placed in each pasture. The animals were allowed access to drinking water containing added Cr-EDTA once daily for six days prior to and during the experiment period. Individual total water consumption by fistulated animals was measured with meters attached to the waterers. Water consumption data and Cr concentration in the water were used to calculate the total amount of Cr consumed.

Individual total fecal collections were made once each week from July 10 to August 27, as described by Rice and Vavra (1971). Fecal grab samples collected daily and composited by weeks were dried, ground, and analyzed for Cr concentration as described below. Fistulated animals were sampled individually, but herd animals were sampled in composite.

Information concerning the Cr concentration in the fecal material in conjunction with total fecal excretion was used to compute total Cr excretion and, hence, percentage fecal recovery of Cr.

Herd Studies

This phase of the study was designed to estimate the quantity of feces excreted and forage consumed by all cattle. Yearling Hereford heifers from local ranchers (herd animals) drank treated water from the common source at 9:00 AM. Cr consumption was determined on a group basis for each pasture. Fecal samples were randomly collected from the ground as they dropped at 9:00 to 12:00 AM from each of seven to eight animals for five days each week from July 10 to September 18. The samples were composited over animals and days to provide one sample per pasture per week. Cr analyses were conducted on dried and ground samples as described below. Total fecal excretion was computed from the ratio of the amount of Cr administered to the concentration of Cr in the fecal samples. The weekly Cr fecal recovery described above was used to adjust the predicted fecal excretion to 100% fecal Cr recovery. Forage consumption was estimated from the ratio of fecal excretion to indigestibility. The later value was determined as described in Rice and Vavra (1971).

At the termination of the recovery studies, a subproject was conducted to study diurnal variation in Cr concentration of the feces. Rectal grab samples were collected at 6:00, 8:00, and 10:00 AM, and at 12:00 noon and 2:00 PM from the 12 herd animals on the lightly grazed pasture. Fecal samples were composited over all animals to provide one sample per period.

Goat Study

Another study was conducted with goats to further evaluate the fecal recovery of Cr-EDTA. Twelve goats were individually housed in digestion crates and fed a measured diet of alfalfa hay. Cr-EDTA was administered via ruminal cannulae for six days prior to and during a six-day collection period. Adequate fecal samples were obtained from each animal, dried, ground, and analyzed for Cr as described below. The percentage fecal recovery of Cr was computed as described for the animals used in the validity study.

Tracer Preparation

The chromium EDTA complex was prepared by slowly adding 266 g (1 mole) of $CrCl_3$ $6H_2O$ and 372 g $Na_2H_2EDTA\text{-}2H_2O$ to 700 ml of hot distilled water with vigorous stirring to make sure that all the particulate matter was dissolved. When all of the $Na\text{-}EDTA\text{-}2H_2O$ had been added, the resulting mixture was boiled for two hours and then placed on a steam bath overnight to insure completeness of the reaction. The resulting material was brought up to one liter with distilled water, and its Cr-EDTA concentration was assumed to be one molar.

Chromium Analysis

Initial studies involving analysis of chromium in fecal material were conducted with the neutron activation technique. It was found that the concentration of interfering substances (presumed to be potassium) present in the fecal material prevented utilization of this technique with low tracer concentrations of fecal chromium. Atomic absorption spectrophotometry was therefore investigated as a possible technique for determining the chromium concentration in the samples. The samples were digested in concentrated nitric acid and diluted to volume with three normal nitric acid. Standard solutions were made in 1% sodium

EDTA to compensate for interference produced by sodium present in the fecal material.

RESULTS

The chromium concentrations in the drinking water are shown in Table 11. The Cr concentration was considerably more variable from week to week than was expected; however, the variability was not considered to be a major problem because the animals used in the validity study and the animals used in the herd study all received the same water, and corrections for variation in Cr concentration in the drinking water could be computed weekly. A relatively low concentration of Cr was found in water sampled before addition of Cr (<0.1 mg/liter) indicating a small Cr background.

The amounts of Cr consumed and excreted in the feces, and the percentages of Cr recovered in feces are shown in Table 12. As was the case with Cr concentration in the drinking water, the percentage fecal recovery of Cr varied considerably from animal to animal and from week to week necessitating the use of weekly recovery data for estimating fecal output by herd animals. Samples of urine obtained from the herd animals contained less than 0.2 mg Cr/liter. Such concentrations would result in urinary Cr excretion of less than 2 mg per day, assuming a total urine excretion of approximately 10 liters. Thus, a portion of the incomplete fecal recovery of the administered Cr can be accounted for by urinary Cr excretion.

The amounts of Cr consumed and the Cr concentrations in the feces of the herd cattle are shown in Table 13. The concentration of Cr present in fecal material obtained from animals not receiving added

Table 11. Chromium concentration in drinking water.

	Date	Cr in Drinking Water (mg/liter)
7	6/12-18	--
8	6/19-25	0.1
9	6/ 9-7/2	--
10	7/ 3-9	--
11	7/10-16	3.3
12	7/17-23	2.0
13	7/24-30	1.5
14	7/31-8/6	1.6
15	8/ 7-13	1.7
16	8/14-20	3.5
17	8/21-27	2.5
18	8/28-9/3	2.0
19	9/ 4-10	2.0
20	9/11-17	3.3
21	9/18-24	3.6
22	9/25-31	1.8

Table 12. Chromium consumed, excreted, and recovered with individual animals.

Date	Measurement	Fistulated animals								
		W1	W2	W3	W4	E1	E2	E3	E4	$\bar{X}$
July 17-23	Cr consumed (mg)	28.0	16.6	20.4	24.2	19.6	22.0	28.0	-	
	Cr excreted (mg)	10.7	10.2	-	8.3	9.7	9.2	-	-	
	Cr recovered (%)	38.2	61.4	-	34.3	49.4	41.8	-	-	45.0
July 24-30	Cr consumed (mg)	19.8	14.7	19.4	31.8	14.2	26.1	16.5	20.4	
	Cr excreted (mg)	12.4	13.6	-	12.3	10.5	14.7	13.3	12.1	
	Cr recovered (%)	62.6	92.5	-	38.7	73.9	56.3	80.6	59.3	72.7
July 31-Aug. 6	Cr consumed (mg)	26.1	11.5	22.4	32.6	26.1	24.2	23.7	22.4	
	Cr excreted (mg)	-	9.9	-	9.8	-	-	-	10.8	
	Cr recovered (%)	-	86.1	-	30.1	-	-	-	48.2	54.8
Aug. 7-13	Cr consumed (mg)	28.4	-	30.3	26.4	18.0	28.4	28.9	23.8	
	Cr excreted (mg)	-	14.5	-	15.2	19.9	18.6	-	12.3	
	Cr recovered (%)	-	-	-	57.6	110.6	65.5	-	51.7	71.4
Aug. 14-20	Cr consumed (mg)	69.0	-	60.9	55.6	57.0	90.0	-	54.2	
	Cr excreted (mg)	-	16.2	18.7	14.4	13.1	15.3	-	17.8	
	Cr recovered (%)	-	-	30.7	25.9	23.0	17.0	-	32.8	25.9
Aug. 21-27	Cr consumed (mg)	53.0	-	50.2	52.0	40.8	59.5	-	45.5	
	Cr excreted (mg)	-	22.6	20.3	22.5	20.3	22.2	-	33.6	
	Cr recovered (%)	-	-	40.4	43.3	49.8	37.3	-	73.8	48.9

Table 13. Chromium consumed and chromium concentration in feces of herd cattle on heavily and lightly grazed pastures.

Date	Cr Consumed (mg/day)		Fecal Cr Concentration (mg/kg D.M.)	
	23W	23E	23W	23E
June 12-18	-	-	0.8	2.0
June 19-25	2.3	2.3	1.4	1.8
June 26-July 2	-	-	-	-
July 3-9	-	-	-	-
July 10-16	78.5	68.6	6.3	6.6
July 17-23	41.6	37.0	4.8	6.7
July 24-30	34.0	30.6	6.9	5.5
July 31-Aug. 6	44.2	34.6	6.5	5.7
Aug. 7-13	45.1	38.6	-	7.7
Aug. 14-20	131.2	94.2	6.5	8.9
Aug. 21-27	63.5	63.5	7.9	8.9
Aug. 28-Sept. 3	50.8	42.4	6.0	7.7
Sept. 4-10	43.2	-	4.7	-
Sept. 11-17	60.1	-	4.2	-
Sept. 18-24	54.4	-	4.3	-
Sept. 25-Oct. 1	27.9	-	3.8	-

Cr (June 19 to 25) varied from 0.8 to 2.0 mg/kg D.M. These "blank" values are a relatively high percentage of the experimental fecal Cr concentrations (3.8 to 8.9 mg/kg D.M.) indicating that higher levels of administered Cr are needed.

Table 14 shows diurnal variation in fecal concentration of Cr in the herd animals. There was a consistent low value at 2:00 PM and a high value at 6:00 AM in three of the four days of sampling. This pattern of excretion aggravated the low recovery of Cr because the fecal samples were collected from 9:00 AM to 12:00 noon, during the time that Cr concentration was at its lowest. The net effect is an overestimate of fecal output.

Fecal excretion, forage digestibility, and forage consumption of herd animals are shown in Table 15. Forage intake estimates are higher than expected for animals weighing 220 to 285 kg (based on a calculated feed consumption of 3% of their body weights).

The data indicate a considerably larger forage intake by animals on the lightly grazed pasture (23W) than by those on the heavily grazed pasture (23E).

Table 16 shows the amount of Cr administered and the amount excreted in the feces of goats which received chromium via ruminal cannulae. The data agree with the validity study conducted with grazing heifers, which indicated a low and variable fecal recovery of tracer chromium administered in the form of Cr-EDTA. It should be noted that the amount of Cr which was administered to the goats was considerably greater than that administered to the grazing cattle. The fecal material of the goats contained approximately 30 times the concentration of Cr as that of the cattle, negating the interfering effects of "blank" feces.

Table 14. Diurnal changes in chromium concentration in fecal dry matter.

Day of Sampling	Time of Sampling							Mean
	6	8	10	Noon	2	4	6	
	(mg/kg)							
1	5.1	4.1	3.2	2.6	2.4	3.3	3.6	3.5
2	4.6	4.3	3.3	3.3	2.3	2.7	3.2	3.4
3	2.2	1.9	2.3	1.6	1.2	1.9	4.0	2.5
4	2.5	2.4	2.5	3.4	2.2	2.2	2.5	2.5
Mean	3.6	3.2	2.8	2.7	2.0	2.5	3.3	2.9

Mean squares: Days ------------- 3.2

Hours ------------ 1.1

Days by Hours ----- 0.4

Table 15. Fecal excretion, forage digestibility, and forage consumption by herd cattle on heavily and lightly grazed pastures.

Date	Fecal Excretion (kg D.M./day)		Forage D.M. Digestibility (%)		Forage Consumption (kg D.M./day)	
	23W	23E	23W	23E	23W	23E
July 17-23	3.9	2.5	64.6	58.4	11.1	5.9
July 24-30	3.6	4.1	64.6	58.4	10.1	9.8
July 31-Aug. 6	3.7	3.3	64.6	58.4	9.6	7.0
Aug. 7-13	-	3.6	61.2	52.2	-	7.5
Aug. 14-20	5.2	2.7	61.2	52.2	13.5	5.7
Aug. 21-27	3.9	3.5	61.2	52.2	10.1	7.3

Table 16. Chromium recovery from individually fed goats.

Goat No.	Cr Consumed (mg/day)	Fecal Cr (mg/kg D.M.)	Fecal Cr (mg/day)	% Fecal Cr Recovered
1	235	-	-	-
2	255	200	102	40
3	215	230	108	50
5	275	220	102	37
6	225	190	97	44
7	220	220	91	41
8	135	250	85	63
9	148	170	60	40
10	185	220	85	46
11	135	150	39	29
12	165	150	48	30
			$\overline{X}$	38

CONCLUSIONS

Fecal recovery of chromium administered in the form of Cr-EDTA to grazing cattle or hand-fed goats was considerably lower and more variable than was anticipated from results in the literature. Low recovery can be attributed in part to urinary excretion of Cr. However, interference from "blank" fecal material and analytical problems may also have contributed to the low recovery. No estimation was made of body retention of Cr. These results would indicate that the use of Cr-EDTA as described above does not provide a satisfactory method of estimating the quantity of feces excreted by grazing cattle.

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