Richard M. HANSEN & Barbara R. CAVENDER

Food Intake and Digestion by Blacktailed Prairie Dogs under Laboratory Conditions

[With 4 Tables]

Four consecutive laboratory feeding trials were made on subadult prairie dogs, *Cynomys ludovicianus* Ord, 1817. Food intake averaged 4.1 ± 0.14 grams and live weight gain 0.88 ± 0.09 grams per 100 grams of body weight per day in the earliest test and decreased to 2.3 ± 0.14 and 0.02 ± 0.07 per grams of body weight per day (respectively) in the last test. There was a significant increase in the percent apparent digestion of organic matter (84.5—87.2), gross energy (84.3—87.0), and dry matter (81.6—84.3) from the first to the last feeding period. There was no difference in the apparent digestion of minerals and nutrients by male and female prairie dogs when computed on an equal live weight basis. Males ($\bar{x} = 945$ g) consumed more energy per day because they averaged 120 g heavier than females ($\bar{x} = 825$ g). The mean live weight of all prairie dogs was 782 g at start and was 988 g at the end of the study.

I. INTRODUCTION

The blacktailed prairie dog, *Cynomys ludovicianus* Ord, 1817, is a dominant squirrel in much of the area of the Central Great Plains of North America (Costello, 1969). It occurs in the shortgrass and mixed prairie east of the Rocky Mountains from southern Canada to Mexico (Hall & Kelson, 1959). Blacktailed prairie dogs were estimated to have totaled five billion during the nineteenth century (Seton, 1929).

It has been reported that the majority of the plants eaten by prairie dogs are the same plants desired by livestock (Kelso, 1939; Taylor & Loftfield, 1924). Smith (1958) reported that blacktailed prairie dog towns are the grazing sites favored by cattle in Kansas. Prairie dogs generally select the most nutritious items to eat, and Koford (1958) suggested that competition between prairie dogs and cattle should be judged in terms of calories and nutrients. Laboratory studies involving

the kcal of food consumed and kcal feces excreted can be used to determine energy intake and apparent digestion of the prairie dogs.

Although much has been written about prairie dogs (Costello, 1970), until now there is little published about the daily consumption and nergetics. It is the objective of this paper to describe the input-output relations of gross energy and some chemical-nutrient components recorded for prairie dogs while consuming a balanced diet in the laboratory, and to estimate the potential energy that prairie dogs may have used in the prairie ecosystem before European man came to North America.

II. MATERIAL & METHODS

The data comprise four feeding trials on a »concentrated ration« which was fed to 20 young blacktailed prairie dogs. This food contained about 16% natural protein, 2% fat, and 22% fiber (Table 1). Measurements (at three-day intervals) were taken for food intake, output of feces and body weights of prairie dogs.

Table 1

The mean composition per gram of food (dry weight) for the ration of 20 young blacktailed prairie dogs during four laboratory feeding periods in 1970.

	Feeding Trial Periods				
Food* Component	Aug. 1 through Aug. 21	Aug. 25 through Sept. 8	Sept. 12 through Sept. 27	Oct. 2 through Oct. 31	Mean overall periods
Gross energy- kcal/g	4.4	4.3	4.4	4.4	4.4
Ash %	8.7	6.9	8.4	6.9	7.7
Sodium %	1.6	1.6	1.7	1.7	1.7
Potassium %	1.6	1.4	1.4	1.1	1.4
Phosphorus %	1.0	0.9	0.9	1.0	1.0
Calcium %	0.03	0.02	0.02	0.02	0.02
Magnesium %	0.04	0.04	0.04	0.04	0.04
Manganese %	0.03	0.01	0.03	0.03	0.03
Cobalt %	0.3	0.3	0.2	0.2	0.3

* The ration was a formulation of natural feeds mixed so it contained about 16% protein, 2% fat and 22% fiber.

Two prairie dogs of the same litter and sex were kept together in each cage throughout the experiments. Excess food and water was always present. The daylight in the laboratory was normal and was not controlled with artificial lights. Ambient laboratory temperature fluctuated around 20°C.

The dates of the feeding tests in 1970 were: August 1—21; August 25-September 8; September 12—27; and October 2—31. The mean live weight of the prairie dogs was 782 g at the start and was 988 g at the end of the study. The average live weight per dog was 857 g, 955 g, 973 g, and 986 g for each consecutive feeding

period, respectively. The young prairie dogs had been kept in their laboratory cages and fed on the concentrated ration for one month before the feeding tests were started.

Forage or feces were each composited for each separate feeding period, on an equal weight basis, for each cage. The pair of »whole samples« for each feeding test were analyzed for oven dry weight, gross energy, ash, potassium, sodium, calcium, cobalt, magnesium, manganese and phosphorous. »Organic matter« was calculated by subtracting the ash weight from the oven dry weight. The mean of a feeding period was derived for each of the ten cages for the chemical-nutrient factors that were determined.

Chemical components were analyzed according to the Association of Official Agricultural Chemists (A.O.A.C.) 1965. Ash was determined by ignition at 600°C for 4 h. Mineral elements were measured after samples were wet-ashed. Potassium and sodium were determined with a Beckmann DU-2 spectrophotometer and calcium, magnesium and manganese were estimated with a Perkin-Elmer 290 atomic absorption spectrophotometer. Phosphorus was measured with a B&L Spectronic 20 colorimeter. Gross energy was determined with a Parr oxygen bomb calorimeter. Oven dry weights were obtained after an air dry sample was kept at 65°C for 48 h, cooled in a dessicator to room temperature, and then weighed.

The computed means were tested for statistical significance ($P=0.05$) by analysis of variance and by co-variance transgenerations. Averages were computed for solid ingesta and solid excreta relationships for each feeding period on an oven dry weight basis.

III. RESULTS

The male blacktailed prairie dogs averaged 120 g heavier in live weight than females (945 g vs 825 g) over all feeding periods. The males consistently ate more food and excreted more feces than did the females. However, on an equal live weight basis the average dry weight of food ingested and the live weight gain was not statistically significantly different between the sexes (Table 2). The apparent digestibility of dry matter, gross energy and minerals was similar for males and females when computed on an equal live weight basis. Therefore, it was possible to standardize the input-output feeding trial data for differences in body weight for all prairie dogs (Table 3).

The feeding tests were started August 1 and lasted until October 31 (three months). Apparently, the young prairie dogs were approaching maturity when the tests were begun because the daily rate of growth was about 1% of the live weight in the first period, 0.1% in the second and third periods and only 0.02% in the last feeding period (Table 2). Also significantly less food and energy was ingested per body weight in each successive feeding period. Forage consumption expressed as a percentage of body weight tends to be highest in the young, and decreases with increasing »physiological age« and weight in all herbivorous mammals. This is due to young herbivores reaching an average forage

Table 2

The average values ($AV \pm SE$) computed per 100 g live body weight per day for the ingestion of food components and live weight gain of 20 young blacktailed prairie dogs during four laboratory feeding trials in 1970.

Component value/100 g	Feeding Trial Periods				
	Aug. 1 through Aug. 21	Aug. 25 through Sept. 8	Sept. 12 through Sept. 27	Oct. 2 through Oct. 31	Mean overall periods
Dry weight Consumption (grams)	4.1 ±0.14	3.8 ±0.14	3.0 ±0.17	2.3 ±0.14	3.3 ±0.13
Ration gross energy (kcal)	18.1 ±0.63	16.3 ±0.59	13.3 ±0.76	10.3 ±0.64	14.6 ±0.58
Organic matter (grams)	3.8 ±0.13	3.5 ±0.13	2.8 ±0.16	2.2 ±0.13	3.0 ±0.12
Live weight gain (grams)	0.88±0.09	0.10±0.03	0.13±0.05	0.02±0.07	0.28±0.07

Table 3

Average percentage of some food components apparently digested by 20 young blacktailed prairie dogs during four laboratory feeding trials in 1970.*

Food Component	Aug. 1 through Aug. 21	Aug. 25 through Sept. 8	Sept. 12 through Sept. 27	Oct. 2 through Oct. 31	Mean overall periods
Organic matter	84.5	85.6	86.3	87.2	85.9
Gross energy	84.3	85.2	86.7	87.0	85.8
Dry matter	81.6	82.8	83.6	84.3	83.1
Ash	50.9	46.1	54.3	45.0	49.1
Sodium	59.1	52.5	47.0	36.8	48.8
Potassium	53.8	42.5	34.7	20.6	37.9
Phosphorus	24.5	19.7	18.8	16.7	20.0
Magnesium	—3.0	—2.7	—2.3	—0.15	—2.4

* Calculated on a dry weight basis.

consumption rate comparable to that of mature animals sometime before mature weight is reached.

The mean compositions of the four rations fed the prairie dogs was similar for most of the food components (Table 1). Total energy assimilation is likely to be slightly lower than the values we obtained since we did not account for energy losses in the urine. D r ó ż d ż (1968) reported that energy losses in urine for wild rodents does not exceed 5⁰/o and for rodents consuming diets of high fiber content the losses are considerably less. The digestion values in this study are a result of the percent of apparent absorbence of the food components on an oven dry weight basis.

Table 4

Diagonal correlation coefficient matrix for four feeding periods for 20 young blacktailed prairie dogs for the absorbance of various components.

	Feeding Period	WT	GE	ASH	K	Ca	Na	Mg	Mn	P
Organic matter = OM	1	.999*	.997*	.900*	.925*	.101	.971*	.076	.692*	.292
	2	.998*	.998*	.271	.898*	.150	.937*	-.124	.368*	.608*
	3	.999*	.999*	.947*	.971*	-.031	.991*	-.325	.926*	.823*
	4	.999*	.999*	.862*	.981*	-.662*	.993*	-.848*	.957*	.841*
Oven-dry weight = WT	1		.997*	.912*	.921*	.096	.968*	.085*	.684*	.279
	2		.998*	.327	.905*	.175	.941*	-.098	.394	.596
	3		.999*	.953*	.975*	-.020	.993*	-.317	.928*	.828*
	4		.999*	.869*	.982*	-.659*	.994*	-.843*	.956*	.839*
Gross energy = GE	1			.903*	.910*	.074	.968*	.044	.667*	.325
	2			.311	.895*	.153	.939*	-.144	.363	.614*
	3			.948*	.975*	-.030	.993*	-.332	.928*	.829*
	4			.856*	.978*	-.678*	.991*	-.860*	.964*	.842*
Ash = ASH	1				.782*	.008	.830*	.198	.510	.058
	2				.385	.454	.344	.780*	.529	-.014
	3				.980*	.160	.967*	-.171	.901*	.854*
	4				.883*	-.427	.868*	-.572	.781*	.621*
Potassium = K	1					.294	.961*	-.080	.669*	.424
	2					.460	.972*	-.107	.606*	.693*
	3					.122	.983*	-.313	.946*	.883*
	4					-.564	.995*	-.807*	.920*	.836*
Calcium = Ca	1						.218	.039	.504	.083
	2						.334	.181	.752*	.360
	3						.042	-.120	.115	.295
	4						-.596	.743*	-.755*	-.529
Sodium = Na	1							-.062	.748*	.448
	2							-.196	.451	.705*
	3							-.347	.923*	.863*
	4							-.832*	.938*	.855*
Magnesium = Mg	1								.225	-.684*
	2								.210	-.685*
	3								-.343	-.417
	4								-.911*	-.836*
Manganese = Mn	1 (August 1 through August 21)									.163
	2 (August 25 through September 8)									.394
	3 (September 12 through September 27)									.652*
	4 (October 2 through October 31)									.822*
Phosphorus = P										

* Correlation coefficients at the 5% and 1% levels of statistical significance at 9 degrees of freedom are .602 and .735, respectively.

$$\% \text{ digestion} = 100 - 100 \times \frac{\% \text{ component in solid ingesta} \times \text{ weight of solid ingesta}}{\% \text{ component in solid excreta} \times \text{ weight of solid excreta}}$$

There was a small but statistically significant (3%) increase in the apparent digestibility of organic matter, gross energy and dry matter from the first to the last feeding period (Table 3). There was a signifficant decline of sodium, potassium and phosphorus digested from the first to the last feeding period. Digestion of manganese was less than 1% but all of the cobalt appeared to have been absorbed. Low and negative digestion indices were recorded for magnesium and calcium in all feeding periods. There was a significant trend from a minus 3% to a minus 1% digestion of magnesium from the first to the last feeding period. Calcium values for digestion were between -0.7% and -0.5% and were not related to the sequence of the feeding periods.

The apparent digestion of organic matter (QM), oven dry weight (WT), gross energy (GE), potassium (K), and sodium (Na), were positively and significantly correlated ($P = 0.01$) within each feeding period (Table 4). Calcium (Ca) digestion was negatively and significantly correlated with OM, WT, GE, and manganese (Mn) in the fourth feeding period but significantly and positively correlated with Mn in the second period. Magnesium (Mg) digestion was negatively correlated with OM, WT, GE, K, Ca, Na, Mn in the fourth feeding period and phosphorus (P) in the first, second and fourth feeding periods (Table 4). Phosphorus digestion was significantly positively correlated with WT and Mn in the third and fourth feeding periods, and with OM, GE, K, and Na in the second, third and fourth feeding periods.

The observed values for the assimilation of minerals and nutrients are within the normal limits reported in the literature for laboratory tests for livestock and other mammals.

IV. DISCUSSION

Life is dependent upon energy fixed in plants, and we can compare the trade-off value of feeding herbivores on the basis of energy conversion and transfer. Consider the energy of the plants consumed annually by the five billion blacktailed prairie dogs which S e t o n (1929) and others estimated to have lived in the Central Great Plains of North America before habitation by European man. The removal of energy from the ecosystem by prairie dogs (prior to livestock grazing) can be shown by considering the food energy consumed as a source of energy for the production of meat for human consumption.

Recently published reports show the diets of cattle include most of the herbaceous species of plants growing in the area historically occupied by prairie dogs (F r e e *et al.*, 1970; C o o k *et al.*, 1967; M e r r i l l *et al.*, 1966; R i c e & V a v r a, 1971; T h e t f o r d *et al.*, 1971). The published reports on the food plants of prairie dogs (K e l s o, 1939; K o f o r d, 1958; C o s t e l l o, 1970) suggest that livestock, if grazed at optimum levels of efficiency, would consume mostly the same plants as prairie dogs.

According to C o o k (1971), 24 megacalories of digestible energy are required to produce one kg of meat in the form of a steer or lamb gaining weight during the spring and summer from native vegetation. Assume that an average prairie dog weighs 750 g (K o f o r d, 1958; C o s t e l l o, 1970) and its average digestible energy requirement is 13 kcal per 100 g of body weight per day (0.86 $\times$ 15 wcal/100 g/day = = 13 kcal/100 g/day). The calories of digestible energy required to feed an average prairie dog per year would be 35,588 kcal (13 kcal/100 g/day$\times$ $\times$750 g/prairie dog$\times$365 day/yr = 3.6×10^6). Therefore, if the digestible energy required by five billion prairie dogs was converted to meat by livestock there would be an annual potential of 741 billion kg of meat.

$$\frac{3.6\times10^6 \text{ kcal/prairie dog/yr}\times5 \text{ billion prairie dogs}}{2.4\times10^4} = 741 \text{ billion kg meat}$$

The per capita consumption of beef per year in the United States at present is about 50 kg. The total beef consumed per year in the United States is about ten billion kg (203,000,000 people in U.S.$\times$50 kg/person = = 10 billion). Therefore, if the 17,794 billion megacalories of digestible energy that might have been consumed by five billion prairie dogs were being converted to beef each person now living in the United States could potentially consume about 365 kg of meat per year. This is equivalent to 7.3 times more beef than that consumed annually in the United States.

The trade-off value of digestible energy consumed by prairie dogs with that of pronghorns and bison, before European man came to the prairies of North America, may nearly approximate the same relations assumed for livestock and prairie dogs. Recent comparisons have been published for the diets and metabolic requirement of livestock, pronghorns and bisons (N a g y & H o o v e r, 1971; N a g y *et al.*, 1971; R i c e & V a v r a, 1971; R i c e *et al.*, 1971; P e d e n, 1971; H y d e r *et al.*, 1971). There is little doubt that on sites consistently able to annually produce at least 2,000 kg/ha prairie vegetation (dry weight) the bison (and now the cattle) was an aid through high grazing intensity to keep the plants short so the prairie dogs could live there and avoid being killed by predators. However, the popular hypothesis that there was a reciprocal ecological

relation between bison and prairie dogs, each tending to aid the other, seems less and less likely as the scientific community obtains more and better knowledge. If there were a beneficial relationship between bison and prairie dogs it is our hypothesis that it might have been primarily one-sided, the prairie dog taking a population gain whenever it could, but giving almost nothing to the bison in return.

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Department of Range Science,
Colorado State University,
Fort Collins, Colorado 80521, U.S.A.

Richard M. HANSEN i Barbara R. CAVENDER

POBRANIE POKARMU I JEGO STRAWNOŚĆ U NIEŚWISZCZY
W WARUNKACH LABORATORYJNYCH

Streszczenie

Nieświszcze, *Cynomys ludovicianus* (O r d, 1817), występują licznie na preriach amerykańskich na wchód od Gór Skalistych, od południowej Kanady aż po Meksyk. Na pastwiskach mogą one konkurować z bydłem domowym, ponieważ odżywiają się tymi samymi roślinami.

Na 20 dorastających nieświszczach, w ciągu trzech miesięcy wykonano 4 kolejne serie doświadczeń żywieniowych, z których każda trwała 15—18 dni. Zwierzęta trzymano dwójkami w klatkach metabolicznych, karmiono je standardową paszą (Tabela 1), określano dokładnie konsumpcję i fekalia. Pasza i kał były analizowane na suchą masę, wartość kaloryczną, zawartość popiołu i materii organicznej oraz potas, sód, wapń, kobalt, magnez i fosfor.

W ciągu trzech miesięcy doświadczeń nieświszcze przyrosły średnio od 782 g do 988 g ciężaru ciała, jednak tempo przyrostu wyraźnie malało w miarę jak zwierzęta dojrzewały (Tabela 2). Dobowa konsumpcja pokarmu osiągała średnio 3,3 g paszy/100 g ciała — doba, co odpowiada 15 kcal/100 g ciała — doba. Konsumpcja liczona na jednostkę ciężaru ciała (100 g) zmniejszała się jednak od 4,1±0,14 g w pierwszej serii doświadczeń do 2,3±0,14 g w ostatniej serii (18—15 kcal/dobę), co wiązało się ze wzrostem badanych zwierząt (Tabela 2). Nieświszcze posiadają wysoką strawność pokarmów (tj. konsumpcja minus kał). Strawność osiągała średnio

85,8% w stosunku do energii pokarmu, 85,9% w stosunku do materii organicznej
i 83,1% dla suchej masy (Tabela 3). Stwierdzono istotną poprawę strawności tych
składników pokarmu (o 2,7%) w miarę jak zwierzęta dorastały. Nie było natomiast
różnic w konsumpcji i strawności paszy pomiędzy samcami i samicami, jeżeli prze-
liczać ją na jednostkę ciężaru ciała (samce były średnio cięższe o 120 g). Wykona-
no analizę korelacji strawności składników odżywczych i mineralnych paszy we
wszystkich seriach doświadczeń (Tabela 4).

Roczne zapotrzebowanie pokarmowe nieświszcza o średnim ciężarze ciała (750 g)
można ocenić na 35.588 kcal energii strawnej. Szacuje się, iż przed kolonizacją euro-
pejską Ameryki Pn. i wprowadzeniem hodowli bydła, na preriach żyło około 5 mi-
liardów nieświszczy. Musiały więc pobierać one rocznie paszę zawierającą 17.794$\times$
$\times 10^{12}$ kcal energii strawnej. Jeżeli by dzisiaj przeznaczyć taką ilość paszy dla wy-
sokowydajnego bydła, to konsumpcja mięsa w USA mogłaby wzrosnąć jeszcze 7,3
krotnie!