Acta Theriologica 38 (1): 61 – 65, 1993.
PL ISSN 0001 – 7051

Digestibility studies of the White-tailed rat *Mystromys albicaudatus*

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Mahida H. and Perrin M. R. 1993. Digestibility studies of the White-tailed rat *Mystromys albicaudatus*. Acta theriol. 38: 61 – 65.

The White-tailed rat *Mystromys albicaudatus* (A. Smith, 1834), has a sacculated bilocular hemiglandular stomach, with the papillated forestomach densely packed with bacteria. Digestibility studies of different feeds varying in protein, carbohydrate, fat and fibre were carried out to determine the role of the forestomach bacteria in the digestive activity of the White-tailed rat. The Pouched mouse *Saccostomus campestris* (Peters, 1846) was used as a control. It has a unilocular hemiglandular stomach and a low density of bacteria in the forestomach. The corpal bacteria of the White-tailed rat appear to have a limited role in the fermentation of fibre, the digestion of soluble carbohydrates and proteins. The significantly higher utilization of fats in *M. albicaudatus* suggests that the corpal bacteria may compensate for the lack of the gall bladder in this rodent.

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Key words: *Mystromys albicaudatus*, digestion

Introduction

The White-tailed rat *Mystromys albicaudatus* (A. Smith, 1834) has a sacculated, bilocular hemiglandular stomach (Maddock and Perrin 1981). The forestomach (corpus) has a large number of papillae which serve as attachment sites for autochthonous bacteria. The presence of forestomach papillae and bacteria suggest pregastric fermentation (Vorontsov 1962).

The forestomach of the White-tailed rat is similar to a rumen, in that it is located at the anterior end of the digestive tract, has papillae and a high density of bacteria. It differs from the rumen in that the papillae are not absorptive and the bacteria are associated with the papillae, while the bacteria in ruminants are mostly free-living. The rumen evolved in mammals feeding on high fibre diets, and the micro-organisms in the rumen are important in the fermentation of cellulose, as the enzyme cellulase is lacking in vertebrates (Schmidt-Nielsen 1990). The gastric microflora of ruminants are also involved in nitrogen recycling and provides a source of proteins for the host (Schmidt-Nielsen 1990). Fermentation

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of soluble carbohydrates and fats are also accomplished by the ruminal bacteria. It appears that the forestomach of the White-tailed rat is in part functionally similar to the rumen.

The assimilation efficiency of the different feeds (varying in protein, carbohydrate, fat and fibre composition) administered to *M. albicaudatus* was determined, in order to ascertain the role of the corpal bacteria in the digestive processes of the rodent. The Pouched mouse *Saccostomus campestris* (Peters, 1846) was used as a control because it has a unilocular hemi-glandular stomach and a low density of bacteria in the forestomach (Perrin and Kokkinn 1986).

Preliminary work by Perrin and Maddock (1983) demonstrated limited fibre fermentation in the forestomach and that the bacteria were important in supplying amylase for the digestion of soluble carbohydrates. However, the introduction of an additional trophic level (bacteria) merely to provide amylase, an enzyme that is produced by the host, is questionable.

Materials and methods

Fifty *M. albicaudatus* and ten *S. campestris* were housed in a temperature-controlled animal room (3 × 3 × 2.7 m) at 25°C with a 12L:12D light cycle. Relative humidity was maintained at 50 percent.

Rodents used in the digestibility experiments were individually housed in the rat cages but without any bedding material, so that faeces and uneaten feed could be easily collected. The rodents were acclimated on a particular experimental feed for two weeks, prior to commencement of the experiments. The animals were weighed at the begining and end of each experiments (7 days) using a top loading Sartorius balance accurate to 0.1 g. If the difference between the two body weights was greater than 5 percent, the results for that rodent were discarded. This negated the effects of energy storage (fat deposition) or utilization (mobilization).

A sufficient quantity of feed was weighed for the experiment and water was supplied *ad libitum*. Faeces were collected daily and the uneaten feed was removed at the end of the experiment. The experimental feeds used were rabbit pellets, rat pellets, crushed maize, dried lucerne and various prepared feed mixtures. The feeds were ground to a powder using a Retch electric mill (Optolobor).

Complete proximate analysis (Allen *et al.* 1974) was undertaken for each feed. Moisture content was determined by drying samples in an oven at 70°C; further analyses were done on the dried samples. Energy content was determined using a adiabatic bomb calorimeter. Crude protein content

Table 1. Mean proximate analysis of experimental diets of rat pellets, crushed maize, rabbit pellets, and lucerne including the analysis of various other feed mixtures (1 – 3).

Feed	1	2	3	Rat pellets	Maize	Rabbit pellets	Lucerne
Energy (kj/g)	17.99	19.29	17.86	19.29	19.12	17.35	19.30
Carbohydrate (%)	67.18	63.57	69.69	61.41	84.58	60.20	45.64
Fat (%)	8.75	5.85	3.10	5.76	4.14	5.42	1.89
Protein (%)	11.79	20.27	13.34	20.38	8.39	16.61	10.47
Fibre (%)	2.90	3.84	6.30	5.32	1.60	8.97	33.08
Water (%)	9.08	10.47	10.44	6.45	10.68	6.75	7.00
Ash (%)	9.38	6.33	7.57	7.13	1.29	8.80	8.92

was determined by the Kjeldahl (Nitrogen × 6.25) method (Lovell 1981), and crude fat content determined by ether extraction in a Soxhlet apparatus. The crude fibre content was determined by the method of Goering and Van Soest (1970), and the ash content was determined using a muffle furnace (550°C for 12 hours). The soluble carbohydrate content was determined by calculation (Maynard and Loosli 1962):

$$\% \text{ soluble carbohydrate} = 100 - (\% \text{ protein} + \% \text{ fat} + \% \text{ fibre} + \% \text{ ash})$$

Complete proximate analyses of all faecal samples were done. Assimilation efficiency was calculated by determining the net feed assimilated as a percentage of gross feed consumption.

Analysis of variance was used to analyse the results (Zar 1974).

Results

The energy contents of the various feeds were similar, ranging between 17.35 – 19.39 kj/g (Table 1). However, there were large variations in the soluble carbohydrate, fat, protein and fibre contents in the different feeds.

The efficiency of energy assimilation in *M. albicaudatus* was significantly higher than in *S. campestris* for all feeds except lucerne (Table 2). Negative assimilation efficiencies were obtained for *M. albicaudatus* for all components of lucerne. Carbohydrate, fat, and protein assimilation efficiencies were significantly higher in *M. albicaudatus* than *S. compestris* for all the feeds, but the difference in fat utilization was much greater (5 – 15%) than that recorded for carbohydrate (2 – 7%) or protein metabolism (3 – 9%). The maximum efficiency of fibre utilization was achieved when the diet contained 3.84% fibre. Higher fibre content in the feed resulted in reduced utilization.

Discussion

M. albicaudatus has a limited capacity for the fermentation of fibre. Parra (1978) showed that if herbivores have a weight of less than 10 kg foregut fermentation is difficult to maintain (if all the energy is to be derived from volatile fatty acids) and hindgut fermentation is a more viable alternative. The volatile fatty acids recorded in various regions of the digestive tract of the White-tailed rat indicate that it is essentially a hindgut fermenter (Mahida 1992). The evolution of the foregut in *M. albicaudatus* and its autochthonous microflora appear to be functionally different from those of a ruminant.

Soluble carbohydrate utilization was significantly higher in the White-tailed rat than the Pouched mouse, but the difference was very small. It appears that the role of the corpal bacteria in the digestion of soluble carbohydrates is limited. According to Maddock (1981) high amylase activity was the results of the large bacterial population in the forestomach. Since the host also produces amylase, it is unlikely that the coevolution of the gastric microflora and host can be explained solely on the basis of amylolysis.

The contribution of the bacteria to protein assimilation was greater than that of soluble carbohydrate digestion. However, the contribution of the bacteria to

Table 2. Comparison of percentage assimilation efficiency of energy, carbohydrate, fat, protein, and fibre by *M. albicaudatus* and *S. campestris*. $\bar{x}$ – mean, SE – standard error, n – sample size, * – significant, $p \leq 0.05$, ns – not significant.

	M. albicaudatus			*S. campestris*			Sig.
	$\bar{x}$	SE	n	$\bar{x}$	SE	n	
Feed 1							
Energy	–	–	–	–	–	–	–
Carbohydrate	88.89	0.12	10	87.20	0.32	10	*
Fat	89.65	0.51	10	84.64	0.46	10	*
Protein	76.34	0.77	10	72.18	1.38	10	*
Fibre	33.96	1.13	10	32.60	1.50	10	ns
Feed 2							
Energy	86.58	0.29	15	84.19	0.42	15	*
Carbohydrate	91.01	0.21	15	89.26	0.21	15	*
Fat	92.58	0.12	15	87.75	0.49	15	*
Protein	81.94	1.21	15	84.19	0.42	15	*
Fibre	45.39	2.10	15	0.1	1.97	15	ns
Feed 3							
Energy	73.70	0.34	10	72.17	0.45	10	*
Carbohydrate	79.58	0.32	10	75.05	0.2	10	*
Fat	86.42	0.56	10	81.16	0.72	10	*
Protein	68.81	1.16	10	65.35	0.70	10	*
Fibre	19.04	0.88	10	18.26	0.91	10	ns
Rat pellets							
Energy	75.08	0.46	18	73.52	0.57	20	*
Carbohydrate	80.86	0.41	18	76.37	0.53	20	*
Fat	76.80	1.48	18	61.51	1.46	20	*
Protein	73.07	0.80	18	69.48	1.79	20	*
Fibre	19.62	1.50	18	16.29	1.48	20	ns
Maize							
Energy	89.57	0.23	27	85.83	0.26	10	*
Carbohydrate	93.79	0.11	27	91.86	0.18	10	*
Fat	82.94	0.31	27	74.98	0.86	10	*
Protein	74.81	0.84	27	65.57	0.88	10	*
Fibre	15.55	2.18	27	13.94	1.28	10	ns
Rabbit pellets							
Energy	55.51	1.01	18	50.10	0.49	10	*
Carbohydrate	67.24	1.04	18	60.68	1.40	10	*
Fat	68.17	1.38	18	57.48	2.01	10	*
Protein	70.15	2.40	18	65.87	0.81	10	*
Fibre	18.51	2.49	18	18.48	0.33	10	ns
Lucerne							
Energy	negative						
Carbohydrate	negative						
Fat	negative						
Protein	negative						
Fibre	negative						

protein assimilation was still small. A unitary explanation based on improved protein assimilation efficiency is unlikely.

With the transition from a high protein diet to herbivory, Vorontsov (1962) suggested a number of adaptations that likely occurred to the digestive system. One of these was the loss of the gall bladder, as has occurred in *M. albicaudatus*. This may have occurred in the White-tailed rat as a results of a change from a high caloric diet to a herbivorous diet. If herbage (low in calories and fat) is consumed regularly, and bile is secreted in small amounts almost constantly, it leads to the loss of the gall bladder. In the absence of bile, the assimilation of fats is limited, resulting in the loss of fats in the faeces.

Since bacteria in the forestomach of *M. albicaudatus* appear to be more important in fat digestion than protein assimilation or carbohydrate catabolism, they may compensate for the absence of the gall bladder.

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Received 16 October 1992, accepted 23 February 1993.