Aspects of the digestion in the Cape porcupine

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The digestive capabilities of the Cape porcupine *(Hystrix africaeaustralis)* were studied using captive and field animals. The stomach contents comprised 6,47% of the body mass and had a low pH (2,0). The Cape porcupine also has a long small intestine (670 cm). The large stomach and small intestine form a very efficient protein digesting (83,8%) apparatus. The caecum is relatively small, constituting 2,7% of the body mass. On a high fibre diet food intake declined and retention time of digesta in the tract increased. Fibre is probably only included in the diet at times of food shortage.

Die verteringsvermoë van die Kaapse krimpvarkie *(Hystrix africaeaustralis)* is ondersoek deur gebruik te maak van diere in gevangenisskap en in die veld. Die inhoud van die maag het 6,47% van die liggaamsmassa uitgemaak en het 'n lae pH (2,0) gehad. Die Kaapse krimpvarkie het ook 'n lang dunderm (670 cm). Die grootmaag en dunderm vorm 'n baie effektiewe proteïenverteringsapparaat (83,8%). Die sakderm is relatief klein en maak 2,7% van die liggaamsmassa uit. Op 'n hoë veseldieet het inname afgeneem en die retensietyd van verteringsmateriaal in die kanaal het toegeneem. Vesel word waarskynlik net by die dieet ingesluit ten tye van voedselskaarste.

Keywords: Porcupine digestion, morphometrics, digestibility, colon fermenter, transit time

Introduction

The Cape porcupine *(Hystrix africaeaustralis)* which is distributed throughout Southern Africa, shows some sympatric overlap with the crested porcupine *(Hystrix cristata,* L. 1758) in Central and Eastern Africa. The Cape porcupine's natural diet consists mainly of indigenous bulbs, roots and fruits (De Graaf, 1981). They also eat carrion and practise osteophagia in phosphorous deficient areas. These animals are notorious for their ring-barking of trees such as *Cordyla africana, Erthria* spp., *Ficus* spp., *Spirostachus africanus, Trichilia emetica* and young *Strychnos pungens* (De Graaf, 1981) and thus include certain quantities of fibre in their diet.

A characteristic feature of the Cape porcupine's faeces is that it contains large quantities of fibrous material. An investigation to determine the digestive capabilities of the porcupine in captivity was undertaken together with a morphometric study of the digestive tract. A comparative study on field animals and their natural diets was also done.

Material and Methods

Seven animals were obtained from a culling program on the farm 'Tussen die Riviere' in the south-eastern Orange Free State (26°07'E, 30°19'S). The digestive tracts were removed by severing the posterior end of the oesophagus and the posterior end of the rectum. The digestive tract was sectioned as shown in Figure 1 and the morphometric data in Table 1 were collected.

Eight animals kept on the University experimental farm were individually housed in open cages at an ambient temperature of 19°C and subjected to digestibility trials. They were divided into two equal groups and fed a high fibre (65,89% NDF)/low protein (4,42% CP) diet of whole maize plants (without cobs) and a low fibre (20% NDF)/high protein (15,13%CP) diet of antelope cubes, respectively. The experiment consisted of a 14-day adaptation period followed by a 7-day collection period. To ensure *ad libitum* intake, the animals were fed twice their mean daily intake. Feed residues and faeces were collected and weighed daily. The residues of the maize plants were also analysed to compensate for food selection. The animals were fed between 15h00 and 18h00 each day and weighed every third day for the duration of the experiment. Cardiac stomach samples and faeces samples, from the descending colon, were collected from field animals (Figure 1). All the samples from the digestibility trials and the field animals were dried at 75°C to constant mass and then ground. All samples were analysed for energy content, nitrogen content and neutral detergent fibre (NDF).

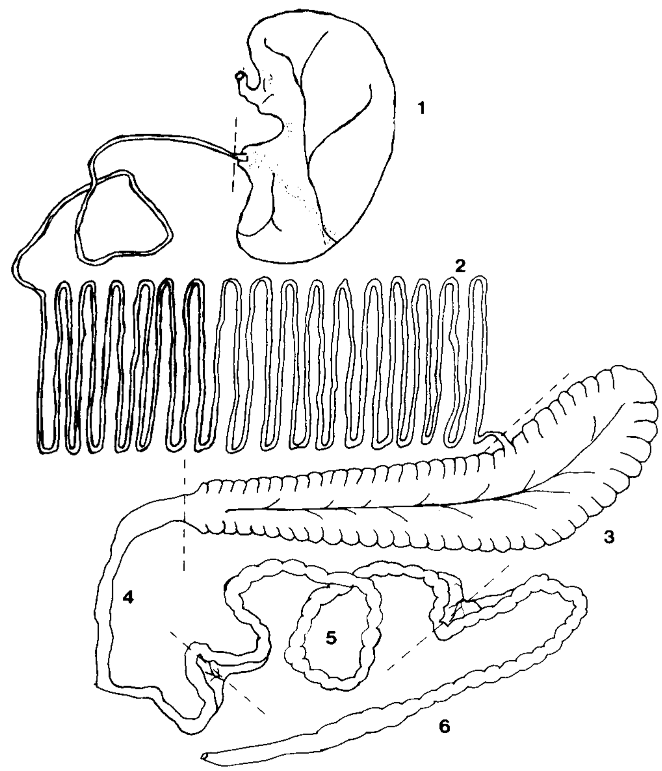

Figure 1 Gut of an adult Cape porcupine.
1. Stomach. 2. Small intestine. 3. Caecum. 4. Ascending colon. 5. Transverse colon. 6. Descending colon.

The energy content of all samples was determined with a Gallenkamp ballistic bomb calorimeter in triplicate using 0,5 g samples. N-content was determined by the Kjeldahl method. The NDF determination was done by the method of Van Soest (1964) using a 'Fibre-tec 1020' hot extraction apparatus. The nitrogen and fibre determinations were done in duplicate using 0,5 g samples.

Because of the large differences in the nature of the feeds,

Table 1 Morphometric data of Cape porcupine gut sections obtained from mature field animals (n = 7) with mean body mass (11,49 ± 2,15 kg)

Gut sections	Measurement: Mean max. vol. ± SD (cm^3)	Mean length ± SD (cm)	Mean mass of contents ± SD (g)	Mean pH ± SD
Stomach	1019,1 ± 241,9	19,7 ± 1,3	812,9 ± 255,9	2,0 ± 0,5
Small intestine	975,6 ± 92,0	670 ± 69,9	599,5 ± 364,3	6,2 ± 0,5
Caecum	953,6 ± 163,6	62,6 ± 6,7	342,6 ± 158,1	5,8 ± 1,2
Ascending colon	483,9 ± 75,2	44,6 ± 4,8	50,0 ± 56,1	6,3 ± 0,6
Transverse colon	379,9 ± 67,4	54,4 ± 7,4	73,8 ± 99,2	6,4 ± 0,3
Descending colon	629,3 ± 62,5	64,1 ± 6,4	89,0 ± 104,3	6,2 ± 0,6

different markers were used. The maize plants were soaked in Safranin – 0 (6 h) and then rinsed in water (6 h). Plastic beads were incorporated into the antelope cubes. The times of first and last appearance of the marker in the faeces were recorded.

Results and Discussion

The Cape porcupine has a simple stomach which is relatively large for a herbivorous rodent. The stomach contents of the field animals had a mass 6,47% that of the body mass (Table 1). Lower values of 14,1% have been reported for the yellow-haired porcupine, *Erethizon* (Johnson & McBee, 1967) and 3,9 ± 1,1 for the hyrax, *Procavia capensis* (Eloff, 1981). The low pH (2,0 ± 0,5) of the stomach makes the occurrence of fermentation in this area of the intestinal tract very unlikely. The Cape porcupine also has a very long small intestine (670 ± 69,9 cm) compared with monogastric man (400 – 600 cm) and *Erethizon* where it is 223 cm (Johnson & McBee, 1967).

The animal's large stomach and small intestine form a very efficient protein digesting apparatus as can be seen from the digestibility measurements in Table 2. The Cape porcupine is, however, also adapted for 'colon fermentation' as it has a caecum and proximal colon which form a single fermentation chamber (Figure 1). The animal's dentition also suggests that it includes roughage in its diet. It has hypsodont teeth with intricate enamel patterns on the occlusal surfaces and an enlarged molariform PM^4 (De Graaf 1981). The Cape porcupine has a relatively small caecum with caecal contents constituting 2,7% that of the body mass, compared with the 6,0% of *Erethizon* and 3,7% of the beaver, *Castor canadensis*. The animals on the high protein diet absorbed 6218 kJ digestible energy per day which is well above Kleiber's predicted metabolic requirement of 2130 kJ/day (Table 3). The animals were, however, housed above ground with very little sun under cool conditions.

The porcupines showed a marked decline in food intake and a subsequent drop in body mass (6%) on the high fibre diet. This drop in food intake to well below the animal's metabolic requirements probably occurred because of the digestive tract's inability to digest large quantities of fibre (Table 2). The animal's long small intestine forms a constriction in the digestive tract which limits the quantity of food that can be consumed by the animal but which enhances enzymatic breakdown and absorption. This constriction is probably also responsible for the increase in retention of digesta when fed the high fibre diet. These data sug-

Table 2 Digestibility of dry matter, fibre and protein by Cape porcupines in captivity fed two different diets. Values are means (± standard deviation) from a seven day collection period. Body mass measured over 21 days, NDF = Neutral detergent fibre, CP = Crude protein, NS = not significant; ★ = different at $P<0,05$

	Low fibre/high protein (20% NDF)/ (15,13% CP) (n = 4)	High fibre/low protein (65,89% NDF)/ (4,42% CP) (n = 4)	Difference between diets
Body mass			
Mean (kg)	14,11 ± 1,36	12,89 ± 3,34	NS
Change (kg per 21 days)	0,00 ± 0,95	−0,8 ± 0,26	NS
Dry matter			
Intake (g per day)	403,55 ± 53,48	108,13 ± 16,45	★
Intake (g per kg $W^{0,75}$ per day)	55,30 ± 0,29	16,19 ± 1,83	★
Apparent digestibility	83,04 ± 2,52	39,02 ± 21,33	★
Neutral detergent fibre			
Intake (g per kg $W^{0,75}$ per day)	11,06 ± 0,78	10,67 ± 1,21	★
Faecal output (g per kg $W^{0,75}$ per day)	3,77 ± 0,13	4,97 ± 1,24	★
Digestibility	65,80 ± 1,88	53,15 ± 11	★
Crude protein			
Intake (g per kg $W^{0,75}$ per day)	8,40 ± 0,61	1,08 ± 0,47	★
Faecal output (g per kg $W^{0,75}$ per day)	1,34 ± 0,38	1,14 ± 0,41	NS
Digestibility	83,79 ± 3,72	−5,56 ± 12,77	★
Transit time	23 h – 64 h	48 h – 96 h	

Table 3 Digestible energy intake and digestibility of gross energy by Cape porcupine in captivity fed two different diets. Values are means (± standard deviation) from a seven day collection period. Body mass measured over 21 days. DE = Digestible energy; CP = Crude protein; NS = not significant; ★ = difference at $P<0,05$

	Low fibre/ high protein (20% NDF)/ (15,13% CP) (n = 4)	High fibre/ low protein (65,89% NDF)/ (4,42% CP) (n = 4)	Difference between diets
Body mass			
Mean (kg)	14,11 ± 1,36	12,89 ± 3,54	NS
Change (kg per 21 days)	0,00 ± 0,95	−0,8 ± 0,26	NS
Energy			
DE intake (kJ per day)	6218,13 ± 808,28	837,90 ± 217,27	★
DE intake (kJ per kg $W^{0,75}$ per day)	852,32 ± 59,37	130,33 ± 53,41	★
Apparent digestibility of gross energy (%)	85,40 ± 1,52	45,07 ± 14,52	★
Kleiber's metabolic requirements (kJ per day)	2145,19 ± 371,09	2004,52 ± 728,00	NS

gest that the animal will no include large quantities of fibre under optimal feeding conditions, but will do so on its maintenance diet during the dry season. The field animals, which were collected in May, had an NDF content of 29,43% ± 5,38 in their stomach contents, indicating a low fibre intake.

The short transit time of 23 h found in the Cape porcupine (Table 2) is faster than of the brushtail possum *(Trichosurus velpecula)* which has a transit rate of 64 h for fluids and 71 h for particulate digesta (Wellard & Hume, 1981). It is also faster than that of the horse (48 h).

In conclusion, the Cape porcupine has an efficient, simple stomach with a long small intestine for enzymatic action and digesta absorption. It can, however, digest small quantities of fibre through colon fermentation. Fibre is probably only included in the diet at times of food shortage.

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