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DIGESTA RETENTION AND FIBRE DIGESTION IN MARAS (*DOLICHOTIS PATAGONUM*) AND GUINEA-PIGS

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Abstract—1. Digestibilities of feed and turnover time ($1/k$), transit time (TT) and mean retention time (MRT: $1/k$ + TT) of fluid and particle markers were measured in maras (*Dolichotis patagonum*) and guinea-pigs (*Cavia porcellus*) fed a diet containing 50% alfalfa.

2. The digestibility of fibre was similar in both animals, however, the digestibilities of crude protein (nitrogen × 6.25) and crude ash were lower in the mara than in the guinea-pig.

3. $1/k$ of the digesta markers were similar in both animals, suggesting that the two animals possess similar dilution and retention time of digesta in their caecum and proximal colon.

INTRODUCTION

The mara (Patagonias cavy) belongs to the same family of cavies as the guinea-pig. However, the mara body form is very different. The body weight of the mara is much greater (large individuals weigh over 10 kg) than the guinea-pig; furthermore, the mara runs like a deer and looks and acts like a rabbit.

The young of maras and guinea-pigs are able to walk immediately after birth. Their eyes are open and they are covered with similar hair to that of their parents and they look like miniatures of their parents. Only these characteristics show that the two species belong to the same family.

The guinea-pig is a strictly herbivorous, non-ruminant animal with a voluminous caecum which can retain digesta for a considerable time (Sakaguchi *et al.*, 1986) and is more efficient in the digestion of fibre and its components than rabbits, hamsters or rats (Sakaguchi *et al.*, 1987). It has been reported that guinea-pigs digest organic matter and crude fibre as efficiently as horses and ponies (Slade and Hintz, 1969).

As information regarding the function of the digestive tract is not available to date, it is uncertain whether the mara possesses the same digestive function as the guinea-pig. The objective of the present study was to compare the digestibility of fibre and the digesta flow in the digestive tract between the mara and the guinea-pig.

MATERIALS AND METHODS

Animals and feeding

Three adult male maras (mean body mass 7.4 kg) and five adult male guinea-pigs (410 g) were used. All animals were housed individually in stainless steel mesh cages, each 1.0 × 1.0 × 0.5 m high for maras and 0.36 m diameter × 0.3 m high for guinea-pigs.

Feed consumption of each animal was recorded daily. Faeces were collected daily during the last 4 days in digestion trials after a 4 day pre-collection period.

Markers of liquid and solid digesta were mixed with a small amount of the experimental diet and given 2 hr after the digestion trials. The animals were starved for 2 hr before they were given the markers.

Feed and water were available freely in both periods and coprophagy was not prevented so that feeding habits were as normal as possible.

Collection procedures

Faecal samples for the mara were taken every 2 hr for the first 14 hr, every 4 hr for the next 28 hr and every 6 hr for a further 36 hr after dosing and every 2 hr for 50 hr after dosing for the guinea-pig. During the experiments, all animals were given an experimental cubed diet containing lucerne (*Medicago sativa*) meal *ad lib.* The composition of the experimental diet is shown in Table 1.

Digesta markers

Cr-mordanted Italian ryegrass (*Lolium multiflorum* L.) cell-wall constituents (Cr-CWC) were used as a particle marker and Co-EDTA was used as a liquid digesta marker to estimate retention time. Cr-CWC were prepared by the methods of Udén *et al.* (1980). Prepared Cr-CWC was ground into coarse particles and passed through a 40 mesh screen. The resulting particles were then passed through a 20 mesh screen and those which remained on the screen were used in the experiment. The diameter of the particles was in the range 0.381–0.840 mm and the length was shorter than 5 mm.

Analytical methods

The pooled faecal samples from the digestion trials were oven dried at 60°C then ground and analysed for dry matter, crude ash and total nitrogen (AOAC, 1980) and for neutral-detergent fibre (NDF) and acid-detergent fibre (ADF) by methods described by Van Soest and Wine (1967) and Van Soest (1963), respectively. Organic matter was determined by subtracting ash from dry matter.

To determine concentations of Cr and Co, faecal samples were oven-dried at 60°C and ashed at 550°C for 5 hr. The ashed samples were treated according to the method described by Williams *et al.* (1962). Analysis of Cr and Co in the treated sample was made by atomic absorption spectroscopy (Atomic absorption spectrophotometer AA-80; Nippon Jarrell–Ash, Kyoto).

Table 1. Composition of experimental diet (g/kg)

Composition	(g/kg)
Ingredients	
Lucerne (*Medicago sativa*) meal	500
Defatted milk powder	150
Wheat bran	150
Maize oil	50
Maize	50
Sucrose	50
Mineral mix*	30
Vitamin mix†	20
Analysis	
Moisture	85
Organic matter	833
Crude protein (nitrogen × 6.25)	196
Diethyl ether extracts	76
Crude fibre	126
NDF	250
ADF	176
Crude ash	82

*Composition (mg/kg mixture): 145.6 $CaHPO_4 \cdot 2H_2O$; 257.2 KH_2PO_4; 93.5 $NaH_2PO_4 \cdot H_2O$; 46.6 NaCl; 350.9 Ca-lactate; 31.4 Fe-citrate; 71.7 $MgSO_4$; 1.1 $ZnCO_3$; 1.2 $MnSO_4 \cdot 6H_2O$; 0.3 $CuSO_4 \cdot 5H_2O$; 0.1 KI.

†Composition (mg/kg mixture): 1000 retinol acetate; 2.5 cholecalciferol; 1200 thiamin hydrochloride; 4000 riboflavin; 800 pyridoxine hydrochloride; 0.5 cyanocobalamin; 30,000 ascorbic acid; 5000 tocopherol acetate; 5200 menadione; 20 D-biotin; 200 pteroylmonoglutamic acid; 5000 calcium pantothenate; 50,000 *P*-aminobenzoic acid; 6000 nicotinic acid; 6000 inositol; 200,000 choline choride; 730,577 cellulose powder.

Calculations

Single exponential regression equations were fitted statistically to the time-course decline of the faecal concentrations of Cr and Co in maras and guinea-pigs. A turnover time of each marker was estimated from the decline in faecal concentration of marker by the function (Brandt and Thacker, 1958):

$$Y = Y_0 \times e^{-kt},$$

where Y is the concentration of Cr or Co in faeces at time t, Y_0 is the constant depending on the level of Cr or Co fed, k is the rate-constant and t is the time interval after feeding of the markers (hr). Turnover time was calculated as the reciprocal of the rate-constant (k) if the exponential curve fitted to the time-course excretion values of the markers after faecal marker concentration reached a maximum. Total mean retention time (MRT) in the gastrointestinal tract was calculated as the sum of the reciprocal of k and transit time (TT) equal to the first appearance of the marker after dose.

Differences between the mean values were evaluated statistically by Student's t-test (Snedecor and Cochran, 1967).

RESULTS

Feed intake and digestibility (*Table* 2)

The maras almost maintained their weights but the guinea-pigs gained slightly in weight (mean 24.0 g) during the experimental period. Daily feed intake on a metabolic body size (per kg body weight$^{0.75}$) basis was significantly ($P < 0.01$) larger in the guinea-pig than in the mara.

Apparent digestibilities of organic matter and fibre components (NDF and ADF) are not statistically different between the maras and guinea-pigs. However, the digestibilities of dry matter and crude protein were significantly ($P < 0.01$) higher in the guinea-pigs than in the maras.

Table 2. Feed intake and apparent digestibilities of feed in the mara and guinea-pig

	Mara ($N = 3$)	Guinea-pig ($N = 5$)
Feed intake (g/kg$^{0.75}$/day)	41.3 ± 9.0*	53.3 ± 1.7
Digestibility (%):		
Dry matter	68.8 ± 0.9*	71.5 ± 0.9
Organic matter	70.0 ± 0.8	71.3 ± 0.8
NDF	45.2 ± 1.5	43.2 ± 2.3
ADF	38.4 ± 3.2	39.0 ± 1.4
Crude protein	67.3 ± 1.3*	74.4 ± 2.6
Crude ash	55.9 ± 1.9*	73.3 ± 1.2

Values are means ± SD.
*Significantly different from the guinea-pig ($P < 0.01$).

Retention of digesta markers (*Fig.* 1 *and Table* 3)

Figure 1 shows faecal marker excretion curves for one animal from each of the two groups studied. The faecal marker concentrations were plotted as the mid-point during the sequence of collections. The marker excretion curves were generally smooth and no difference can be detected between Cr and Co in the two species. There was no difference between the mara and guinea-pig in the rate constant of the regression line fitted to the decline in the faecal marker concentrations. However, the time interval

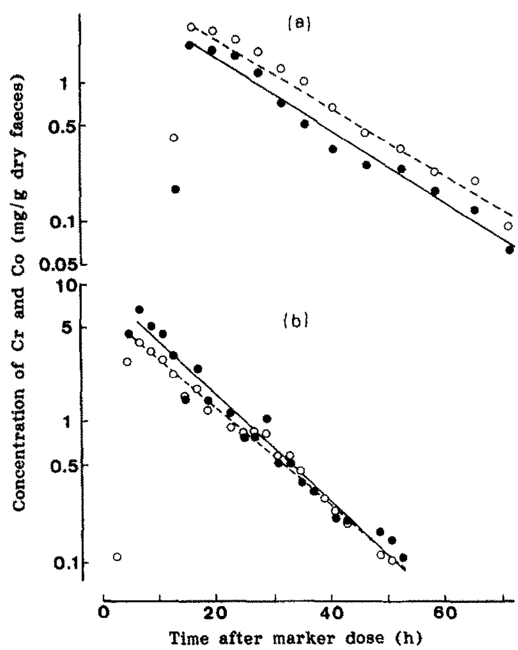

Fig. 1. Faecal marker concentrations in dry faeces following an oral dose in one example for each of the animal species studied: (a) maras, (b) guinea-pigs. Chromium-mordanted cell walls (●) and Co-EDTA (○) were given at a single feeding with the diet. The regression lines of the time-course reductions in Cr (——) and Co (---) are expressed as $Y = Y_0 \times e^{-kt}$, where Y is the concentration of Cr or Co at time t, Y_0 is the constant depending on the level of Cr or Co feed, k is the rate constant and t is the time interval after feeding of the markers (hr). The values of Y_0 and k for Cr are 5.310, 0.0606 for the mara and 9.451, 0.0875 for the guinea-pig. The values of Y_0 and k for Co are 7.763, 0.0594 for the mara and 6.633, 0.0811 for the guinea-pig.

Table 3. Measures of retention of digesta markers in the mara and guinea-pig

	Mara ($N = 3$)	Guinea-pig ($N = 5$)
Particle (Cr)		
$1/k$	17.0 ± 1.2	16.1 ± 5.1
TT	10.3 ± 3.1†	4.8 ± 0.5
MRT	27.3 ± 2.1*	20.9 ± 5.3
Fluid (Co)		
$1/k$	17.2 ± 0.4	14.5 ± 3.1
TT	9.7 ± 3.1†	4.4 ± 0.9
MRT	26.8 ± 2.8†	18.9 ± 3.3

Values are means $\pm$ SD.
k is a rate constant which is the dilution rate per hr of the marker in the digestive tract. TT (transit time) is the time interval between feeding and first appearance of the marker in the faeces. MRT is the sum of $1/k$ and TT. *, †Significantly different from the guinea-pig ($P < 0.05$, $P < 0.01$, respectively).

between feeding and first appearance of the marker in the faeces was longer in the mara than in the guinea-pig.

There was no difference in the values of $1/k$, TT and MRT($1/k$ + TT) between particle marker (Cr) and liquid marker (Co) in both animals. There was no difference in the value of $1/k$ between two species, whereas TT and MRT were longer in the maras than in the guinea-pigs (Table 3).

DISCUSSION

The guinea-pigs gained weight but the maras maintained their weights in the experimental period. This should correlate to the lower intake of feed per unit body mass in the mara than in the guinea-pig.

The mara digested the fibre component (NDF and ADF) as efficiently as the guinea-pig, but the digestibility of dry matter and crude protein in the mara was lower than in the guinea-pig. The lower digestibility of crude ash and crude protein might have resulted in the lower digestibility of dry matter.

Coprophagy is commonly observed in many rodents. Guinea-pigs have been demonstrated as being coprophagous (Björnhag and Sjöblom, 1977). However, it is not clear if the mara is coprophagous. Coprophagy was not prevented in the present experiment. As bacterial protein synthesized in the caecum and proximal colon is re-ingested by coprophagy, crude protein digestibility is generally higher when coprophagy is permitted (Hörnicke and Björnhag, 1980). If the extent of coprophagy was negligible in the mara, the digestibility of crude protein should be lower than that of the animal which practised coprophagy to a large extent. Therefore, the result obtained in the present experiment may show that the extent of coprophagy in the mara is negligible or much lower than in the guinea-pig.

In the guinea-pig, digesta are retained longest in the caecum and upper proximal colon (Sakaguchi *et al.*, 1985). When markers are injected into the caecum, the rate-constant of marker dilution in caecal contents agrees with that in faeces. Furthermore, the rate-constant of marker dilution in the faeces after oral application agrees closely with that in caecal and that in the faeces after caecal injection (Sakaguchi *et al.*, 1986). These findings suggest that the dilution rate of marker in the faeces can be regarded as a reflection of marker dilution in the caecum after oral application. The retention time of digesta in the large intestine (mainly caecum) can, therefore, be calculated from the faecal values for marker excretion in the guinea-pig.

The dilution rate of digesta marker in the faeces of the mara is similar to that of the guinea-pig. Both animals appear to lack any selective retention of fluid or fine particles. The large intestine of the brushtail possum functions much like the caecum of the guinea-pig, with no selective retention of digesta; brushtail possums digest more fibre (both ADF and NDF) than rabbits which retain fluid and fine particle digesta selectively on a 44.4% alfalfa diet (Sakaguchi and Hume, 1990). Guinea-pigs also digest fibre more efficiently on a 50% alfalfa diet (Sakaguchi *et al.*, 1987). The mara digests fibre as efficiently as the guinea-pig. The extent of fibre digestion in four small hindgut fermenters fed a common diet was related more closely to the turnover time ($1/k$) of large particles in the caecum than to their MRT in the whole digestive tract (Sakaguchi *et al.*, 1987). These suggest that the site, pattern and rate of digesta retention are very similar in the mara and guinea-pig.

The difference in MRT of digesta between the mara and guinea-pig can be considered to be connected with the difference in their body mass because passage time tends to increase with body size for species with similar food habits and from the same vertebrate class, as discussed by Karasov *et al.* (1986). The larger value of TT results in the larger value of MRT in the mara, therefore, it can be considered that only the length of the digestive tract per unit body mass is longer in the mara than in the guinea-pig. Clemens and Stevens (1980) noted that the rate of marker movement was reasonably constant (2–5 cm/hr) for most mammal species investigated.

In conclusion, the two animals possess a similar function of fibre digestion and the $1/k$ might represent turnover time of digesta in the fermentation chamber, caecum and proximal colon in the mara as in the guinea-pig, suggesting that the site, pattern and rate of digesta retention are very similar in the mara and guinea-pig.

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