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The effect of forage quality and level of feeding on digestibility and gastrointestinal transit time of oat straw and alfalfa given to ponies and donkeys

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Four donkeys and four ponies were fed molassed dehydrated alfalfa or oat straw, either *ad libitum* or restricted to about 70 % *ad libitum* intake in a Latin-square design for four periods of 21 d. Measurements of apparent digestibility and gastrointestinal transit time were made on the last 7 d of each period. When the forages were provided *ad libitum*, all animals ate significantly ($P < 0{\cdot}01$) more of the alfalfa than of the oat straw. Ponies consumed significantly ($P = 0{\cdot}007$) more of both diets per unit live weight than donkeys. Higher apparent digestibilities of dietary DM, energy and fibre fractions were seen in donkeys, at both levels of feeding, compared with the ponies. This partly compensated for the lower intakes by the donkeys when fed *ad libitum*. When intake of alfalfa was restricted, the apparent digestibility of DM was higher compared with the corresponding values when fed *ad libitum,* but the reverse was true for straw. This may be because restriction of a low-quality diet reduced selection of the more digestible parts of the forage. Donkeys and ponies consumed more energy and protein than required when fed alfalfa *ad libitum*. Both oat straw treatments provided insufficient protein to meet the predicted requirements of ponies and donkeys. Straw intakes *ad libitum* exceeded the estimated energy requirement for ponies by 34–51 %, but donkey energy requirements were only just met. When the amount of straw offered was restricted, 78–90 % of the estimated energy requirement for donkeys was met compared with 90–105 % for the ponies.

Apparent digestibility: Forage intake: Equids

Donkeys are an important source of power for transport and crop production in smallholder agriculture in tropical countries. For most of the year they are fed on crop residues and mature bush grasses of poor nutrient quality, each being low in N and with a high fibre content. Better quality forages, such as alfalfa, are available in many areas, but are expensive (Pearson, 1998). Ponies often fare better, but, even in temperate areas, their staple rations are often poor quality hay and straw diets, which are low in N. In order to determine the quantity of nutrients donkeys and ponies can obtain from both poor- and good-quality forages, it is important to know how much they consume and how well they digest these feeds when given them either *ad libitum* or when they receive a restricted ration.

Comparative studies (Pearson & Merritt, 1991) of the voluntary food intakes of donkeys and ponies fed moderate- or poor-quality roughage diets (meadow hay and barley straw respectively) have shown that donkeys tend to consume less DM/d. As a result, they have a slower rate of passage of digesta through the gastrointestinal tract and, as a consequence, have a higher apparent digestibility of both organic matter and fibre fractions than has been measured in ponies. Greater intakes by ponies fed these forages seemed to compensate for the measured differences in the digestibility of feed components between the donkeys and the ponies when they were allowed access *ad libitum* (Pearson & Merritt, 1991). The results suggested that both species obtain similar quantities of nutrients from these diets when offered *ad libitum* (Pearson & Merritt, 1991) by two seemingly different strategies. However, nutrient intake was at or below that needed to sustain live weight (LW). It is not clear whether ponies and donkeys would continue to show these differences in intake and nutrient digestibility if they were given better quality forage diets that provided nutrients in a more accessible form. For example, would feeding strategies change and

Abbreviations: CP, crude protein; DE, digestible energy; LW, live weight; MRT, mean retention time; NDF, neutral-detergent fibre.

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would the relative differences in intake and digestibility between the two species disappear if the animals were provided with good quality forages?

The ability of Thoroughbreds, Highland ponies, donkeys and Shetland ponies to digest forage diets of different fibre content (different proportions of alfalfa and oat straw) was investigated by Cuddeford *et al.* (1995). When the animals were fed a restricted ration, estimated to meet energy requirements for maintenance according to National Research Council (1989) recommendations, donkeys retained food residues in the gastrointestinal tract longer than did the other equids, irrespective of diet type. As a consequence, the donkeys digested fibre more effectively than did the other equids. All animals digested the components of the high-fibre diets less well than those of the low-fibre diets (Cuddeford *et al.* 1995). However, since the animals in the study were fed to meet energy requirements, DM intakes were higher when they were fed low-quality diets compared with when they were fed better quality diets, making it difficult to distinguish between the effects of diet quality and DM intake on nutrient digestibility.

In order to determine the effect of feeding level on the quantity of nutrients donkeys and ponies can obtain from poor- and good-quality forages, this present study investigated the relationships between diet quality, food intake, digestibility and gastrointestinal transit time of two forages in donkeys and ponies. The forages offered were oat straw and alfalfa. Preliminary results of part of this study have been reported by Pearson *et al.* (1998). The results will help determine recommendations for feeding these animals particularly where forage is the only source of nutrients available.

Material and methods

Experimental design

Short-chopped (10–15 cm), molassed (20 g/kg) oat straw and short-chopped (10–15 cm) molassed (20 g/kg) dehydrated alfalfa produced by Dengie Crops Ltd, Maldon, Essex, were offered to donkeys and ponies either *ad libitum* or in restricted amounts (70 % intake *ad libitum*) in 4×4 Latin-square design. Each animal received each of the four dietary treatments in turn over four 21 d periods and in each period, one donkey and one pony received each diet. The compositions of the two forages (Table 1) were determined by standard methods (Association of Official Analytical Chemists, 1990) after sub-sampling diets offered daily.

Table 1. Composition of diets offered to donkeys and ponies (Mean values with their standard errors for four samples of each diet)

	Alfalfa		Oat straw	
	Mean	SE	Mean	SE
DM (g/kg)	937	8·3	936	9·3
Organic matter (g/kg DM)	913	3·4	948	7·7
Neutral-detergent fibre (g/kg DM)	443	19·6	715	21·1
Acid-detergent fibre (g/kg DM)	339	23·7	487	20·9
Crude protein (g/kg DM)	146	5·5	38·8	4·52
Gross energy (MJ/kg DM)	17·6	0·21	17·7	0·26

Animals and their management

The experiment was carried out between June and September 1994 at the Centre for Tropical Veterinary Medicine, Edinburgh, Scotland, UK. Four adult donkeys (mean weight 189 kg) and four adult Welsh-cross ponies (mean weight 250 kg) were housed in individual stalls (about 1·4 m × 2·5 m) next to each other in a barn. The barn was open on one side so they received natural daylight. Urine was allowed to drain down channels in the floor away from the area where faeces were voided. Clean drinking water was always available from individually monitored supplies. The daily ration for these animals was divided into four equal meals and given at 08.00, 12.00, 16.00 and 20.00 hours in deep-sided troughs to reduce spillage. Any food refusals and uneaten spillage were collected at 08.00 hours each day before fresh food was offered. Each animal was walked in hand for 30 min/d. The daily intakes of feed were assessed before the experiment when animals were fed each diet in turn, *ad libitum* for a 2-week period. These daily intakes were re-evaluated during the experiment based on the voluntary intake of those animals receiving the *ad libitum* treatments. Animals on the *ad libitum* treatments were offered feeds daily in sufficient quantity to enable them to refuse at least 200 g DM/kg DM of feed offered. The amount of feed offered was adjusted daily on the basis of the intake of the previous day to achieve the target refusal rate.

Measurements and rate of passage markers

Each animal was weighed at the start of the experiment and twice weekly thereafter to the end of the experimental period. For the first 14 d of each period, the animals were allowed to adapt to the new diet. During the final 7 d, measurements of food intake (from the amount of DM in feed and in each individual's feed refusals, with trough and floor refusals determined separately) and faecal output were made. Mean retention time (MRT) of two indigestible food markers, Co-EDTA, a liquid phase marker, and Cr-mordanted hay fibre (Cr-fibre), a solid phase marker, were measured using the techniques described by Pearson & Merritt (1991). These markers have been found to be satisfactory for studying rate of passage of digesta in herbivores eating high-fibre rations (e.g. Uden *et al.* 1982). A single dose of each marker was administered at 23.00 hours on the day preceding the collection period (day 13). Cr-fibre (70 g) was mixed with five 'Polo mints' (Nestle, York, UK) to increase palatability, pelleted, and given by hand to each animal. Co-EDTA (100 ml) was given as a drench by syringe at the back of the throat. Feeding of the appropriate diet was resumed immediately after the animals had been given the markers.

Complete faecal collections were made at regular intervals from 23.00 hours on day 14 (when markers were administered) for 7 d until the end of the period (08.00 hours on the morning of day 22). For estimation of MRT, faeces were collected from each animal at 9, 11, 13,

15, 17, 20, 23, 31, 33, 35, 37, 39, 41, 46, 54, 57, 60, 64, 69, 80, 84, 88, 93, 104, 112, 128, 136, 152, 160 and 176 h after marker administration. Individual faecal collections were weighed, thoroughly mixed and a sub-sample taken for the determination of DM and marker concentrations. A further sample from each collection (20 g/kg) was stored frozen before pooling over the 7 d period for each animal for subsequent analysis. All food and faecal samples were dried in a forced-draught oven at 60°C to constant weight and then ground through a 1 mm screen before analysis. Acid-detergent fibre, neutral-detergent fibre (NDF), crude protein (CP), gross energy and organic matter were determined according to the methods reported by the Association of Official Analytical Chemists (1990).

Calculations and statistical analyses

Apparent digestibility coefficients were calculated from DM intakes and faecal DM outputs over the 7 d collection periods:

Apparent digestibility of DM

$$= \text{wt of food DM} - \text{wt of faeces DM}/\text{wt of food DM}.$$

Similar calculations were made to calculate the apparent digestibility of NDF, acid-detergent fibre, CP, organic matter and gross energy. The MRT of Cr-fibre and Co-EDTA were calculated using the methods described by Pearson & Merritt (1991). Digestible energy (DE) and digestible CP intakes were expressed per unit LW to enable comparisons between species to be made.

The formula used to estimate maintenance requirements for DE (MJ) was:

$$\text{DE} = 4{\cdot}184\ (0{\cdot}975 + 0{\cdot}021 \times \text{M}),$$

where M is the live weight. This formula was derived from metabolic studies with horses (National Research Council, 1989). For ponies:

$$\text{DE} = 0{\cdot}465 \times \text{M}^{0{\cdot}75},$$

a formula developed by Ellis & Lawrence (1980) for use with native ponies in the UK.

Digestible protein requirements for maintenance (g/d) were estimated using the formula $0{\cdot}6 \times \text{M}$ (National Research Council, 1989). In view of the lack of information specifically available on the energy and protein requirements of donkeys, the assumption has been made that energy and protein requirements for donkeys can be estimated using the same formulas. This may overestimate requirements for donkeys.

The experiment was a change-over design comparison using two Latin-squares, one for each species. The data obtained were subjected to an analysis of variance using GENSTAT 5 (release 3.4, 1993; Lawes Agricultural Trust, Rothamsted Experimental Station, Harpenden, Bucks, UK). In the analysis, the total sum of squares was partitioned into three strata representing variation between animals and periods together with an animal×period interactions. Overall species effects were estimated and tested from the between-animal stratum (d.f. = 6). Diet effects and species×diet interactions were estimated and tested from the animal×period stratum (d.f. = 15). Residual effects of dietary treatment were tested for carry-over using covariance analysis and were not found to be significant for any of the measurements made.

Results

Temperature and relative humidity

Ambient temperatures and humidities were monitored in the animal shed. The readings for maximum, minimum and dry bulb temperatures and relative humidity were taken daily at 10.00 h. The mean values of the daily values recorded during each collection period (*n* 7) were calculated. The ranges of the mean values were 14·6–19·6°C for maximum daily temperature, 7·2–11·4°C for minimum daily temperature, 9·4–13·7°C for dry bulb temperature and 83–92 % for relative humidity.

Period effects

The amount of experimental variation that could be accounted for by time period effects (i.e. time of feeding relative to the time from the start of the experiment) was not significant.

Food and water intake

Ponies consumed significantly ($P < 0{\cdot}01$) more feed and water than the donkeys (Table 2). During the experiment, the restricted intakes of alfalfa and oat straw by the ponies averaged 43 and 71 % of their intake *ad libitum* respectively. Similarly, the restricted intakes of alfalfa and oat straw by the donkeys averaged 51 % and 86 % respectively. The voluntary intake of alfalfa by two ponies and one donkey increased continuously and that of oat straw by one donkey decreased continuously over the 21 d periods they were on these treatments. These occurrences probably accounted for the failure to achieve the target intakes for the restricted treatments of 70 % of intake *ad libitum*.

Apparent digestibility of nutrients

Donkeys had significantly ($P < 0{\cdot}05$) higher apparent digestibilities for the main dietary components of the forages (Table 3) compared with those measured in ponies. The differences were more pronounced when the good quality, alfalfa diet was provided than when the poorer quality straw diet was fed.

The apparent digestibilities of DM and energy in alfalfa were higher ($P < 0{\cdot}001$) than that of the straw in both species, with the digestibility of this feed being greater in donkeys when intake was restricted ($P < 0{\cdot}05$). The opposite effect occurred when oat straw was fed. The apparent digestibilities of both DM and energy were higher when oat straw was offered *ad libitum* than when it was fed in restricted amounts ($P < 0{\cdot}05$). These differences were reflected in the values for NDF and acid-detergent fibre digestibilities for donkeys ($P < 0{\cdot}05$). For straw-fed

Table 2. Daily DM, digestible energy (DE), digestible crude protein (CP) and voluntary water intakes and average live weight (LW) of ponies and donkeys fed alfalfa (A) or oat straw (OS) *ad libitum* (AL) or restricted (R) to about 0·70 of *ad libitum* intake†

(Mean values with standard errors of the difference for four donkeys and four ponies)

		A		OS			Statistical significance of effects	
	Species of equid	AL	R	AL	R	Mean	Effect	*P* value
Daily intake of:								
DM (g/kg LW)	Pony	38·6	17·9	24·0	17·0	24·4	Species	**
	Donkey	26·7	15·0	16·3	14·4	18·1	Diet	***
	Mean	32·7	16·4	20·1	15·7		Species×diet	*
	SED 2·56‡		SED 2·30§		SED 1·62‖	SED 1·63¶		
DM (g/kg $LW^{0·75}$)	Pony	155·0	70·2	94·7	67·5	96·9	Species	***
	Donkey	100·0	54·9	59·8	52·7	66·9	Diet	***
	Mean	127·6	62·5	77·3	60·1		Species×diet	*
	SED 9·10‡		SED 8·67§		SED 5·14‖	SED 6·13¶		
DE (kJ/kg LW)	Pony	373	169	158	111	203	Species	
	Donkey	284	171	132	100	172	Diet	***
	Mean	329	170	145	105		Species×diet	
	SED 30·88‡		SED 27·3§		SED 19·0‖	SED 19·3¶		
Digestible CP (g/kg LW)	Pony	2·36	1·12	0·04	−0·09	0·86	Species	
	Donkey	1·90	1·64	0·08	−0·17	0·86	Diet	*
	Mean	2·13	1·38	0·06	−0·13		Species×diet	
	SED 0·694‡		SED 0·727§		SED 0·292‖	SED 0·514¶		
Water (l/kg DM)	Pony	4·35	4·74	3·77	4·52	4·35	Species	*
	Donkey	3·21	4·31	3·18	3·80	3·62	Diet	
	Mean	3·78	4·52	3·48	4·16		Species×diet	
	SED 0·495‡		SED 0·472§		SED 0·303‖	SED 0·304¶		
Water (ml/kg LW)	Pony	171	80	89	77	104	Species	*
	Donkey	87	64	52	55	64	Diet	**
	Mean	129	72	70	66		Species×diet	*
	SED 16·6‡		SED 13·7§		SED 11·7‖	SED 9·7¶		
Live weight (kg)	Pony	266	241	254	251	253	Species	*
	Donkey	197	182	182	178	185	Diet	***
	Mean	231	212	218	214		Species×diet	
	SED 26·9‡		SED 4·68§		SED 26·6‖	SED 3·31¶		

*$P < 0·05$, **$P < 0·01$, ***$P < 0·001$.
† For details of diets and procedures, see Table 1 and p. 600 respectively.
‡ SED for comparison between two means for different species of equid.
§ SED for comparison between two means for the same species of equid.
‖ SED for comparison between overall means for equine species.
¶ SED for comparison between overall means for diet types.

ponies, NDF digestibility was higher when straw intake was restricted although this difference was not significant.

Rate of passage of feed residues

MRT of the solid and liquid phases of the digesta are reported in Table 4. In all cases, Cr-fibre ($P < 0·001$) and Co-EDTA ($P = 0·04$) passed through the gastrointestinal tract of ponies more quickly than through the gastrointestinal tract of donkeys. Significantly ($P < 0·01$) longer MRT were measured in both species fed restricted amounts of alfalfa compared with values recorded when it was fed *ad libitum.* When fed oat straw, the ponies had longer MRT when it was restricted, however, donkeys retained straw particles in their gastrointestinal tract longer when they were fed *ad libitum*.

Live weight and intake of digestible nutrients

Although ponies consumed more DM than donkeys, in terms of DE intake (kJ/kg LW), a comparison between the species showed that the differences were small (Table 2), reflecting the compensating effect of the higher apparent digestibility of organic matter in donkeys than in ponies (Table 3). Significant differences in LW were seen between treatments with the lowest weight on the restricted straw diets and highest on alfalfa *ad libitum* (Table 2).

Daily intakes of DE and digestible CP were compared with estimated daily requirements for these nutrients. Although the ponies consistently consumed more energy relative to their requirements than donkeys, the difference between species was only significant ($P < 0·05$) when the comparisons were based on the Ellis & Lawrence (1980) standards. Intakes of alfalfa *ad libitum* by ponies exceeded estimated requirement 3·2–3·6-fold and intake in donkeys exceeded requirement 2·2–3·1-fold. LW was the highest on this diet for both species (Table 2). Restricting the intake of alfalfa almost halved the DE intake:DE requirement ratio of ponies, (1·3–1·6), less so in donkeys (1·2–1·5) and was reflected in a lower LW than on the alfalfa *ad libitum* (Table 2).

Straw intakes *ad libitum* exceeded pony energy requirements by between 34 and 51 %, but donkey energy requirements were only just met. Limiting access to straw had less effect on DE intakes. Pony LW on this diet was higher and donkey LW was the same as on the restricted alfalfa treatment (Table 2), which may reflect the more bulky nature of the straw diet and hence a greater gut-fill.

Table 3. Mean apparent digestibility of DM, organic matter (OM), gross energy (GE), crude protein (CP), acid-detergent fibre (ADF) and neutral-detergent fibre (NDF) in ponies and donkeys given alfalfa (A) or oat straw (OS) *ad libitum* (AL) or restricted (R) to about 0·70 of *ad libitum* intake†

(Mean values with standard errors of the diffrence for four donkeys and four ponies)

		A		OS			Statistical significance of effects	
	Species of equid	AL	R	AL	R	Mean	Effect	*P* value
Apparent digestibility coefficients:								
DM	Pony	0·58	0·58	0·43	0·40	0·50	Species	*
	Donkey	0·63	0·66	0·50	0·43	0·55	Diet	***
	Mean	0·60	0·62	0·47	0·42		Species×diet	
	SED 0·028‡		SED 0·023§		SED 0·019‖	SED 0·017¶		
OM	Pony	0·58	0·58	0·44	0·43	0·51	Species	*
	Donkey	0·63	0·66	0·49	0·45	0·56	Diet	***
	Mean	0·60	0·62	0·47	0·44		Species×diet	
	SED 0·026‡		SED 0·022§		SED 0·017‖	SED 0·015¶		
GE	Pony	0·54	0·54	0·41	0·37	0·46	Species	*
	Donkey	0·60	0·63	0·46	0·39	0·52	Diet	***
	Mean	0·57	0·58	0·43	0·38		Species×diet	
	SED 0·028‡		SED 0·023§		SED 0·020‖	SED 0·016¶		
CP	Pony	0·67	0·68	−0·03	−0·11	0·30	Species	*
	Donkey	0·75	0·81	0·09	−0·10	0·38	Diet	***
	Mean	0·71	0·74	0·03	−0·10		Species×diet	
	SED 0·089‡		SED 0·099§		SED 0·024‖	SED 0·070¶		
ADF	Pony	0·37	0·39	0·46	0·43	0·41	Species	*
	Donkey	0·47	0·50	0·51	0·46	0·48	Diet	
	Mean	0·42	0·44	0·48	0·45		Species×diet	
	SED 0·033‡		SED 0·030§		SED 0·020‖	SED 0·021¶		
NDF	Pony	0·38	0·42	0·47	0·48	0·43	Species	*
	Donkey	0·47	0·54	0·51	0·46	0·49	Diet	
	Mean	0·43	0·48	0·49	0·45		Species×diet	
	SED 0·038‡		SED 0·033§		SED 0·026‖	SED 0·023¶		

*$P < 0·05$, **$P < 0·01$, ***$P < 0·001$.
† For details of diets and procedures, see Table 1 and p. 600 respectively.
‡ SED for comparison between two means for different species of equid.
§ SED for comparison between two means for the same species of equid.
‖ SED for comparison between overall means for equine species.
¶ SED for comparison between overall means for diet types.

On the restricted straw diets, donkeys did not satisfy their energy needs, whereas ponies almost achieved an energy balance. When the amount of straw offered was restricted, 78 and 90 % energy requirement was consumed by the donkeys compared with 94 and 105 % by the ponies. LW were lowest on these dietary treatments in both species (Table 2).

When fed restricted amounts of straw, the animals were in negative protein balance and could not satisfy protein needs even when the straw was fed *ad libitum*. Unrestricted access to alfalfa provided nearly four times the protein requirement and more than 1·75 times the protein needs for both species when alfalfa was restricted. In the latter instance, donkeys obtained more digestible protein than ponies, presumably reflecting the higher protein digestibility coefficient with this species (Table 3).

Table 4. The mean retention time of Chromium-mordanted hay fibre (Cr-fibre) and cobalt-EDTA in the digestive tract of ponies and donkeys given alfalfa (A) or oat straw (OS) *ad libitum* (AL) or restricted (R) to about 0·70 of *ad libitum* intake†

		A		OS			Statistical significance of effects	
	Species of equid	AL	R	AL	R	Mean	Effect	*P* value
Mean retention time (h):								
Cr-fibre	Pony	21·3	30·5	31·5	36·0	29·8	Species	***
	Donkey	32·8	39·8	44·3	38·3	38·8	Diet	**
	Mean	27·0	35·1	37·9	37·1		Species×diet	
	SED 3·19‡		SED 3·31§		SED 1·40‖	SED 2·34¶		
Co-EDTA	Pony	20·5	26·8	30·0	33·5	27·7	Species	*
	Donkey	25·3	31·3	38·0	34·0	32·1	Diet	***
	Mean	22·9	29·0	34·0	33·8		Species×diet	
	SED 2·73‡		SED 2·35§		SED 1·82‖	SED 1·66¶		

*$P < 0·05$, **$P < 0·01$, ***$P < 0·001$.
† For details of diets and procedures, see Table 1 and p. 600 respectively.
‡ SED for comparison between two means for different species of equid.
§ SED for comparison between two means for the same species of equine.
‖ SED for comparison between overall means for equine species.
¶ SED for comparison between overall means for diet types.

Discussion

Daily voluntary DM intakes of the dehydrated alfalfa by the ponies (155 g/kg $LW^{0.75}$) were higher than the range reported for dried alfalfa pellets, cubes or wafers (88–138 g/kg $LW^{0.75}$; Haenlein *et al.* 1966; Cymbaluk, 1990; Todd *et al.* 1995) and the range for alfalfa hays (75–122 g/kg $LW^{0.75}$; Haenlien *et al.* 1966; Cymbaluk, 1990; Todd *et al.* 1995; Crozier *et al.* 1997; Dulphy *et al.* 1997*a*,*b*). Daily DM intakes of the dehydrated alfalfa by the donkeys (100 g/kg $LW^{0.75}$) were higher than those reported in donkeys consuming grass and grass–legume–hay mixtures (67–88 g/kg $LW^{0.75}$; Pearson & Merritt, 1991; Tisserand *et al.* 1991; Mueller *et al.* 1994) and millet stover (60–77 g/kg $LW^{0.75}$; Mueller *et al.* 1994). Intakes of the oat straw in donkeys and ponies in the present experiment were higher than intakes reported of barley straw (37 g/kg $LW^{0.75}$ and 60 g/kg $LW^{0.75}$; Pearson & Merritt, 1991) and wheat straw (57 g/kg $LW^{0.75}$ and 53 g/kg $LW^{0.75}$; Tisser- and *et al.* 1991) by donkeys and ponies respectively, but considerably less than the daily intakes of hays reported in the literature.

The high voluntary intakes of the oat straw and alfalfa in the present experiment compared with values in the literature may be due to seasonal effects on intake. The present experiment was undertaken in the summer months and it may be that forage intakes are higher in the summer than in the winter in temperate areas due to photoperiod effects. There is little information available on the effects of season on forage intake by equids, however Fuller *et al.* (1998) observed higher DE intakes by young ponies on long 'day-lengths' than on short 'day-lengths' in a study using simulated daylengths at constant temperatures.

Dulphy *et al.* (1997*b*), in a review of forage intakes by horses, observed that voluntary DM intake in horses was not influenced by CP, crude fibre or NDF content and as a result it was difficult to predict voluntary intake of horses from the characteristics of ingested forages. They found intakes of straws were lower than those of other forages (12–15 g/kg LW compared with intakes of grass hays of 17–21 g/kg LW and of lucerne hays of 21–23 g/kg LW), which they attributed largely to organoleptic differences between the straw and the other forages (Dulphy *et al.* 1997*b*). They suggested predicted intakes of straws by horses should be lower than those of other forage types. The results of the present experiment suggest that the same situation also applies for forage intakes by ponies and donkeys.

The low CP content of the cereal straws (40 g/kg DM, present study) compared with other forages may be a contributing factor to the low intake of the straw diets by the donkeys and ponies in the present experiment, through inhibition of microbial digestion in the hindgut. Diets that contain < 80 g CP/kg DM depress intake in ruminants, through their slow rates of fermentation in the rumen (Van Soest, 1994). Hyslop *et al.*(1997) showed that the microflora of equine hindgut had many characteristics of those in the rumen. They were as effective as rumen foregut microflora in digesting feed ingredients. Suhartanto *et al.* (1992) observed increased volatile fatty acid production in the caecum of ponies and donkeys following N supplementation of a wheat straw diet by ponies and donkeys and higher intake compared with that of unsupplemented straw. Other factors may contribute to reduced intakes by equids on cereal straws. Dulphy *et al.* (1997*a*) suggested low palatability was a factor, while the effects of extent of gut-fill of the digestive tract on the control of appetite are not well known (Ruckebusch, 1984) and warrant further investigation.

Generally the digestibility coefficients of the main dietary components of forages measured in donkeys are higher than those measured when the same feeds are fed to ponies or horses (e.g. Araújo *et al.* 1997). In the present study, differences were greater on the oat-straw diet than on the alfalfa diet, a similar observation to that seen in other comparative studies of digestion of straw and alfalfa diets by equids (Pearson & Merritt, 1991; Pearson *et al.* 1992). The negative measurement of protein apparent digestibility may have resulted from high levels of endogenous N being present in the faeces. Izraely *et al.* (1989*b*) found that when donkeys were fed on wheat straw at maintenance, the amount of N recycled considerably exceeded that consumed in the food. The ability of donkeys to recycle urea effectively, up to 75 % on wheat straw (Izraely *et al.* 1989*a*), may account for their ability to maintain DE intakes on diets with low CP contents, as low as 39 g/kg DM in the present study.

The effect of level of feeding on digestibility of feed by the donkeys and ponies was influenced by forage type. The apparent digestibility of DM was higher for the oat-straw diet when it was fed *ad libitum* than when it was restricted, particularly in the donkeys. When the alfalfa diet was eaten by the donkeys the opposite effect of level of feeding was true and digestibility of the feed tended to be higher when intake was restricted. This effect was less noticeable in the ponies.

Improved selection offers an explanation for the improved digestibility of the oat straw when the diet was offered *ad libitum*. Feeding a low-quality diet *ad libitum* may enable selection of the more digestible fractions of the diet. Although the composition of feed refusals was not measured in the present experiment, evidence from other studies of donkeys fed cereal straw diets suggests that selection may play a significant role in the improved digestibility of straw when it is fed *ad libitum* to this species. Tisserand *et al.* (1991) found that on hay diets, donkeys ate more fibre and less nitrogenous matter than the ponies, but on straw diets they selected less fibre, particularly when the N content of the diet was low. They suggested that donkeys restrict their intake of fibre more than ponies when fed forages that are lignified (Tisserand *et al.* 1991). Van Soest (1994) suggested the relatively narrow muzzle of the donkey as compared with the horse indicates selectivity to be a characteristic of their feeding strategy. The level of feed excess may influence the amount of digestible nutrients available to equids. Fernandez-Rivera *et al.* (1994) found sheep fed on pearl millet (*Pennisetum americanum*) were able to select a more digestible diet if level of feed excess was at least 15 % greater than voluntary intake. Savadogo *et al.* (2000) when feeding sheep sorghum stover advised that a very high feeding level, where only 53 % was eaten was required to

reach the maintenance level of digestible organic matter intake. However, it is rare in practice that donkeys would have access to such a surplus of crop residue from which to feed, since priority is usually given to supplementation of other livestock in many of the countries where donkeys are used for work (Pearson, 1998). Time allowed for feeding may also be important in diet selection by donkeys. Smith (1999) found that time of access to pasture influenced selection. Donkeys selected a more digestible diet (in terms of NDF, CP and *in vitro* digestibility) when allowed 23 h access to pasture than when allowed only 8 h access.

Cuddeford *et al.* (1995) found that when Thoroughbreds, Highland ponies, donkeys and Shetland ponies were fed a restricted ration to meet estimated energy requirements for maintenance, regardless of forage type, donkeys retained food residues in the gastrointestinal tract longer than did the other equids and consequently the donkeys digested fibre more effectively than did the other equids. The present study has confirmed this observation and suggests that differences between equid types also apply when equids are given alfalfa and oat straw diets *ad libitum*. Whether these differences in retention time are due to differences in anatomical or physiological differences between the species remains to be determined. Differences in water intakes exist between the two species. Donkeys consumed less water per unit DM and per unit LW than the ponies did, possibly reflecting their origins in a hot, semi-arid environment, and other differences. There may also be differences in the type and proportions of micro-organisms in the hindgut and hence in microbial activity between donkeys and ponies. Suhartanto *et al.* (1992) observed higher concentrations of volatile fatty acids in the caecal fluid of donkeys than in ponies on low N wheat straw-based diets and differences in the proportions of butyric and acetic acids which they suggested may account for differences in retention time and differences in fibre digestibility between the two species.

The lower voluntary intakes of straw and alfalfa, longer retention times and relatively higher digestibilities of feed by donkeys compared with the ponies seen in the present experiment may only apply to forage diets. Cuddeford & Hyslop (1996) found that differences in feed intake and digestion strategy were not evident when both species were offered a high-quality fibre-based concentrate feedstuff *ad libitum*.

Donkeys and ponies when offered the alfalfa forage *ad libitum* ate more than their calculated DE requirements. Similar observations were made by Cymbaluk (1990) in horses and Cuddeford & Hyslop (1996) in donkeys and ponies offered grass and legume hays *ad libitum*. Hyslop *et al.* (1998) found that ponies consumed DE equivalent to approximately 2·5 times theoretical requirements when offered dehydrated grass or hay made from the same grass crop. Cuddeford & Hyslop (1996) proposed that penned equids do not regulate their energy intake according to requirements in the short term. The results in the present experiment support this finding.

Differences in intakes of DE by donkeys and ponies were small, despite the higher DM intake of the ponies. This suggests that the better apparent digestibilities of nutrients by donkeys on forage diets compared with that of ponies enables them to compensate fairly successfully for their lower intakes of feed. The ponies' strategy appears to be to consume greater quantities of the feed with shorter retention times in the gastrointestinal tract and lower apparent digestibilities of nutrients, whereas the donkey appears more 'ruminant-like', with longer retention times of feed in the tract, lower intakes and better apparent digestibilities of nutrients. In situations where the forage supply is limited, the donkey would exploit the nutrients available more effectively than the pony could. Janis (1976) considered that equids generally, because of higher intakes, were at an advantage relative to ruminants when there is a plentiful supply of poor quality forage. However, in view of the fact the donkey seems to adopt a more 'ruminant-like' nutritional strategy with lower intakes and higher feed digestibilities, it is perhaps inappropriate to consider the donkey in the same terms as the horse and pony. It may be that the mechanisms of regulation of forage intake, which still have to be defined in detail for horses and ponies, are similar in donkeys, but the relative contributions of each mechanism to regulation of intake may be different in the two species.

Conclusions

This study has provided further evidence of the effect that type of forage and feeding level can have on the intake and digestibility of forages by equids. Good quality forages did not reduce the differences in the strategies employed by donkeys and ponies to obtain nutrients from poorer quality forages. On cereal straw diets, it appears better to feed *ad libitum*, to allow for the possibility of some selection, to improve feeding value to the equids. On legume forages, restricting access can maximise digestibility of the dietary components, and prevent animals eating more than their requirement.

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