Digestibility of Diets Containing Different Proportions of Alfalfa and Oat Straw in Thoroughbreds, Shetland Ponies, Highland Ponies and Donkeys

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Summary

A systematic study was carried out to establish whether there are differences in the ability of different equine types to digest roughage diets containing varying amounts of fibre and protein. In a 4 x 4 Latin square design four types of equids (Thoroughbreds, Highland ponies, Shetland ponies and donkeys), were fed one of four molassed diets containing different proportions of alfalfa and oat straw: 100 : 0, 67 : 33, 33 : 67, 0 : 100, respectively. Four of each type of equids were kept in individual pens and fed each diet in turn for three weeks. The animals were exercised for two hours per day. Feed intake and digestibility were measured. All animals digested the high fibre diets less well than the low fibre diets, and donkeys digested fibre more effectively than the other equids.

Verdaulichkeit von Rationen mit unterschiedlichen Anteilen von Luzerne und Haferstroh bei Vollblütern, Shetlandponys, Hochlandponys und Eseln

In der vorliegenden Studie sollte überprüft werden, ob zwischen verschiedenen Equiden Unterschiede in der Verdauungskapazität für Rohfaser bestehen. Die Versuchsanordnung erfolgte nach einem 4 x 4 lateinischen Quadrat mit 4 verschiedenen Equiden (Vollblüter, Hochlandponys, Shetlandponys und Eseln). Die Tiere erhielten je eine von 4 melassierten Rationen mit unterschiedlichem Anteil an Luzerne und Stroh und entsprechender Variation des Protein- und Rohfasergehaltes (Luzerne : Stroh: 100 : 0, 67 : 33, 33 : 67, 0 : 100). Jeweils 4 Tiere der betreffenden Equiden wurden in Einzelboxen gehalten und erhielten nacheinander die oben genannten Rationen für je 3 Wochen. Die Tiere wurden 2 Stunden pro Tag bewegt. Die rohfaserreichen Rationen wiesen bei allen Tieren eine geringere Verdaulichkeit auf. Esel verdauten Rohfaser effizienter als Pferde.

Introduction

In their review of the nutrition of the horse *Olsson* and *Ruudvere* (1955) showed that whilst horses and cattle were equally effective in digesting low fibre feeds, cattle were better able to digest high fibre feeds. They showed that generally, as the fibre content of the ration increased, the digestibility of organic matter was less for both horses and cattle, but that the reduction in digestibility for horses was greater. *Slade* and *Hintz* (1969) compared the digestion of alfalfa (252 g crude fibre CF/kg DM) and alfalfa/grain diets (178 g CF/kg DM) in non-ruminant herbivores and whilst they found no significant difference between horses (Thoroughbred and Quarter horse mares) and ponies (Shetland mares), digestibility coefficients for the proximate constituents measured in the ponies were higher. This difference was consistent with both diets although the magnitude of the difference was slightly less on the low fibre diet. Although there was a trend for ponies to be more efficient than horses in digesting the components of the diet, the authors concluded that it was justifiable to use the pony as a model for horse nutrition studies. Later work (*Uden* and *Van Soest,* 1982) confirmed that ruminants were superior in digesting timothy hay fibre compared to equids, but that there was a large individual variation in this latter species in their ability to digest the same diet. Ponies (mean live weight 132 kg) were more efficient at digesting cell walls, cellulose, hemicellulose, lignin and dry matter than horses (mean live weight 388 kg). The largest horse (500 kg) had the lowest cell wall digestibility (0.30) whilst the smallest pony (90 kg) had the highest (0.44). Furthermore, the ponies consumed 20.7 g of timothy hay/kg live weight compared to the horses, who only consumed 16.1 g/kg live weight. This contrasts with the foraging strategies of equids and ruminants proposed by *Janis* (1976); where the voluntary food intake of horses is usually greater than that of ruminants, but by way of compensation the digestibility of food nutrients is usually higher in the ruminants than in horses. From this it might be expected that higher intakes in the ponies would be associated with lower digestibilities. Recent work (*Pearson* and *Merritt,* 1991) compared the digestion of hay and barley straw by ponies and donkeys and showed that the donkeys ate less, had slower rates of passage, but digested the food components more effectively than the ponies.

The current study was designed to examine the differences between horses, different types of pony and donkeys in their ability to digest fibrous diets and to investigate the anomalies apparent in the literature with reference to level of intake and subsequent nutrient digestibility.

Materials and methods

Animals and management

Four adult Highland pony geldings (454, 477, 529, 560 kg at the start of the experiment), four adult gelding donkeys (157, 173, 179, 187 kg at the start of the experiment) and four adult Shetland ponies, one gelding and three stallions (89, 96, 108, 138 kg at the start of the experiment), were

housed in pairs in climate rooms (one pony with one donkey or two ponies together). The rooms were maintained at a temperature of approximately 13°C. The animals were tethered at each side of the climate room and separated by a central partition so that the faeces from each animal could be identified easily. Four adult Thoroughbred geldings (488, 504, 576, 624 kg at the start of the experiment) were housed in individual stalls alongside each other in a stable. Urine was allowed to drain down channels in the floor away from the area where faeces were voided in both the rooms and the stalls. Clean drinking water was always available from individually metered supplies and artificial light provided a constant day-length of 12 h. Each animal was walked in hand or on a horse-walker at a comfortable walking speed (up to 1.67 m/s) for 2 h per day.

Diets

Four molassed diets containing differing proportions of precision-chopped oat straw and dehydrated alfalfa were prepared. The proportions of straw and alfalfa in each diet were 0 : 100, 33 : 67, 67 : 33 and 100 : 0, respectively. The composition of each diet is given in Table 1. The diets were fed to each of the four equine types according to a Latin Square design; there were four 21-d periods and one donkey, one Thoroughbred, one Shetland and one Highland pony received each diet in turn over each period.

Each day individual animals were fed an amount calculated to provide sufficient energy to meet their maintenance energy requirements according to the formula DE (MJ/day) = 4.184 (0.975 + 0.021 W), where DE is digestible energy and W is the live weight (kg) of the horse (*Pagan* and *Hintz*, 1986). The daily ration was divided into four equal feeds and given at 8 h, 12 h, 16 h and 20 h. Any food refusals were collected at 8 h each day prior to feeding.

Measurements

Each animal was weighed at the start of the experiment and twice weekly to the end of the experimental period. For the first 14 days of each period the animals were allowed to adapt to the new diet. During the final seven days, measurements of food intake and total faecal collections were made. These collections were made at regular intervals from 23 h on day 14 for the seven days until the end of the period. Individual faecal collections were weighed, thoroughly mixed and a 2 per cent by weight sub-sample was taken. These subsamples were pooled over the 7-day period for each animal. All samples were dried in a forced draught-oven to constant weight, ground through a 1 mm screen and then analysed. Acid detergent fibre (ADF), neutral detergent fibre (NDF), crude protein (CP), gross energy (GE) and organic matter (OM) were determined according to the Association of Official Analytical *Chemists* (1990).

Calculations and statistical analyses

Apparent digestibilities were calculated from total feed dry matter intake and faecal dry matter output over the seven day collection periods. The design of the experiment was a standard changeover design comprising four Latin squares, one for each type of equid. In the analysis, the total sum of squares was partitioned into three strata representing variation between animals, variation between periods, and animal x period interaction. Overall equine effects were estimated and tested from the between-animal stratum (D. F. = 12). Diet effects and equid x diet interaction were estimated and tested from the animal x period stratum (D. F. = 33).

Results

Food and water intakes

Most animals consumed all of the feed offered each day, with the exception of those fed 100 per cent oat straw. Two of the Shetland ponies intermittently refused up to 30 per cent of the straw allocation, one of the Highland ponies often left up to 25 per cent and the Thoroughbreds had refusals, but not exceeding 20 per cent of their allocation. Daily DM intakes per kg live weight 0.75 were significantly ($P < 0.01$) higher in the Thoroughbreds compared to the other equids. The Shetland ponies consumed significantly ($P < 0.01$) less DM than other equids and donkeys and Highland ponies had intermediate values (table 2). However, when DM intake was expressed per kg live weight the differences were not significant. This was expected because the animals were rationed on the basis of live weight. Using the different diets to meet maintenance energy requirements meant that the daily allowances and actual intakes of the low energy, high fibre 100 per cent oat straw diet were significantly ($P < 0.001$) higher than those of the less fibrous, more energy dense 100 per cent alfalfa ration. The intakes of the other two rations were in between (table 2). Water intake was not significantly different on any of the dietary treatments when expressed per unit of DM con-

Table 1: The mean (± s.e.; n = 10) composition of the diets offered (values are g/kg dry matter otherwise stated)

Alfalfa (%) Oat straw (%)	100 0	67 33	33 67	0 100
Dry matter (g/kg)	865 ± 3.2	844 ± 4.2	815 ± 4.8	764 ± 10.4
Organic matter	907 ± 1.4	908 ± 1.7	908 ± 2.1	914 ± 2.2
Neutral detergent fibre	401 ± 6.5	459 ± 13.5	523 ± 12.0	621 ± 15.8
Acid detergent fibre	317 ± 6.8	328 ± 9.7	365 ± 7.6	389 ± 12.0
Crude protein	171 ± 4.3	138 ± 3.4	100 ± 4.1	48 ± 2.0
Gross energy (MJ/kg DM)	18.01 ± 0.10	18.07 ± 0.09	17.80 ± 0.09	17.19 ± 0.14

summed, but did differ significantly ($P < 0.01$) between the different types of equid. The donkeys had the lowest water intakes, followed by the Shetlands. Both these types had significantly ($P < 0.01$) lower water intakes than the Thoroughbreds and the Highland ponies (table 2).

Apparent digestibility coefficients

There was a wide range of values for the digestibility coefficients of the food nutrients (table 2) which depended on dietary composition; digestibility coefficients for DM, OM, GE and CP decreased as straw was included in the diet. Surprisingly, the differences in fibre digestibility between the diets were not so marked; the greatest difference in ADF digestibility was seen between the 100 per cent alfalfa ration and the other forage combinations; there was little difference in NDF digestibility between diets. Digestibility coefficients for protein in animals fed the 100 per cent oat straw diet are included for completeness, but are of little relevance in view of the very low protein content of the straw.

There were significant differences between the types of equids in their ability to digest the diets. In general, the differences were greatest between the Shetland ponies and the other animals. Differences between the Thoroughbred horses, Highland ponies and the donkeys were less marked. The Shetland ponies had a significantly lower ($P < 0.01$) digestibility of DM, OM, and GE than the other equids. The effect was more noticeable in animals when they were fed the 100 per cent alfalfa diet than when they were fed the 100 per cent oat straw diet. Donkeys had higher digestibilities of DM, OM, GE, ADF and particularly of NDF on the diets containing oat straw compared to the other equids. These differences were significant ($P < 0.01$) for OM, GE, ADF and NDF. Digestion of fibre tended to vary considerably between diets and between individuals, particularly when the animals were fed the mixed roughage diets. The ADF and NDF of the 67 per cent alfalfa diet was digested less well by the Shetland ponies compared to that of the other diets, and compared to that by other equids. The only significant ($P < 0.05$) interactions between diet and equine type were seen in the digestibility of OM, GE and NDF (table 2). The Thoroughbreds appeared to digest the OM and GE in the diets with the higher levels of alfalfa better than the Shetlands, but the opposite effect was seen on the 100 per cent straw ration.

Discussion

The Shetlands consumed more dry matter (g/kg live weight) on each diet compared to the horses. This finding is similar to that reported by *Uden* and *Van Soest* (1982), although in the present study, the Shetlands did not appear

Table 2: Mean daily dry matter (DM), water, digestible energy (DE) and digestible crude protein (DCP) intakes and apparent digestibility of dry matter (DM), organic matter (OM), gross energy (GE), crude protein (CP), acid detergent fibre (ADF) and neutral detergent fibre (NDF) of diets containing differing proportions of alfalfa (ALF) and oat straw (OS) by Thoroughbreds, Highland ponies (H pony), donkeys and Shetland ponies (S pony) (n = 4)

Daily intake of							Apparent digestibility coefficients of					
Diet ALF	Diet OS	Type of Equid	DM g/kg $m^{0.75}$	Water l/kg DM	DE kJ/kg M	DCP g/kg M	DM	OM	GE	CP	ADF	NDF
100	0	Thoroughbred	49.7	3.94	120	1.41	0.69	0.68	0.64	0.77	0.47	0.44
100	0	H pony	45.0	3.71	113	1.36	0.68	0.69	0.65	0.74	0.49	0.43
100	0	Donkey	40.2	1.19	132	1.36	0.67	0.70	0.65	0.74	0.50	0.45
100	0	S pony	39.9	2.21	128	1.09	0.59	0.62	0.57	0.66	0.42	0.43
67	33	Thoroughbred	55.2	3.91	117	1.01	0.61	0.60	0.57	0.68	0.39	0.43
67	33	H pony	49.5	4.72	105	0.95	0.58	0.59	0.55	0.64	0.40	0.42
67	33	Donkey	44.7	1.95	132	0.99	0.62	0.64	0.59	0.66	0.46	0.50
67	33	S pony	45.2	2.51	123	0.74	0.52	0.52	0.48	0.56	0.31	0.33
33	67	Thoroughbred	63.0	3.84	122	0.57	0.56	0.55	0.53	0.55	0.38	0.44
33	67	H pony	58.3	4.12	116	0.61	0.55	0.56	0.53	0.58	0.38	0.41
33	67	Donkey	51.7	2.00	142	0.60	0.56	0.59	0.56	0.57	0.42	0.47
33	67	S pony	48.2	2.51	140	0.60	0.54	0.55	0.52	0.55	0.42	0.46
0	100	Thoroughbred	65.9	3.78	101	0.05	0.48	0.48	0.43	0.10	0.37	0.41
0	100	H pony	57.5	4.34	98	0.05	0.50	0.51	0.47	0.11	0.42	0.47
0	100	Donkey	56.1	2.59	123	0.05	0.48	0.51	0.47	0.10	0.44	0.49
0	100	S pony	49.0	2.36	125	0.04	0.46	0.51	0.47	0.08	0.44	0.47
s.e.d. between types			2.41	0.52	6.4	0.02	0.014	0.007	0.007	0.021	0.014	0.019
s.e.d. within types			3.36	0.48	8.4	0.03	0.020	0.018	0.011	0.027	0.031	0.030
Significance of effects of		Type of equid	**	**	**	***	**	***	***	ns	**	ns
		Diet	***	ns	**	***	***	***	***	***	***	*
		Type of Diet	ns	ns	ns	**	ns	*	**	ns	ns	*

to be more efficient at digesting food nutrients when compared to Thoroughbreds. In contrast, the donkeys consumed almost as much dry matter per kg live weight as the Shetlands, but the digestibility of food nutrients measured in these animals were consistently the highest. It would appear that the present findings do not support a consistent relationship between dry matter intake (expressed per kg live weight) and nutrient digestibility in equids. The greater ability of donkeys to digest fibre in roughage diets compared to that of ponies agrees with previous observations in both restricted (*Wolter* and *Velandia*, 1970) and ad libitum fed (*Pearson* and *Merritt*, 1991; *Tisserand* et *al.*, 1991) animals. Fluctuations in live weight were no more than would be expected from changes in gut-fill on the different diets, and so it was considered that intake of energy was sufficient to meet maintenance requirements. That some animals did not consume their whole ration, but maintained live weight suggested either a higher efficiency of digestion or a difference between animals in maintenance energy needs, although the latter seems more likely.

The mean digestibility coefficients for OM, CP and ADF of dehydrated alfalfa fed to the equids in the present study were 0.67, 0.72 and 0.47 respectively. Previous studies in this laboratory with dehydrated alfalfa (304 g ADF/kg DM) fed to Thoroughbred horses showed similar OM (0.63) and CP (0.74), but lower ADF (0.35) coefficients of digestibility (*Cuddeford* et *al.*, 1992). The data in the current study are similar to those reported by *Hintz* (1969) with alfalfa hay (310 g crude fibre/kg DM) which were 0.59, 0.75 and 0.41 (crude fibre, not ADF) respectively and obtained with horses. An alfalfa hay (227 g CP and 319 g ADF/kg DM) fed to donkeys was reported (*Izraely* et *al.*, 1989) to have an ADF digestiblity of 0.47 which is similar to the value (0.50) obtained in the present study.

The mean digestibility coefficients reported here for OM (0.50) and ADF (0.41) of oat straw fed to equids are different from those reported by *Hintz* (1969). However, oat straw used in the present study contained 389 g ADF/kg DM whereas that cited by *Hintz* (1969) contained 400 g crude fibre/kg DM. Surprisingly, the digestibility of the latter crude fibre was high at 0.51, whereas the OM digestibility was only 0.44. Digestibility values for oat straw in donkeys were not available, but coefficients for other straws have been recorded. The ADF digestibility for wheat straw (484 g ADF/kg DM) in donkeys was 0.42 (*Izraely* et *al.*, 1989) compared to a value of 0.44 for oat straw in the current study. The ADF digestibility for barley straw (567 g ADF/kg DM) in donkeys was 0.52 (*Pearson* and *Merritt*, 1991), which was associated with an OM digestibility of 0.48.
For equids, the fibre content of a diet has usually been found to have a great influence on the digestibility of nutrients (*Fonnesbeck* et *al.*, 1967); the higher the fibre the lower the nutrient digestibility. This relationship was observed in the present study when the Thoroughbred, Highland ponies and donkeys consumed the various diets. However, the level of fibre in the diet seemed to have little effect on the animals' abilities to digest the fibrous components, even on the 100 per cent oat straw diet which had the highest fibre content. However, *Uden* and *Van Soest* (1982) showed that there is considerable variations in the digestibility of fibre by individual equids; this was confirmed in the present study. The relationship between fibre content and digestibility was less clear for the Shetland ponies used in the present study, probably because of the low digestibilities measured in these animals on the 67 per cent alfalfa diet.

The amount of nitrogen available to the microflora in the hind-gut will effect the ability of the equid to digest fibrous plant cell wall constituents. Variation in ADF and NDF digestibilities between diets and between animals in this study may be partly due to differences in nitrogen availability and hence hind-gut digestion. The lack of any marked change in ADF and NDF digestibility associated with the decrease in digestible crude protein intake as straw content increased in the diet (see table 2) suggests that when protein content is low the equid has some mechanism that sustains nitrogen supply to the hind-gut. That the donkey is apparently the most successful equid at digesting fibre on low protein diets suggests that it may have the best developed mechanism for nitrogen recycling. *Izraely* et *al.* (1989) observed a decrease in the urea filtration rate combined with an increase in the fractional urea resorption, which increased retention of urea nitrogen and recycling of nitrogen into the gut when donkeys were fed low protein (45 g CP/kg DM) wheat straw compared with high protein (360 g/kg DM) alfalfa hay.

The situation with horses and ponies is unclear although *Prior* et *al.* (1974) produced evidence to show that urea is recycled to the gut of ponies. However, nothing is known of the controlling circumstances under which the return occurs or the extent to which it presents a contribution to or a penalty on the nitrogen economy of the animal.
The poorer nutrient digestibility measured in the smallest animals, compared to that in the other equids, was more noticeable as the alfalfa content of the diet increased. This anomalous situation may have been due to a low digestible crude protein intake per kg live weight compared to the other equids. The measurement of digestibility, particularly of roughage diets, in very small equids (under 100 kg) may not be representative of the situation in larger equids. This may be because their small size may reduce the effectiveness of digestive processes, particularly fermentation which is affected by both the size of the reaction vessel and out-flow rate (*Hume* and *Sakaguchi*, 1991).

Lower water intakes per kg food consumed in donkeys compared to other equids have been reported elsewhere (e. g. *Mueller* and *Houpt*, 1991) and may reflect the donkeys' desert origins. Water intake per kg DM increased with increasing straw inclusion in the diet by a factor of 2.1. Although, this trend was not significant, it may reflect greater water retention in the lumen of the gut and may affect rate of passage of digesta. The relationship between water intake and nutrient digestibility in the donkey is as yet untested.

It has been proposed that compared to the ruminant, the horse is better adapted to deal with fibrous foods when they are available ad libitum (*Illius* and *Gordon*, 1990). The adaptation is that the horse will eat more low quality roughage than the ruminant, although the digestibility of the nutrients will be less in the horse. It is not known whether, within equids, there are different strategies employed by the animals to digest high fibre diets. For example, is there any attempt to regulate intake and rate of passage of ingesta thereby affecting exposure time to enzymatic and microbial activity? The results of the current study suggest that donkeys have a different strategy from other equids, because they have a high intake and a high nutrient digestibility in constrast to the horses which had lower intakes and nutrients digestibilities. Previous work (*Pearson* and *Merritt*, 1991) has shown that donkeys fed straw ad libitum had a slower rate of passage, and higher organic matter digestibility compared to ponies fed the same diet. It is proposed that donkeys are more efficient at digesting fibrous foods because they have a higher mean retention time of food particles in the gut regardless of intake. Where the food resource is limited, the donkey would have the advantage, however, where there are unlimited food supplies, the pony/horse can compensate for reduced digestive efficiency by processing more food.

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References

Association of Official Analytical Chemists (1990): Official Methods of Analysis of the Association of Analytical Chemists (15th edn.). Association of Official Analytical Chemists, Virginia, USA.

Cuddeford, D., Woodhead, A. and *Muirhead, R.* (1992): A comparison between the nutritive value of short-cutting cycle, high temperature-dried alfalfa and timothy hay for horses. Equine Vet. J. 24, 84 – 89.

Fonnesbeck, P. V., Lydman, R. K., Van Der Noot, G. W., and *Symons, L. D.* (1967): Digestibility of the proximate nutrients of forate by horses. J. Ani. Sci. 26, 1039 – 1045.

Hintz, H. F. (1969): Review article: equine nutrition. Comparisons of digestion coefficients obtained with cattle, sheep, rabbits and horses. The Veterinarian, 6, 45 – 51.

Hume, I. D. and *Sakaguchi, E.* (1991): Patterns of digesta flow and digestion of foregut and hindgut fermenters. In: Physiological Aspects of Digestion and Metabolism in Ruminants: Proceedings of the Seventh International Symposium on Ruminant Physiology, pp. 427 – 451. Academic Press.

Illius, A. W., and *Gordon, I. J.* (1990): Constraints on diet selection and foraging behaviour in mammalian herbivores. In: Behavioural Mechanism of Food Selection (ed. R. N. Hughes). Springer-Verlag, Berlin.

Izraely, J., Chosniak, I., Stevens, C. E., Demment, M. W., and *Shkolnik, A.* (1989): Factors determining the digestire efficiency of the dometicated donkey (Equus asinus asinus). Quarterly Journal of Experimental Physiology, 74, 1 – 6.

Janis, C. (1976): The evolutionary strategy of the Equidae and the origins of rumen and caecal digestion. Evolution, 30, 757 – 773.

Mueller, P. J., and *Houpt, K. A.* (1991): A comparison of the responses of donkeys (Equus asinus) and ponies (Equus caballus) to 36 hours of water deprivation. In: Donkeys, Mules and Horses in Tropical Agricultural Development (eds. D. Fielding and R. A. Pearson), pp. 86 – 95. Centre for Tropical Veterinary Medicine, The University of Edinburgh, U. K.

Olsson, N., and *Ruudvere, A.* (1955). Nutrition of the horse. Nutrition Abstracts and Review, 25, 1 – 18.

Pagan, J. D., and *Hintz, H. F.* (1986): Equine energetics. I. Relationship between body weight and energy requirements in horses. J. Ani. Sci., 63, 815 – 821.

Pearson, R. A., and *Merritt, J. B.* (1991): Intake, digestion and gastrointestinal transit time in resting donkeys and ponies and exercised donkeys given ad libitum hay and straw diets. Equine Vet. J., 23, 339 – 343.

Prior, R. L., Hintz, H. F., Lowe, J. E., and *Visek, W. J.* (1974): Urea recycling and metabolism in ponies. J. Ani. Sci., 38, 565 – 571.

Slade, L. H., and *Hintz, H. F.* (1969): Comparison of digestion in horses, ponies, rabbits and guinea pigs. J. Ani. Sci., 28, 842 – 843.

Tisserand, J. L., Faurie, F., and *Tore, M.* (1991): A comparative study of donkey and pony digestive physiology. In: Donkeys, Mules and Horses in Tropical Agricultural Development (ed. D. Fielding and R. A. Pearson), pp. 67 – 72. Centre for Tropical Veterinary Medicine, University of Edinburgh, U. K.

Uden, P., and *Van Soest, P. J.* (1982): Comparative digestion of timothy (Phleum pratense) fibre by ruminants, equines and rabbits. Br. J. Nutr., 47, 267 – 272.

Wolter, R., and *Velandia, J.* (1970): Digestion des fourrages chez l'Ane. Recuil de Médicine Vétérinaire d'Alfort, 146, 141 – 152.

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