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Foraging enrichment for individually housed horses: Practicality and effects on behaviour

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Abstract

The stabled (UK) or stalled (USA) horse is commonly fed a restricted-forage diet in contrast to the varied ad libitum high-fibre diet it evolved to consume. A low-forage diet has been linked to the performance of stereotypical behaviour and health problems including gastric ulceration and impaction colic (in cases where horses are bedded on straw). Provision of a diet closer to that which the horse is adapted to and which enables more natural feeding behaviour warrants investigation.

This trial aimed to establish whether the behavioural effects observed in short-term trials when stabled horses were provided with a multiple forage diet persist over longer periods. It also aimed to develop a practical methodology for maintaining stabled horses under forage-enriched conditions.

Nine horses (aged 5–20 years, various breeds), acting as their own controls, participated in an 18-day, cross-over, Latin Square designed trial, in which they received comparable weights of two dietary treatments: a Single Forage (SF, hay) diet and a Multiple Forage (MF) diet (three long-chop and three short-chop commercially available forages). Following a 2-day acclimatisation, horses were maintained on the forage treatments for 7 days. Horses were observed on alternate days, morning and afternoon, during the 25 min following forage presentation. Horses then crossed over onto their second treatment and, following a further 2 days' acclimatisation, the same protocol was

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followed for a further 7 days. Observations from video were made using The Observer 3.0® and SPPS (version 11).

Horses on the MF treatment performed foraging behaviour significantly more frequently and for significantly longer periods than horses on the SF treatment. On the MF treatment horses sampled all forages during observations. However, there were significant differences in the frequency and duration of foraging on individual forages, indicating that horses demonstrated individual preferences for particular forages. Stereotypic weaving behaviour only occurred on the SF treatment.

The results indicate that the potentially beneficial behavioural effects of short-term multiple forage provision do persist when horses are managed on a MF diet for a 7-day period. They suggest that a MF diet provides a means of enriching the stabled horse's environment, by offering variety and enabling patch foraging behaviour. The methodology proved practical for maintaining horses under forage-enriched conditions and could easily be adopted by horse owners to facilitate foraging behaviour.

Keywords: Horse; Foraging behaviour; Eating; Feeding; Enrichment; Welfare

1. Introduction

The horse evolved as a grazing and browsing herbivore (Goodwin, 1999), adapted to consume a diet of high-fibre, fresh forage (Harris, 1999a). Free ranging and pastured horses graze and browse for up to 18 h/day (Harris, 1999a), selectively foraging on a wide variety of species (Waring, 1983). However, many horses are managed under conditions far removed from the free-ranging environment, frequently with restricted access to forage. This has an impact on their foraging behaviour and may affect their welfare.

The term 'foraging behaviour' encompasses all types of feeding behaviour: grazing, browsing and feeding behaviour whilst stabled. Goodwin et al. (2002) define foraging behaviour as sniffing, manipulating, biting, chewing or ingesting food; this facilitates comparisons of feeding behaviour under different circumstances. Foraging behaviour is influenced by internal and external factors including the weather, season, hunger, bite frequency, gender and management (Carson and Wood-Gush, 1983).

Stabling represents the most common form of equine housing the UK (Harris, 1999b), Europe and the USA where it is known as stalling. Here the horse is entirely dependent upon humans for the timing, selection and delivery of its diet (Fraser, 1974). Infrequent, meal-based, energy-dense, high-concentrate diets with limited forage and little if any variation are commonly fed. As a consequence, the behaviour of the intensively managed horse is very different to that seen among free ranging horses (Davidson, 1999). As dietary and social restrictions increase, horses spend less time eating and more time standing (Kiley-Worthington, 1997). With limited forage available, feeding cannot occupy a comparable amount of time as when free ranging. This has a number of implications for the physical and mental health of the horse.

Low-forage diets have been associated with the development of gastric ulcers (Andrews and Nadeau, 1999), which is especially prevalent among racehorses (Vatistas et al., 1999), a group of horses commonly fed low-forage diets (Pagan, 1997). Consumption of other sources of roughage, e.g. wheat straw, has been implicated in the development of impaction colic by

owners and some veterinary practitioners in the UK (Higgins and Wright, 1998). Horses are often observed to consume straw bedding when kept in limited-forage environments. In their review of dietary and management factors associated with colic in horses Cohen et al. (1999) included feeding low quality hay characterised as high fibre and low protein. This places increased demand on the large intestine to digest nutrients while accommodating the indigestible fibre fraction. Though they do not mention straw specifically the same rationale could be applied to wheat straw. Cohen et al. (1999) also considered high quality hay as more digestible and less likely to contribute to impaction colic.

Further circumstantial evidence for the involvement of straw bedding in impaction colic could be the associated increased risk of impaction colic with increased stabling time reported by Hillyer et al. (2002). An association between colic, housing and forage quality has also been reported by Goncalves et al. (2002). In a trial assessing comparative digestibility of oat straw and alfalfa mixes presented to Thoroughbreds, ponies and donkeys Cuddeford et al. (1995) reported that all animals digested high fibre diets less well than low fibre diets. Hudson et al. (2001) have reported that the risk of impaction colic is highest in Thoroughbred horses.

Low-forage diets have also been associated with a greater incidence of stereotypical behaviours (McGreevy et al., 1995). These physical and mental health consequences associated with forage provision are a matter for concern because they have serious implications for the horse's welfare, can detrimentally affect performance and can have considerable financial consequences.

Providing horses free access to pasture and allowing them to perform associated behaviour (Davidson, 2002) is not possible for many owners. An alternative solution is enrichment of the environment, which aims to enhance the restricted conditions many captive and domestic animals are housed in (Newberry, 1995). Environmental enrichment can take various forms but should aim to facilitate performance of adaptive behaviour (Appleby, 1997). Foraging enrichment shows great potential for the stabled horse, aiming to promote more natural feeding behaviour.

When providing stabled horses with multiple forages in short term trials, Goodwin et al. (2002) reported foraging behaviour closer to that seen among free ranging horses. The present study aimed to determine whether these effects persist when horses are managed under enriched conditions for longer periods of time and to establish whether it is practical to manage horses in this manner.

2. Materials and methods

2.1. Horses

Nine horses (Table 1) maintained at an equine college yard participated in the trial in July 2002. The horses were kept at grass at night, in single sex groups, and then individually stabled during the day (0730–1630 approximately) on straw beds in rubber-matted Monarch stables in a large barn. To ensure the horses received a standard amount of human-directed daily exercise, they were exercised at walk each morning for 20 min on a horsewalker, in two groups, immediately after being brought in.

Table 1
Height, weight, sex, age and breed of study horses

Horse no	Height (HH)	Weight (kg)	Sex	Age (years)	Breed
1	15.1	639	Mare	20	Cob
2	18.0	814	Gelding	15	Shire X TB
3	15.0	588	Mare	10	Connemara X
4	15.1	577	Mare	16	Welsh cob X TB
5	16.1	545	Gelding	6	TB
6	16.1	675	Mare	14	TB X
7	15.1	596	Gelding	5	Cob
8	15.2	562	Gelding	5	Welsh cob X TB
9	17.0	663	Gelding	14	WB

TB: thoroughbred; HH: hands high.

2.2. Trial design

The horses, acting as their own controls, participated in an 18-day, cross-over, Latin Square designed trial, in which they received two dietary treatments. The horses were matched into pairs by height, weight, sex and breed, then randomly allocated to one of the two treatment groups. One treatment group commenced with the Single Forage (SF) diet and the other with the Multiple Forage (MF) diet. Treatments ran in parallel to control for environmental effects. Following a 2-day acclimatisation to the first treatments, the horses were observed on alternate days, during the morning and afternoon of each, for 7 days. The horses then crossed over onto their second treatments and, following a second 2-day acclimatisation, were observed for a further 7 days.

As the pairs were presented with their forages one at a time, taking approximately 2–3 min per pair, the conditions in which each pair was handled were not standardised, e.g. the first pair's observations commenced while activity with the other four pairs continued outside, while as soon as the last pair commenced their observation session, all horses were immediately left undisturbed. To minimise such order effects, the order in which the pairs received forages was randomised using 5×5 Latin Squares so that it altered on a daily basis. The order in which horses within each pair received their treatments was also randomised, as were the positions of the nets and buckets on the MF treatment (3×3 Latin Squares).

Camcorders mounted at the rear of each stable videotaped the horses' behaviour for up to 50 min following forage presentation in each observation session. In morning sessions, forages were presented as close to 0930 as possible, the presentation taking 10–20 min, then the horses were left undisturbed until the afternoon. In the afternoon session, fresh forages were presented as close to 1530 as possible, after which the horses were left undisturbed for at least 30 min, then turned out for the night.

2.3. Forage presentation

The SF treatment consisted of 6.0 kg hay per feed, which was soaked for 5–10 min according to the recommendation of Warr and Petch (1992) to minimize nutrient loss and respiratory challenge. It was presented in a single haynet tied at the front of each stable.

Table 2
Multiple forage treatment, forage chop length coded as short (SC) or long (LC)

Forage	Description	Chop length	Presentation
F1	Yard's own soaked hay (HAY)	LC	Net
F2	Ryegrass haylage (RGH)	LC	Net
F7	Ryegrass and timothy haylage (RTH)	LC	Net
F8	Molassed, chopped, dried alfalfa (MCA)	SC	Bucket
F9	Molassed, chopped, dried grass (MCG)	SC	Bucket
F10	Chopped, dried grass (CDG)	SC	Bucket

Approximately 1 kg of each forage was provided. The short chop forages were measured by volume rather than weight and as a consequence, 0.5 kg of F10 was provided because it was approximately equal in volume to 1 kg each of F8 and F9.

The MF treatment comprised three long-chop and three short-chop commercially available forages, weighing 5.5 kg per feed in total (Table 2). The long-chop forages were presented in nets tied at the front of each stable; the short-chop forages were presented in buckets placed in tyres beneath them. Sufficient forage was provided in both treatments to enable horses to forage continuously throughout the two observation periods per session, however, some preferred forages may have been entirely consumed towards the end of each observation period.

Forages were presented in a standard manner in each session and handled by the same person throughout the trial. The procedure was as follows:

(1) First pair of horses removed from stables and tied up.
(2) Relevant forages put into the two stables and, on observation days, camcorders started.
(3) First pair of horses returned to stables as quickly and quietly as possible.
(4) Steps 1–3 repeated for remaining four pairs.
(5) Horses left undisturbed for at least 30 min after the last horse returned to its stable.
(6) On observation days, camcorders then switched off and, according to the time of day, headcollars removed or horses turned out.

2.4. Behavioural observations

Observations from videotape were made using The Observer 3.0®. The horses were observed in morning and afternoon sessions to account for diurnal variations in behaviour. Two 5-min observation periods per session were selected: the first (EARLY) began as the door to each horse's stable was closed; the second (LATE) began 15 min after completion of the EARLY observation period. Given the differing external conditions identified above, these two periods allowed for observation of each horse: (a) when first presented with the full range of forages, but when external yard conditions varied as some horses were being moved when others' EARLY sessions were beginning; (b) when external yard conditions were standard, but the range of forages remaining may have varied.

Data was recorded from videotape according to an ethogram of 14 mutually exclusive behaviours developed from that used by Goodwin et al. (2002) (Table 3). Continuous focal sampling was used to record all behaviours for each horse in order to measure their

Table 3
Ethogram of behaviours studied

Behaviour	Coded	Description
Forage on F1	F1	Sniff, manipulate, bite, chew or ingest hay
Forage on F2	F2	Sniff, manipulate, bite, chew or ingest F2
Forage on F7	F7	Sniff, manipulate, bite, chew or ingest F7
Forage on F8	F8	Sniff, manipulate, bite, chew or ingest F8
Forage on F9	F9	Sniff, manipulate, bite, chew or ingest F9
Forage on F10	F10	Sniff, manipulate, bite, chew or ingest F10
General forage	GENFG	Sniff, manipulate, bite, chew or ingest a forage which cannot be identified
Forage on straw	STRW	Sniff, manipulate, bite, chew or ingest straw
Stand	STND	Horse standing still
Look out	LOOK	Horse standing with head over door, looking out
Move	MOVE	Horse moves around box
Other	OTHR	Horse performing any other behaviour, e.g. drinking, scratching, urinating, defaecating, pawing or weaving
Out of view	OUTV	Horse out of view

F1 = HAY, F2 = RGH, F7 = RTH, F8 = MCA, F9 = MCG, F10 = CDG.

frequencies, durations and latencies. The occurrence of weaving and pawing behaviour was included in the ethogram and coded as OTHR behaviour.

2.5. *Foraging behaviour*

To facilitate comparison of foraging behaviour between treatments, behaviour was grouped into three categories:

1. FORAGE consisted of foraging on the individual forages provided – these included the yard's own soaked hay (F1), ryegrass haylage (F2), ryegrass and timothy haylage (F7), mollased chopped alfalfa (F8), mollassed chopped grass (F9), and chopped dried grass (F10) (coded to facilitate comparison with forages used in other foraging behaviour trials, Goodwin et al. (2004) AABS under review) and general foraging when individual forage substrates being foraged could not be identified (coded as GENFG). Foraging on straw (STRW) was not included as it occurred only once among 277[1] observation periods.
2. SEARCH was based on a grouping used by Goodwin et al. (2002) and consisted of behaviours that may be indicative of a motivation to search for alternative resources; these were Move, Look Out and Out of View of Camera, which horsed were if they retreated to the rear metre of the stable: (coded as MOVE, LOOK and OUTV).
3. REMAINING consisted of all behaviour not included in the above categories – Other, Stand and Straw (coded as OTHR, STND and STRW) – and enabled evaluation of the overall spread of behaviours.

[1] Of the 288 planned observations (four per day for each of the nine horses on eight observation days), only 277 could be used due to camcorder problems such as condensation.

3. Results

The data could not be normalised by transformation, so non-parametric analysis was used. There was no significant effect on the horses' behaviour arising from their gender, the order in which they received treatments or the time of day at which observations were made.

3.1. Comparison of behaviour between treatments

Horses on the MF treatment performed foraging behaviour significantly more frequently ($T = 0$, $P < 0.01$, Wilcoxon's test for matched pairs) and for longer periods ($T = 2$, $P < 0.05$, Fig. 1) than horses on the SF treatment. Horses on the SF treatment spent significantly longer periods performing behaviour considered indicative of a search for alternative resources (SEARCH $T = 2$, $P < 0.05$, Fig. 1). Search behaviour was also more frequent on the SF treatment than on the MF treatment, but the difference was not statistically significant.

Fig. 2 demonstrates the relative durations of the three grouped behaviour categories (FORAGE, SEARCH, REMAINING) for the two treatments. Forage behaviour occupied the greatest proportion of time on both treatments, but was of greater duration on the MF treatment. Search duration was greatest on the SF treatment. The duration of Remaining behaviours was approximately equal on the two treatments.

3.2. Forage preferences in MF treatment

To test whether horses stabled in a multiple forage environment express preferences for certain forages, the Friedman test (SPSS, 2001) was used to determine whether there was a significant difference between the frequencies and durations of foraging on the six multiple forages.

There were significant differences in the frequency ($P < 0.001$, $\chi^2 = 37.435$, $\nu = 5$, Friedman test) and the duration ($P < 0.001$, $\chi^2 = 31.174$, $\nu = 5$, Fig. 3) of foraging on the

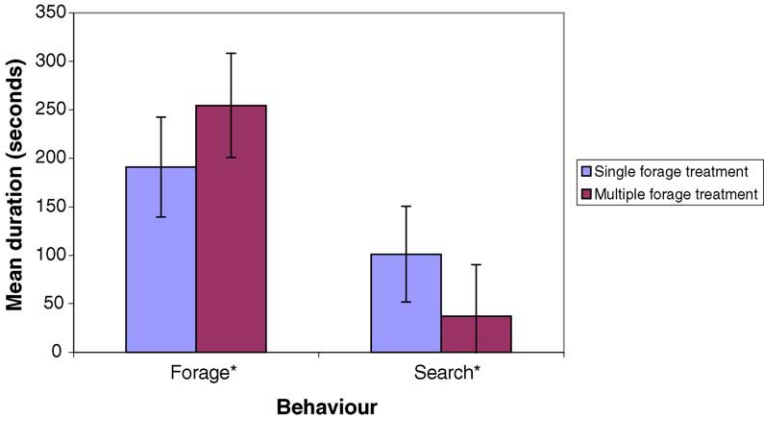

Fig. 1. Mean duration (s) of FORAGE and SEARCH behaviour during single and multiple forage treatments (±1 S.E.). Significant differences indicated by $^{*}P < 0.05$.

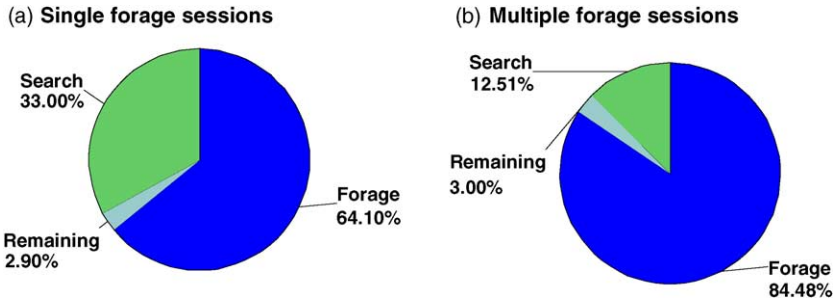

Fig. 2. Percentage duration of FORAGE, SEARCH and REMAINING behaviours in (a) single forage and (b) multiple forage sessions Of the composite SEARCH behaviour, OUTV accounted for 0.2% total duration on the SF treatment and 0.1% total duration on the MF treatment.

six individual forages available during the MF treatment. Ranking of the data (Table 4) indicates that F8 was the preferred forage, F7 and F1 were the least-preferred forages, and that short-chop forages were preferred to long-chop. Despite demonstrating preferences for particular forages, the horses sampled all the forages available.

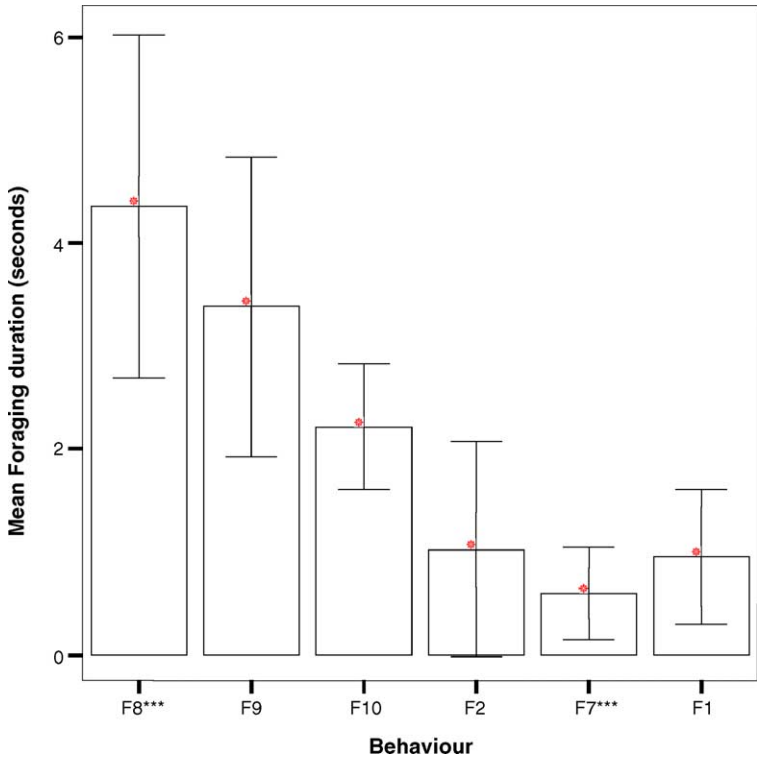

Fig. 3. Mean foraging duration in seconds on individual forages during multiple forage sessions (±1 S.D.). *** Indicates pair between which there was a significant difference ($P < 0.001$). F1 = HAY, F2 = RGH, F7 = RTH, F8 = MCA, F9 = MCG, F10 = CDG.

Table 4
Frequency and duration (mean ± 1 S.D.) of the six foraging behaviours performed on the Multiple forage treatment, showing relative rankings

Behaviour	Mean frequency (±1 S.D.) (oop^{-1})	Relative rank of frequency	Mean duration (±1 S.D.) (s)	Relative rank of duration[a]
F8	4.4 ± 1.7***	1	110.158 ± 38.274***	1 (46%)
F9	3.4 ± 1.5	2	63.865 ± 42.453	2 (26%)
F10	2.2 ± 0.6	3	35.992 ± 32.931	3 (15%)
F2	1.0 ± 1.0	4	15.906 ± 19.354	4 (7%)
F7	0.6 ± 0.5***	6	7.943 ± 12.938	5 (3%)
F1	0.9 ± 0.7	5	7.940 ± 9.683***	6 (3%)

F1 = HAY, F2 = RGH, F7 = RTH, F8 = MCA, F9 = MCG, F10 = CDG; S.D.: standard deviation.
[a] Percentage total duration of the six foraging behaviours shown in parenthesis.
*** Pair between which there is a significant difference ($P < 0.001$).

3.3. Comparison of behaviour between observation periods

During EARLY (full range of forages available but external conditions varying), horses were observed to forage more frequently and for longer (both not significantly so) than during LATE (Fig. 4). On the MF treatment the frequency ($T = 0$, $P < 0.01$, Wilcoxon's test for matched pairs) and duration ($T = 1$, $P < 0.05$, Fig. 5) of foraging on F8 was greater during EARLY, whereas the frequency and duration of foraging on the other five forages available (F9, F10, F2, F7, F1) were greater during LATE (significant for the frequency of foraging on F2, F7 and F1, and duration of foraging on F2, F7, F1 and F10, Fig. 5). This suggests F8 was the preferred MF treatment forage and that short-chop forages were generally consumed prior to long-chop forages. On the SF treatment, the frequency ($T = 2$, $P < 0.05$) and duration (not significantly so) of F1 were greater during EARLY.

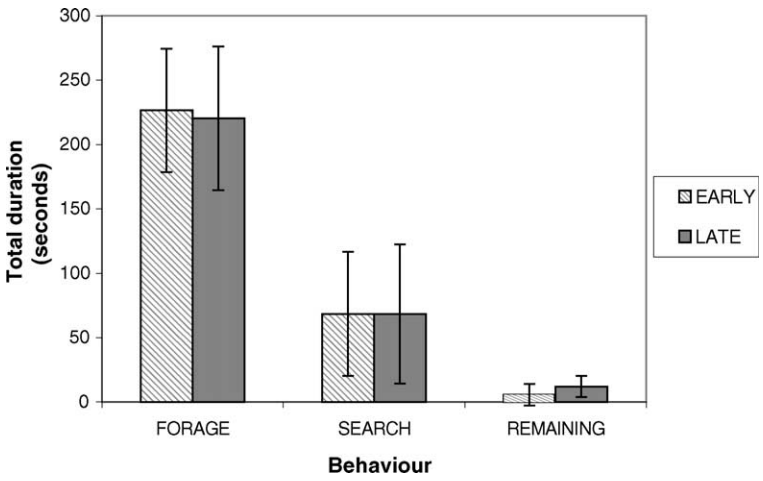

Fig. 4. Mean duration (s) of composite behaviours during EARLY and LATE observation periods. Error bars show mean ± 1 S.D.

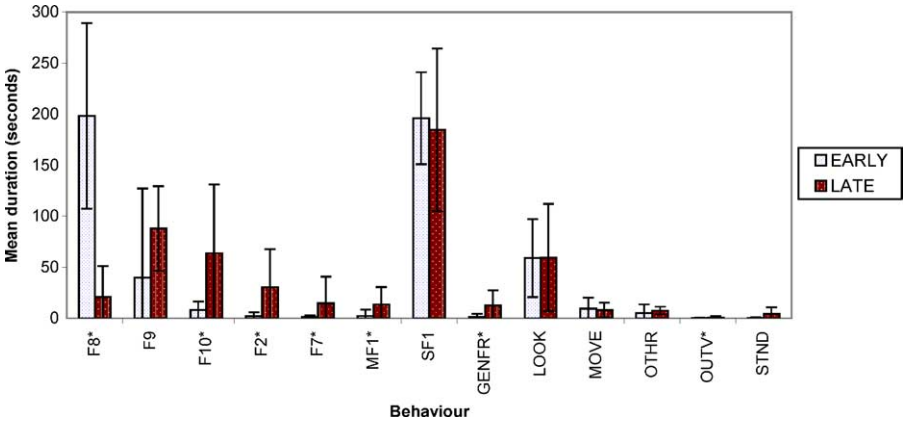

Fig. 5. Total duration (mean) (s) of behaviours during EARLY and LATE observation periods. Significant differences indicated by $^{*}P < 0.05$. Error bars show mean ± 1 S.D. F1 = HAY, F2 = RGH, F7 = RTH, F8 = MCA, F9 = MCG, F10 = CDG.

3.4. Stereotypic and redirected behaviour

Stereotypic weaving behaviour only occurred on the SF treatment and redirected pawing behaviour was only observed on the MF treatment.

4. Discussion

4.1. Comparison of behaviour between treatments

Forage behaviour was recorded more frequently ($P < 0.01$) and for longer ($P < 0.05$, Fig. 1) on the MF treatment than on the SF treatment. This suggests that the MF treatment facilitates highly motivated foraging behaviour by providing multiple, palatable, varied forages. FORAGE duration was greater than SEARCH duration on both treatments (Figs. 1 and 2), which indicates that horses devote most of their time to foraging behaviour, irrespective of the forages available. This makes biological sense as free ranging and pastured horses may spend up to 18 h/day grazing (Harris, 1999a). A forage-fed stabled horse, even allowing for the ready availability and higher nutrient content of feeds, is adapted to devote the majority of its time to obtaining an adequate diet. This corresponds with herbivore patch foraging strategies which evolved to enable selection of a better than average diet from a variable resource (Prache et al., 1998). Kiley-Worthington (1997) demonstrated that given an ad libitum forage diet, stabled horses, though spending less time eating than feral Camargue horses, will still spend approximately 50% of their time eating.

The lower frequency and duration of FORAGE behaviour on the SF treatment (Figs. 1 and 2) cannot have been due to physical limitation in the amount of forage available because a greater weight of forage was presented on the SF treatment (6.0 kg per feed compared to 5.5 kg per feed on the MF treatment). Instead, the horses may have been

experiencing monotony towards the SF diet (Goodwin et al., 2002). In addition, sensory-specific satiety, in which the horse becomes satiated by one food type but still motivated to consume others (Rolls, 1986), may have left the horses satiated by hay on the SF treatment but still motivated to consume other forages. As alternative forages were not available, this motivation may have led the horses to SEARCH for alternative resources, which could explain the longer duration ($P < 0.05$) and higher frequency (not significant) of SEARCH behaviour on the SF treatment.

The less frequent and shorter performance of Forage behaviour on the SF treatment does not necessarily imply a low/lower motivation to Forage, as preventing behaviour does not mean the motivation behind it is also 'switched off'. If Foraging behaviour is stimulated (e.g. by hunger) but is prevented (because a satisfactory forage is not available), the motivation to Forage will continue to increase and the horse may reach a point where it begins to act on the motivation and a redirected form of behaviour may occur (Cooper and Mason, 1998). The redirected behaviour may be 'normal', e.g. the horse may be driven to perform more SEARCH behaviour, or may be considered 'abnormal', e.g. weaving (Cooper and Mason, 1998). The apparently higher motivation to SEARCH on the SF treatment may therefore be due to a desire to find resources to satisfy the motivation to FORAGE. The results suggest that horses are more motivated to SEARCH when resources are limited in variety.

Differences in the duration of REMAINING (non-FORAGE, non-SEARCH) behaviours were virtually negligible between the two treatments (2.9% total duration on SF treatment; 3.0% on MF treatment) (Fig. 2). This indicates that an increase in Forage behaviour (64.1% total duration on SF treatment; 84.5% on MF treatment) does not affect the performance of Remaining behaviours, most of which were maintenance behaviours (Fraser, 1992). Increase in FORAGE is, however, associated with a decrease in SEARCH behaviour (33.0% total duration on SF treatment; 12.5% total duration on MF treatment).

4.2. Comparison of behaviours between observation periods

As expected, the horses' behaviour varied between the EARLY and LATE observation periods because the external conditions varied greatly between them. Other factors may also have been influential, such as sequential forage selection, forage preferences and an overall 'settling' effect.

The durations of FORAGE and SEARCH (Fig. 4) were greater in EARLY than LATE, though not significantly so, whilst REMAINING was highest during LATE. These results suggest that activity was greatest during EARLY and that the horses may have settled with time. Activity outside the boxes was greatest during EARLY, possibly distracting the horses, but quieter conditions during LATE may have allowed the horses to express more 'settled' behaviour, i.e. that unaffected by external influences. In this case, LATE could be considered more representative of 'settled' behaviour, but it must be remembered that the range of forages available to each horse was not standard throughout LATE.

4.3. Forage preferences on MF treatment

The results show that horses express preferences for certain forages (Table 4). F8 appeared most preferred, F7 least preferred (very close with F1 and F2) and, overall,

short-chop forages appeared to be preferred to long-chop forages. Fig. 5 also shows that behaviour changes over short time periods. Further insight was provided by comparison of mean forage durations and also non-foraging behaviour during EARLY and LATE observation periods.

These results suggest that the horses became more likely to forage on a variety of forages over time, having focused initially, though not exclusively, on a preferred forage during EARLY. If, as suggested above, LATE was more representative of 'settled' behaviour than EARLY, then it can be concluded that, given the opportunity, horses will sample a variety of forages.

The horses' preferences could have been influenced by a number of factors. The apparent preference for molassed F8 and F9 over the unmolassed forages could be explained by the fact that horses are attracted by sweet tastes and deterred by sour (Randall et al., 1978). The preference for short-chop forages over long-chop forages may have been further influenced by the fact that pulling forages from a net may require more effort than eating from a bucket; the ground simulates a grazing position (Sweeting et al., 1985); and horses may associate buckets with highly palatable, easily consumed feed. LaCasha et al. (1999) demonstrated that forage selection by young horses is influenced by previous forage experience.

As hay formed part of the horses' normal diet, it was predicted that they might experience long term monotony towards it (Goodwin et al., 2002). Hay (F1) had the joint shortest forage duration (Table 4), and second lowest forage frequency of the six MF treatment forages. However, foraging duration on hay may have been associated with lower long-chop forage consumption overall. Sensory specific satiety towards hay may also have influenced preferences (Rolls, 1986). Goodwin et al. (2002) investigated forage preferences between trials and postulated that they resulted from short-term monotony to particular forages, or sensory-specific satiety, in which the horse becomes satiated towards one forage but still motivated to consume others. It is possible that the horses were more easily satiated by the long-chops, which take longer to consume and appear to be less palatable than the short-chops.

Unlike Goodwin et al. (2002), it was not possible to fully investigate sequential selection, but from general observation it was clear that each horse tended to follow the same selection sequence during each observation period. Apart from one individual (Horse 1), all horses consumed preferred and less-preferred forages, which was anticipated from the work of Archer (1973) who demonstrated that horses prefer variety in grazing. Goodwin et al. (2002) observed the same effect and suggested that sensory-specific satiety, driving sequential selection, is an adaptive patch foraging strategy that motivates the horse to select from all forage resources available to obtain a better-than-average diet.

4.4. Comparison with results of short-term investigation

This study found that the short-term results obtained by Goodwin et al. (2002) generally do persist when horses are managed under forage-enriched conditions in week-long trials. Goodwin et al. (2002) also found very similar forage preferences, but straw consumption varied greatly between the two studies, occurring infrequently during Observation Periods in this study, although horses were occasionally seen to eat their bedding at other times.

The difference in straw consumption may be due to the fact that horses in this study spent approximately 12 h in their fields overnight, so may have been less motivated to consume wheat straw, whereas horses in the short-term study only had access to fields for 4 h in the morning and all but one were bedded on straw.

4.5. Practicality of methodology for maintaining horses under forage-enriched conditions

The methodology worked well and could easily be adopted by horse owners, being simple, relatively cheap and requiring no specialist equipment. However, preparing large numbers of nets and buckets was time-consuming and spilt short-chop forages often made the stables very messy, so it may require modification for those with limited time or managing large numbers of horses. Modifications could include feeding forages from wall-mounted racks or mangers to make the method less time and labour consuming, or presenting fewer than six forages.

4.6. Effects of forage enrichment

The results suggest that stabled horses' environments can be enriched by providing a MF diet, which encourages the performance of foraging behaviour and reduces the performance of behaviour indicative of a search for alternative resources. There are other potential benefits, e.g. feeding practices that increase eating time may help prevent ulceration, which has been associated with fasting and episodic feeding (Murray and Eichorn, 1996; Cuddeford, 1999). Foraging enrichments may also have a role in reducing stereotypy performance. Conclusions about the effect of a MF diet on straw bedding consumption (and therefore its role in preventing impaction colic) could not be drawn due to the low occurrence of straw foraging behaviour in the study, however, this remains worthy of further investigation.

It was not possible to statistically investigate the effect of MF provision on stereotypy performance within this study as only two horses exhibited weaving and only four horses were observed pawing. However, as weaving did not occur in MF treatment this agrees with the findings of Goodwin et al. (2002). This could be because the MF treatment reduced the horses' motivation to search for alternative resources. This may have indirectly reduced the motivation to weave, which is thought to reflect a frustrated motivation to move (Mills and Nankervis, 1999) and could indicate a desire to search elsewhere for resources. This suggests that an MF diet could have a role in reducing weaving performance, but further study would be required to confirm this.

The fact that pawing occurred only on the MF treatment is different to Goodwin et al. (2002). In the current trial horses only pawed when foraging on molassed short-chops from buckets, never when foraging long-chops from head-height nets. This may indicate that the provision of a palatable range of forages can be a source of frustration for some horses (Houpt, 1998). It may represent conflict between the drive to consume a highly palatable feed and fear of loosing visual contact with the environment (Sweeting et al., 1985). This result indicates that the provision of highly palatable short-chop forages may be over-stimulating for some horses (Appleby, 1997).

5. Conclusions

The results show that horses on the MF diet perform foraging behaviour more frequently ($P < 0.01$) and for longer periods ($P < 0.05$) than horses on a SF diet. Stereotypic weaving behaviour only occurred on the SF treatment. In addition, the results show that horses on an MF diet express significant preferences for certain forages, with short-chop forages preferred to long-chop, but still sample all forages available, indicating a preference for variety in the diet. The results also demonstrate that, in general, the behavioural effects of short-term MF provision do persist when horses are managed on an MF diet for 1 week, though further study is required over longer periods.

An MF diet appears to offer a means of enriching the environment of stabled horses, offering them a diet closer to that to which they are adapted and encouraging the performance of more natural feeding behaviour. It has potential for improving the welfare of the stabled horse through a variety of mechanisms requiring further investigation. Foraging enrichment may contribute to the prevention of gastric ulceration and reduction of stereotypical behaviour. It may also provide secondary benefits to the owner, e.g. reduced veterinary costs. The methodology utilised in this study was practical and successful, representing a feeding practice that could be cheaply and simply adopted by any horse owner, and is flexible enough to be further modified to make it more time and labour-efficient.

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References

Andrews, F.M., Nadeau, J.A., 1999. Clinical syndromes of gastric ulceration in foals and mature horses. Eq. Vet. J. Suppl. 29, 30–33.

Appleby, M.C., 1997. Life in a variable world: Behaviour, welfare and environmental design. Appl. Anim. Behav. Sci. 54 (1), 1–19.

Archer, M., 1973. The species preferences of grazing horses. J. Brit. Grassl. Manage. 28, 123–128.

Carson, K., Wood-Gush, D.G.M., 1983. Equine behaviour. II. A review of the literature on feeding, eliminative and resting behaviour. Appl. Anim. Ethol. 10, 179–190.

Cohen, N.D., Gibbs, P.G., Woods, A.M., 1999. Dietary and other management factors associated with colic in horses. J. Am. Vet. Med. Assoc. 215 (1), 53–60.

Cooper, J.J., Mason, G.J., 1998. The identification of abnormal behaviour and behavioural problems in stabled horses and their relationship to horse welfare: a comparative review. Eq. Vet. J. Suppl. Suppl. 27, 5–9.

Cuddeford, D., 1999. Why feed fibre to the performance horse today? In: Harris, P.A., Gomarsall, G.M., Davidson, H.P.B., Green, R.E. (Eds.), Proceedings of the BEVA Specialist Days on Behaviour and Nutrition. Newmarket, Eq. Vet. J. 50–54.

Cuddeford, D., Pearson, R.A., Archibald, R.F., Muirhead, R.K., 1995. Digestibility and gastrointestinal transit-time of diets containing different proportions of alfalfa and oat straw given to thoroughbreds, shetland ponies, highland ponies and donkeys. Anim. Sci. 61, 407–417.

Davidson, H.P.B., 1999. Natural horse – unnatural behaviour: why understanding natural horse behaviour is important. In: Harris, P.A., Gomarsall, G.M., Davidson, H.P.B., Green, R.E. (Eds.), Proceedings of the BEVA Specialist Days on Behaviour and Nutrition. Newmarket, Eq. Vet. J. 7–10.

Davidson, H.P.B., 2002. The impact of nutrition and feeding practices on equine behaviour and welfare, in The Dorothy Russell Havermeyer Foundation Workshop on Horse Behavior and Welfare, 13–16 June 2002 [www document]. http://www2.vet.upenn.edu/labs/equinebehavior/hvnwkshp/hv02/davidson.htm (accessed 8 November 2002).

Fraser, A.F., 1974. Farm Animal Behaviour. Ballière Tindall, London, p. 8.

Fraser, A.F., 1992. The Behaviour of the Horse. CABI Publishing, Wallingford, Oxon, p. 59.

Goncalves, S., Julliand, V., Leblond, A., 2002. Risk factors associated with colic in horses. Vet. Res. 33 (6), 641–652.

Goodwin, D., 1999. The importance of ethology in understanding the behaviour of the horse. Eq. Vet. J. Suppl. 28, 15–19.

Goodwin, D., Davidson, H.P.B., Harris, P., 2002. Foraging enrichment for stabled horses: effects on behaviour and selection. Eq. Vet. J. 34 (7), 686–691.

Harris, P.A., 1999a. How understanding the digestive process can help minimise digestive disturbances due to diet and feeding practices, In: Harris, P.A., Gomarsall, G.M., Davidson, H.P.B., Green, R.E. (Eds.), Proceedings of the BEVA Specialist Days on Behaviour and Nutrition. Newmarket, Eq. Vet. J. 45–49.

Harris, P.A., 1999b. Review of equine feeding and stable management practices in the UK concentrating on the last decade of the 20th century. Eq. Vet. J. Suppl. 28, 46–54.

Higgins, A.J., Wright, I.M., 1998. The Equine Manual. Saunders, London, pp. 466, 470, 483.

Hillyer, M.H., Taylor, F.G.R., Proudman, C.J., Edwards, G.B., Smith, J.E., French, N.P., 2002. Case control study to identify risk factors for simple colonic obstruction and distension colic in horses. Eq. Vet. J. 34 (5), 455–463.

Houpt, K.A., 1998. Domestic Animal Behaviour for Veterinarians and Animal Scientists, 3rd ed. Manson Publishing, London, p. 355.

Hudson, J.M., Cohen, N.D., Gibbs, P.G., Thompson, J.A., 2001. Feeding practices associated with colic in horses. J. Am. Vet. Med. Assoc. 219 (10), 1419–1425.

Kiley-Worthington, M., 1997. Equine Welfare. J.A. Allen, London, p. 48.

LaCasha, P.A., Brady, H.A., Allen, V.G., Richardson, C.R., Pond, K.R., 1999. Voluntary intake, digestibility, and subsequent selection of Matua Bromegrass, Coastal Bermudagrass, and Alfalfa hays by yearling horses. J. Anim. Sci. 77, 2766–2773.

McGreevy, P.D., Cripps, P.J., French, N.P., Green, L.E., Nicol, C.J., 1995. Management factors associated with stereotypic and redirected behaviour in the Thoroughbred horse. J. Eq. Vet. J. 27 (2), 86–91.

Mills, D., Nankervis, K., 1999. Equine Behaviour: Principles and Practice. Blackwell Science, Oxford, p. 215.

Murray, M.J., Eichorn, E.S., 1996. Effects of intermittent feed deprivation, intermittent feed deprivation with ranitidine administration, and stall confinement with ad libitum access to hay on gastric ulceration in horses. Am. J. Vet. Res. 57 (11), 1599–1603.

Newberry, R.C., 1995. Environmental enrichment: increasing the biological relevance of captive environments. Appl. Anim. Behav. Sci. 44, 229–243.

Pagan, J.D., 1997. Gastric ulcers in horses: a widespread but manageable disease. World Eq. Vet. Rev. 2 (4), 28–30.

Randall, R.P., Schurg, W.A., Church, D.C., 1978. Response of horses to sweet, salty, sour and bitter solutions. J. Anim. Sci. 47 (1), 51–55.

Rolls, B.J., 1986. Sensory-specific satiety. Nutr. Rev. 44, 93–101.

Prache, S., Gorson, I.J., Rook, A.J., 1998. Foraging behaviour and diet selection in domestic herbivores. Ann. Zootech. 47 (5–6), 335–345.

Sweeting, M.P., Houpt, C.E., Houpt, K.A., 1985. Social facilitation of feeding and time budgets in stabled ponies. J. Anim. Sci. 60 (2), 369–374.

Vatistas, N.J., Snyder, J.R., Carlson, G., Johnson, B., Arthur, R.M., Thurmond, M., Zhou, H., 1999. Cross-sectional study of gastric ulcers of the squamous mucosa in Thoroughbred racehorses. Eq. Vet. J. Suppl. 29, 34–39.

Waring, G.H., 1983. Horse Behavior: The behavioral traits and adaptations of domestic and wild horses, including ponies. Noyes Publications, Park Ridge, New Jersey, p. 79.

Warr, E.M., Petch, J.L., 1992. Effects of soaking hay on its nutritional quality. Eq. Vet. J. 5 (3), 169–171.