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Foraging enrichment for stabled horses: effects on behaviour and selection

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Summary

The restricted access to pasture experienced by many competition horses has been linked to the exhibition of stereotypic and redirected behaviour patterns. It has been suggested that racehorses provided with more than one source of forage are less likely to perform these patterns; however, the reasons for this are currently unclear. To investigate this in 4 replicated trials, up to 12 horses were introduced into each of 2 identical stables containing a single forage, or 6 forages for 5 min. To detect novelty effects, in the first and third trials the single forage was hay. In the second and fourth, it was the preferred forage from the preceding trial. Trials were videotaped and 12 mutually exclusive behaviour patterns compared. When hay was presented as the single forage (*Trials 1* and *3*), all recorded behaviour patterns were significantly different between stables; e.g. during *Trial 3* in the 'Single' stable, horses looked over the stable door more frequently ($P<0.001$), moved for longer ($P<0.001$), foraged on straw bedding longer ($P<0.001$), and exhibited behaviour indicative of motivation to search for alternative resources ($P<0.001$) more frequently. When a previously preferred forage was presented as the single forage (*Trials 2* and *4*) behaviour was also significantly different between stables, e.g in *Trial 4* horses looked out over the stable door more frequently ($P<0.005$) and foraged for longer in their straw bedding ($P<0.005$).

Further study is required to determine whether these effects persist over longer periods. However, these trials indicate that enrichment of the stable environment through provision of multiple forages may have welfare benefits for horses, in reducing straw consumption and facilitating the expression of highly motivated foraging behaviour.

Introduction

Many stabled horses are maintained in conditions very different from those in which they evolved (MacFadden 1994). The diet of feral horses includes many grasses and browse species (Hansen 1976; Putman *et al.* 1987); however, most stabled horses are provided with a single forage and maintained on a relatively indigestible straw bed, ingestion of which is associated with impaction colic (Greet and Rossdale 1987).

The restricted access to pasture experienced by many competition horses has been linked to the exhibition of stereotypic behaviour patterns (McGreevy *et al.* 1995a), with the suggestion that racehorses provided with more than one source of forage are less likely to perform stereotypic behaviour (McGreevy *et al.* 1995b). However, it is unclear whether the number of different forages was important in itself, or whether the additional time spent feeding simply left less time available for stereotypical behaviour.

In this series of 4 trials, the behaviour of stabled horses was compared between a stable where a single forage (Single) was provided *ad libitum* and an otherwise identical stable with 6 types of forage (Multiple) available *ad libitum*.

Materials and methods

Up to 12 horses, maintained at a competition yard, took part in these trials (Table 1). The horses were all stabled, fed hay and a variety of concentrates to their specific energy requirements, and had access to mixed species grass paddocks for 4 h/day. All trial sessions took place between 1300 and 1530 h when the horses were normally stabled, in an attempt to approximate standard hunger levels, as direct intervention in their routine management was not possible. Total observed time was 675 min.

TABLE 1: Age, breed and sex of trial horses plus trials participated in

Horse	Age (years)	Sex	Breed	Trials
GII	7	Gelding	ID x TB	1
GIII	16	Gelding	TB	1, 2
G1	26	Gelding	PB Arab	3, 4
G2	11	Gelding	Arab x TB x Trakhener	1, 2, 3, 4
M1	1	Mare	ID x Shire x Connemara	1, 2, 3, 4
M2	24	Mare	Welsh x Hackney	3, 4
G3	18	Gelding	TB	1, 2, 3, 4
G4	11	Gelding	TB x Warmblood	1, 2, 3, 4
G5	11	Gelding	ID x TB	1, 2, 3, 4
G6	12	Gelding	ID x TB	1, 2, 3, 4
M3	4	Mare	ID x TB	1, 2, 3, 4
G7	5	Gelding	TB	1, 2, 3, 4
M4	11	Mare	PB New Forest	3, 4
G8	11	Gelding	ID x TB	1, 2, 3, 4

ID = Irish Draught; TB = Thoroughbred; PB = Part-bred.

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Two identical stables (3.65 x 3.65 m) were used throughout the study. Each stable contained 2 water buckets and a wheat straw bed covering the rear 3/4 of the floor. The bedding was cleared of droppings at the start of every trial period but could not be totally replaced. The front 1/4 of the stable floor was bare concrete and all forages were presented at this end.

At the start of each trial session, a horse was introduced into one stable and the door closed. Its behaviour was then recorded using a wall-mounted videocamera for a total of 5 min. The camera view covered the front 3/4 of the stable, but if the horse moved to the back of the stable it was out of range of the camera. Horses wore headcollars for the duration of all trial sessions. The horse was then removed and introduced into the second stable for a further 5 min period. Fifty percent of the horses were introduced initially into the Single stable and 50% into the Multiple stable. In the second replicate, the stable in which horses commenced the trial was alternated to allow for order effects. The order in which horses were tested within the replicates was determined by their owners' variable schedules and was, therefore, effectively randomised.

Trial 1

In the Single stable, 2 slices of the yard's own hay (approximately 4 kg) were hung in a haynet on the front wall. In the Multiple stable, 3 forages were presented in haynets hanging from the front wall: hazel (HZ: three 1 m lengths of leafy hazel twigs, cut from the paddock hedges, hung as a bunch); hay in a haynet (HY: 1 slice of the yard's own hay, approximately 2 kg); and a ryegrass haylage in a haylage net (1 slice of HG[1], approximately 2 kg). On the floor at the front of this stable, 3 buckets were presented which contained 1.5 kg fibre cubes (FC)[2], a large swede (SW: approximately 1 kg) and approximately 1 kg whole carrots (CA), respectively. These quantities were sufficient to ensure that some forage remained at the end of each trial period even if the horse chose to eat only one type, including the HY only ration. With the exception of hazel, these forages have all been used currently or historically (Evans 1960) as the bulk forage source for horses. Hazel has palatable leaves eaten by browsing New Forest ponies (Gill 1988) and was available daily to the horses in their paddocks. Eleven horses (See Table 1) were tested on 4 days between 17/8/99 and 1/9/99.

Trial 2

This trial presented the same forages as *Trial 1* in the Multiple stable, but the single forage presented was each individual's previously preferred forage, as determined by total foraging duration during the *Trial 1* Multiple sessions. Eight individuals preferred FC and 2 horses (G4 and G7) preferred CA in *Trial 1*. The same horses took part in this trial, but one (GII) was moved to another yard at the end of the first replicate and the total number of horses completing the trial was, therefore, reduced to 10.

In order to allow for effects of sensory-specific satiety (Rolls 1986), when a horse may become satiated with respect to one food type while remaining motivated to forage on others, in *Trial 2* the Multiple and Single sessions were divided into four 2.5 min sessions. Therefore, at the start of each trial session a horse was introduced into one stable and its behaviour recorded for a period of 2.5 min. The horse was then transferred to the second stable for a further recorded 2.5 min period; then returned to the first stable for another recorded 2.5 min, followed by an additional 2.5 min in the second stable. All trial sessions took place on 4 days between 21/9/99 and 6/10/99.

TABLE 2: Ethogram of 12 mutually exclusive behaviour patterns [*Trials 1* and *2*]/(*Trials 3* and *4*)

Behaviour	Description
HY	Sniff, manipulate, bite, chew or ingest HY
HG	Sniff, manipulate, bite, chew or ingest HG
[FC] (HM)	Sniff, manipulate, bite, chew or ingest [FC]/(HM)
[HZ] (RG)	Sniff, manipulate, bite, chew or ingest [HZ]/(RG)
[SW] (MC)	Sniff, manipulate, bite, chew or ingest [SW]/(MC)
[CA] (AA)	Sniff, manipulate, bite, chew or ingest [CA]/(AA)
Stand	Horse stands still
Move	Horse moves around stable
Look Out	Horse stands with head over stable door looking out
Out	Horse moves out of view of camera
Straw	Sniff, manipulate, bite, chew or ingest straw
Other	Infrequent behaviour patterns, e.g. roll, self-groom, elimination

HY = hay; HG = ryegrass halage; FC = fibre cubes; HM = ryegrass and timothy haylage; HZ = hazel; RG = heat-dried grass chaff; SW = swede; MC = molassed oat straw chaff; CA = carrots; AA= molassed alfalfa chaff.

Trial 3

Nine of the horses included in *Trials 1* and *2*, plus 3 others at the same yard (Table 1), took part in this trial. *Trial 3* was a repeat of *Trial 1* but incorporated the modifications of *Trial 2*. Six commercial forages, more similar in physical form than those presented in the preceding trials, were presented. The single forage was again 2 slices (approximately 4 kg) of the yard's own hay hung in a haynet on the front wall. In the Multiple stable, 3 forages were presented hanging from the front wall and 3 short chop forages were presented in 14.5 l buckets on the floor. The forages were HY in a black haynet (1 slice of the yard's own hay, approximately 2 kg); HG in a green haylage net (1 slice of HG[1], approximately 2 kg); a rygegrass and timothy haylage in a yellow haynet (HM[3] approx 2 kg); heat-dried grass chaff (3/4 full black bucket RG[2], approximately 0.25 kg); molassed oat straw chaff (3/4 full yellow bucket MC[4], approximately 0.25 kg); and molassed alfalfa chaff (3/4 full green bucket AA[5], approximately 0.25 kg). These quantities were sufficient to ensure that some of each type of forage remained at the end of each trial period even if the horse chose to eat only one type.

To control for the effects of order and proximity of adjacent forages on selection, the position of the forages was randomised between replicates. To facilitate identification of forages on videotape yellow, green and black haynets and buckets were used as horses are unable to distinguish yellow and green from grey (Macuda and Timney 1999). Grey haynets and buckets were unavailable so black was substituted. All trial sessions took place between 14/12/99 and 23/12/99.

Trial 4

This trial was a repeat of *Trial 2* incorporating the method developments of *Trials 2* and *3*. The forage presented in the Single sessions was that preferred in the Multiple sessions of *Trial 3*. For

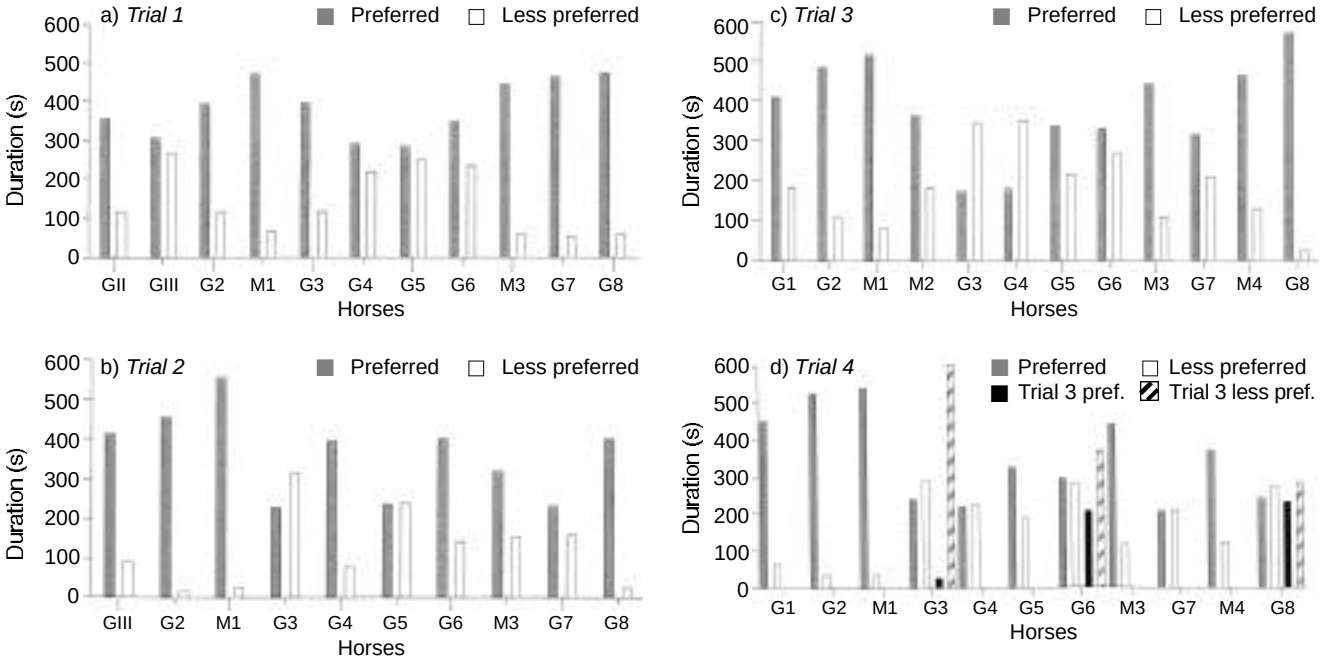

Fig 1: Total duration of foraging on the preferred (grey) and combined less-preferred (white) forages per horse in Multiple sessions. Three horse changed their preferences in Trial 4; previously preferred forage from Trial 3 (black), less preferred forages (hatched). a) Trial 1 = Multiple session (HY presented as single forage); b) Multiple session (FC presented as single forage); c) Multiple session (HY presented as single forage); d) Multiple session (AA presented as single forage).

11 horses this was AAand for 1 gelding (G3) HM; the forages in the Multiple sessions were as in *Trial 3*. The same 12 horses that completed *Trial 3* took part in this trial. All trial sessions took place between 25/1/00 and 3/2/00.

Data collection and analysis

An ethogram of 12 mutually exclusive behaviour patterns was used to record frequency and duration of behaviour for all trials (Table 2). Data were transcribed from videotapes using continuous sampling in the Observer 3[6] package, extracted into spreadsheets Lotus 123v5[7] and analysed in SPSS v8[8]. Initial exploration of the behavioural data revealed that square root transformations normalised the behavioural data, allowing factorial analysis of variance (ANOVA) to test differences between stables.

Results

Trial 1

Mean duration of foraging on each forage during Multiple sessions are shown in Table 3. All forages were accepted; 9 individuals spent most time foraging on FC and 2 (G4 and G7) foraged mostly on CA. HY was the least preferred forage. Horses consumed less-preferred forages along with their preferred forage during Multiple sessions (Fig 1). Differences in horses' behaviour between the 2 stables are shown in Table 4. Horses foraged more frequently ($P<0.0001$) and for longer ($P<0.001$) in the Multiple stable. All other recorded behaviour patterns were significantly higher in the Single stable. In order to determine whether this was simply a result of horses spending more time eating and, therefore, having less time available to exhibit other behaviour, those behaviour patterns which could indicate a motivation to search for alternative resources, i.e. durations of Move, Look and Out (definitions Table 2) were grouped and expressed as a proportion of the noneating time (Search). A nonsignificant trend in this proportional data revealed a tendency to exhibit more searching behaviour in the Single stable.

Trial 2

The mean duration of foraging on each forage type during Multiple sessions (Table 5) were mainly consistent with *Trial 1*, although the relative rankings of SW and HG were reversed. When confined to the Multiple stable, 9 out of 10 horses foraged for longest on the same forage they preferred during *Trial 1*. The exception was G3, who foraged longest on FC in *Trial 1* but, when these were presented as the single forage in *Trial 2*, foraged longest on CA during the Multiple sessions. As in *Trial 1*, horses consumed less-preferred forages in addition to their preferred forage during the Multiple session. There were fewer significant differences in behaviour patterns (Table 5) between the stables than recorded during *Trial 1*, but the direction of the differences agreed with *Trial 1*. Horses foraged more frequently ($P<0.01$) in the Multiple stable and stood for longer ($P<0.05$) and foraged in their straw bedding for longer ($P = 0.059$) in the Single stable.

Trial 3

Although this trial presented forages which were more similar in physical form than in *Trials 1* and *2*, there was again a clear preference for one forage type (AA; Table 6). All forages were accepted and HY was again the least preferred forage. Individual preferences revealed that 11 horses preferred AA, while G3 preferred HM. The horses again consumed less-preferred forages along with the preferred forage during the Multiple sessions (Fig 1).

TABLE 3: Mean ± s.e. duration (s) and SE of foraging on each forage source in Multiple forage sessions in all Trials

Forage	*Trial 1*	*Trial 2*	Forage	*Trial 3*	*Trial 4*
FC	174.7 ± 19.4	73.4 ± 12.9	AA	92.4 ± 10.8	85.5 ± 8.9
CA	64.5 ± 16.8	41.7 ± 12.5	RG	16.9 ± 3.7	21.1 ± 7.2
SW	6.5 ± 1.3	3.0 ± 0.9	MC	15.6 ± 2.7	4.0 ± 1.0
HZ	3.3 ± 1.0	0.7 ± 0.2	HM	7.3 ± 3.4	2.2 ± 0.6
HG	16.3 ± 7.0	1.6 ± 0.4	HG	8.3 ± 3.9	14.5 ± 5.9
HY	1.8 ± 0.6	0.6 ± 0.2	HY	1.3 ± 0.4	1.3 ± 0.4

For abbreviations, see Table 2.

TABLE 4: *Trial 1* behaviour (mean ± s.e.) of horses in the Single and Multiple stables (n = 11, durations back transformed means in seconds)

Behaviour	Single	Multiple	Direction of difference	F value	Signif. P value
Forage (D)	84.0 ± 13.7	266.4 ± 5.7	Multi>Single	47.5	<0.000
Forage (Fr)	6.5 ± 0.8	13.7 ± 1.6	Multi>Single	23.8	<0.00
Look (D)	31.1 ± 8.6	11.2 ± 3.4	Single>Multi	3.9	0.07
Move (D)	32.4 ± 4.1	2.4 ± 1.2	Single>Multi	42.7	<0.000
Move (Fr)	13.4 ± 1.6	0.9 ± 0.5	Single>Multi	51.2	<0.000
Other (D)	4.5 ± 3.6	0.8 ± 0.9	Single>Multi	5.8	<0.05
Out (D)	44.5 ± 9.9	0.2 ± 0.8	Single>Multi	48.2	<0.0001
Out (Fr)	3.6 ± 0.5	0.1 ± 0.2	Single>Multi	62.5	<0.0001
Stand (D)	19.4 ± 4.5	2.0 ± 0.7	Single>Multi	32.3	<0.0001
Stand (Fr)	4.4 ± 0.9	0.7 ± 0.3	Single>Multi	28.7	<0.0001
Straw (D)	25.4 ± 11.1	1.7 ± 2.8	Single>Multi	27.2	<0.0001
Straw (Fr)	3.2 ± 0.6	0.6 ± 0.4	Single>Multi	32.2	<0.0001
Search (P^n)	0.77 ± 0.03	0.70 ± 0.02	Single>Multi	1.7	NS

Signif. = significance; D = duration; Fr = frequency; P^n = proportion; NS = not signficant. F value = $\frac{\text{between-samples variance}}{\text{within-samples variance}}$

The mean duration of foraging was longer in the Multiple stable (P<0.001) and the frequency of foraging bouts was greater (P<0.0001; Table 6), reflecting transitions from one forage to another, as recorded in previous trials (Tables 4, 5). When nonforaging behaviour was compared between stables, all of the behaviour patterns recorded were significantly different (Table 6). In order to test whether differences in behaviour could indicate a motivation to search for alternative resources, grouped durations of Move, Look and Out (Search) were again expressed as a proportion of the total noneating time and compared. This proportional data indicated that the horses showed significantly more searching behaviour in the Single stable (P<0.005).

Trial 4

Mean duration of foraging on each forage type during Multiple sessions (Table 3) were mainly consistent with *Trial 3*, although the relative rankings of MC and HG were reversed.

The single forage presented was that preferred in *Trial 3*; however, the frequency and duration of foraging was significantly longer (P<0.01) in the Multiple stable (Table 7). Horses looked out over the stable door more frequently (P<0.001) and for longer (P<0.0001), and foraged in their straw bedding more frequently and for longer (P<0.005), in the Single stable. When the grouped proportional behaviour pattern (Search) was compared, it was again higher in the Single stable (not significantly).

TABLE 5: *Trial 2* behaviour (mean ± s.e.) of horses in the Single and Multiple stables (n = 10, durations back transformed means in seconds)

Behaviour	Single	Multiple	Direction of difference	F value	Signif. P value
Forage (D)	112.1 ± 4.0	120.1 ± 3.6	Multi>Single	1.9	NS
Forage (Fr)	3.7 ± 0.3	6.7 ± 0.6	Multi>Single	12.0	<0.01
Stand (D)	13.7 ± 2.4	5.0 ± 1.5	Single>Multi	7.1	<0.05
Stand (Fr)	2.4 ± 0.4	1.2 ± 0.2	Single>Multi	3.5	0.1
Straw (D)	0.5 ± 0.5	0.2 ± 0.1	Single>Multi	4.7	0.059
Search (P^n)	0.5 ± 0.4	0.6 ± 0.4	Multi>Single	3.2	NS

For abbreviations, see Table 4.

TABLE 6: *Trial 3* behaviour (mean ± s.e.) of horses in the Single and Multiple stables (n = 12, durations back transformed means in seconds

Behaviour	Single	Multiple	Direction of difference	F value	Signif. P value
Forage (D)	16.1 ± 5.1	140.7 ± 1.9	Multi>Single	171.5	<0.0001
Forage (Fr)	3.1 ± 0.3	8.9 ± 0.6	Multi>Single	58.2	<0.0001
Look (D)	65.0 ± 4.5	1.4 ± 4.4	Single>Multi	211.2	<0.0001
Look (Fr)	4.3 ± 0.5	0.1 ± 0.1	Single>Multi	66.0	<0.0001
Move (D)	11.4 ± 1.0	0.2 ± 0.2	Single>Multi	161.6	<0.0001
Move (Fr)	8.8 ± 0.6	0.2 ± 0.2	Single>Multi	144.1	<0.0001
Other (D)	1.5 ± 1.8	0.02 ± 0.50	Single>Multi	8.3	<0.05
Other (Fr)	0.3 ± 0.3	0.001 ± 0.030	Single>Multi	8.5	<0.05
Out (D)	18.1 ± 2.7	0.5 ± 0.7	Single>Multi	67.0	<0.0001
Out (Fr)	2.2 ± 0.3	0.1 ± 0.1	Single>Multi	41.0	<0.0001
Stand (D)	3.8 ± 1.0	0.2 ± 0.4	Single>Multi	22.8	<0.01
Stand (Fr)	1.7 ± 0.3	0.1 ± 0.1	Single>Multi	34.8	<0.0001
Straw (D)	6.1 ± 1.4	0.5 ± 1.0	Single>Multi	36.0	<0.0001
Straw (Fr)	1.7 ± 0.3	0.2 ± 0.1	Single>Multi	50.4	<0.0001
Search (P^n)	0.88 ± 0.01	0.54 ± 0.07	Single>Multi	12.3	<0.0001

For abbreviations, see Table 4.

In the Multiple sessions, 9 out of 12 horses foraged for longest on the same forage they preferred during *Trial 3*. The exceptions were G3, who foraged longest on HM in *Trial 3* but, when this was presented as the single forage in *Trial 4*, foraged longest on AA during the Multiple sessions; and G6 and G8, who preferred AA during *Trial 3*, but foraged for longest on RG in the Multiple sessions of *Trial 4* (Fig 1). As in all previous trials, horses consumed less-preferred forages in addition to their preferred forage during the Multiple session.

Discussion

The mean duration of foraging in the Multiple sessions of all trials indicated that HY was the least preferred forage throughout. The other routinely available forage presented was HZ (*Trials 1* and *2*), which was the second least preferred forage in those trials. This suggests that the horses are showing long-term monotony (Rozin 1976; Bradshaw *et al.* 1996) towards the forages routinely available to them, although this could also be due to the relatively high palatability of some of the alternative forages provided in the Multiple stable.

TABLE 7: *Trial 4* behaviour (mean ± s.e.) of horses in the Single and Multiple stables (n = 12, durations back transformed means in seconds)

Behaviour	Single	Multiple	Direction of difference	F value	Signif. P value
Forage (D)	117.5 ± 3.5	128.6 ± 3.1	Multi>Single	9.5	<0.01
Forage (Fr)	4.2 ± 0.3	8.4 ± 0.5	Multi>Single	46.7	<0.0001
Look (D)	12.6 ± 1.8	5.8 ± 1.4	Single>Multi	23.1	<0.0001
Look (Fr)	1.4 ± 0.2	1.1 ± 0.2	Single>Multi	13.2	<0.005
Straw (D)	1.5 ± 3.5	0.3 ± 1.2	Single>Multi	13.0	<0.005
Straw (Fr)	0.5 ± 0.2	0.1 ± 0.1	Single>Multi	13.7	<0.005
Search (P^n)	0.77 ± 0.03	0.69 ± 0.03	Single>Multi	1.0	NS

For abbreviations, see Table 4.

In all trials, horses consumed less-preferred forages with their preferred forage during multiple forage sessions (Fig 1). This suggests that horses were motivated to ingest multiple forage sources and reflects the findings of Archer (1971, 1973), who studied grazing preferences for horses. Archer found that bouts of grazing on the most preferred species of herbs and grasses were repeatedly interrupted by regular movement away from these sites, to areas where less preferred species were consumed. This reflects a need for multiple forages in the domestic horse which resembles diet selection by feral horse populations in the USAand UK (Hansen 1976; Putman *et al.* 1987). The results of *Trials 1–4* indicate that providing a range of forages is important to the stabled horse, although this is routinely restricted under traditional management regimens, even if unconsciously so.

If horses are responding to long-term monotony towards HY, coupled with a motivation to select a variety of forages, this may be driving their foraging on straw in *Trials 1* and *2* as the only alternative, though relatively indigestible, forage. However, foraging on straw was greater in the Single stable in all trials, even when a previously preferred forage was available. The results of these trials suggest that consumption of straw in stabled horses can be significantly reduced, at least in the short term, by the provision of alternative forage sources which may, therefore, have great potential in reducing the risk of straw impaction colic (Greet and Rossdale 1987). However, further study will be required to determine whether these effects persist over a longer timescale.

Changes in forage preference between trials, when previously preferred forages were presented in Single sessions, suggests that horses are responding to short-term monotony, or to sensory-specific satiety. This may reflect evolutionary adaptive behaviour allowing grazers to exploit the heterogeneity of resources through selective grazing, choosing a diet of better quality than the average vegetation on offer (Prache *et al.* 1998). There is currently no evidence of sensory-specific satiety in the literature for horses, although this is well documented in wild and domestic carnivores (Church *et al.* 1996). The modification to the methods in *Trials 2–4* aimed to allow some investigation of the effects of sensory-specific satiety in the horse, and to overcome a problem that could have arisen using the *Trial 1* method if those horses which commenced the trial in the Multiple stable had chosen to eat only their preferred forage for the whole of the 5 min. If then transferred to the Single stable for the second 5 min session, they would only have been able to exhibit a response to sensory-specific satiety by ceasing to forage. The change in preferences within and between trials suggests that this is an area of diet selection in the horse which warrants further investigation.

When nonforaging behaviour was compared between Single and Multiple stables, differences were most pronounced in *Trials 1* and *3* when HY was provided as the single forage. However, some differences in behaviour (Tables 5, 7) were also apparent during *Trials 2* and *4*, which suggest that the results of these trials were not being driven by novelty or the palatability of the forages alone.

In order to test whether the differences in behaviour between the Single and Multiple stables could be interpreted as enrichment in the Multiple stable and were not simply a function of the horses spending more time eating, behaviour which could indicate a motivation to search for alternative resources (Move, Look and Out; definitions Table 2) were grouped and expressed as a proportion of the total noneating time (Search). This searching behaviour occupied a significantly greater proportion of horses' total noneating time in the Single stable during *Trial 3* ($P<0.005$). There was also a nonsignificant trend indicating more searching behaviour in the Single stable during *Trials 1* and *4*. These results suggest that the restricted foraging opportunities in the single forage stable result in highly motivated foraging behaviour being expressed through searching behaviour, possibly in an attempt to locate alternative forage resources. This search for alternative forages in the single forage stables may be associated with foraging in the relatively indigestible straw bedding. Horses foraged in straw significantly more frequently in 3 trials (Tables 4, 6, 7) and for longer in all trials (Tables 4–7).

Although there were not enough data to analyse statistically, 3 of the horses (G2, G6 and M3) exhibited stereotypical behaviour patterns, weaving and pawing, when looking out over the door in the Single stable, but never did so in the Multiple stable. Pawing has been interpreted as a frustration behaviour which occurs when a horse is prevented from reaching a desired goal or resource (Odberg 1973). Stereotypical behaviour patterns have also been considered to be coping responses in a suboptimal environment (McGreevy 1997). Both tend to support the hypothesis that a stable with a straw bed and a haynet represents a suboptimal environment for foraging behaviour.

Preference testing may not always be relied upon to indicate optimum environmental conditions, as some individuals will select diets which may make them fat (Broom 1988). Waran (1997) has also questioned whether studies of feral horse behaviour can be used to assess domestic horse welfare, as feral horses rarely experience optimum environmental conditions. However, studies of feral horses do allow us to identify highly motivated adaptive behaviour patterns. It is probable, therefore, that domestic horse welfare could be improved by allowing them to perform highly motivated foraging behaviour patterns.

In conclusion, these trials showed that supplying multiple forages significantly affected the behaviour of stabled horses, promoted natural foraging behaviour patterns, reduced foraging behaviour directed towards straw, and reduced the amount of nonforaging behaviour which could indicate motivation to search for alternative resources.

These results also suggest that there is considerable work to be done in assessing the role of selection, sensory-specific satiety (Rolls 1986; Church *et al.* 1996) and the short- and long-term effects of monotony in the equine diet. The results described in these short-term trials require further investigation over longer periods to determine whether the effects are consistent when horses are maintained using single and multiple forages. However, as horses are currently and commonly maintained on restricted

and monotonous diets, these results suggests that, by providing multiple forages, it may be possible to reduce the amount of straw consumed by stabled horses, enrich their environment and also promote the welfare of domesticated horses. The results could also have a great impact on environmental and behavioural enrichment for all stabled equines, by simply encouraging owners, trainers and zoo curators to provide more than one forage for the equids in their care. This idea is also attractive as it is relatively simple, cheap to implement and many suitable forages are already commercially available for horses.

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Manufacturers'addresses

[1]Marksway, Paignton, Devon, UK.
[2]Spillers Horse Feeds, Milton Keynes, Bucks, UK.
[3]Haymax,Belford, Northumberland, UK.
[4]Mark Westway & Son, Paignton, Devon, UK.
[5]Dengie Crops Ltd., Southminster, Essex, UK.
[6]Noldus Information Technology, Wageningen, The Netherlands.
[7]Lotus Development European Corp., Staines, Middlesex, UK.
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