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The effect of a foraging device (a modified 'Edinburgh Foodball') on the behaviour of the stabled horse

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Abstract

Horses that are stabled under confined conditions may develop stereotypies (e.g. stall-walking), which may be caused by the inability of horses to express foraging behaviour. The objective of this study was to determine whether horses will use a foraging device (modified version of the 'Edinburgh Foodball,' British Patent No. 9200499.3) and if so, whether it has an effect on their overall time budget. The Foodball comprised a cylinder shaped casing with a food dispensing hole and an internal food store. Five Standardbred, individually stabled horses were subjected to the following three consecutive test periods as follows. Baseline (B): the animals were observed in their stable under normal management practises for three consecutive days; Foodball (F): for the following five consecutive days the Foodball, containing 4 kg of a high fibre pelleted diet was introduced to the horse and was refilled morning and evening; and Post enrichment (P): for the following three consecutive days the Foodball was removed from the stable. The horses were video recorded between 19:00 h and 12:00 h for the duration of the experimental period (allowing the horses outside for 7 h per day in order to allow exercising and grazing) and behavioural data were collected by time sampling every 2 min.

The horses used the Foodball for more than 0.14 of their overall time budget and except for Horse 1, in a manner resembling normal foraging behaviour. The use of the Foodball was associated with significant decreases in the following behaviours when compared with baseline conditions: ingesting concentrates ($P < 0.05$); moving ($P < 0.01$); standing ($P < 0.01$); and nose bedding ($P < 0.05$). All behaviours except eliminate, were found to be highly significantly affected by time of day and the effect of test period significantly altered the allocation of the

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proportion of time spent ingesting concentrates, moving and standing. The change in the overall time budget of the horses is more comparable with that of their free ranging counterparts, which is indicative of good animal welfare.

Keywords: Horse; Feeding; Grazing; Species-specific behaviour; Environment; Behavioural enrichment

1. Introduction

The stabled environment for the horse is vastly different from the wild situation and this may give rise to the performance of stereotypies such as crib-biting, wind-sucking (aerophagia), weaving and box walking (Schilder, 1986; Winskill et al., 1995). A stereotypy can be defined as a repeated, relatively invariant sequence of movements with no obvious function (Broom and Kennedy, 1993). It has been suggested that over 15% of domesticated horses exhibit such stereotypies (Luescher et al., 1991), which could be indicative of an inadequate environment (Mason, 1991).

Feeding practices are thought to be of particular importance in the causation of stereotypies (Mason, 1991). For example, food restriction has been found to be a major cause of stereotypic behaviour in the tethered sow (Appleby and Lawrence, 1987) and in broiler breeders (Lawrence and Terlouw, 1993). Diet and feeding method are also thought to play a role in the occurrence of stereotypies in the stabled horse (Broom and Kennedy, 1993; Marsden, 1993; McGreevy et al., 1995).

Horses under 'wild' conditions consume their nutritive requirements by grazing, which under extensive management conditions may occupy up to 16 h a day (Fraser and Broom, 1990). If fed a low fibre diet, a stabled horse may consume its daily ration in 1 or 2 h (Kiley-Worthington, 1987) providing the animal with more time to engage in other behaviours. A study by Willard et al. (1977) found that horses fed a concentrated diet spent significantly more time chewing wood and engaging in coprophagy than those fed hay. Broom and Kennedy (1993) suggest that the inability to show the feeding behaviour itself is likely to be a problem for the horse and a recent study revealed that time spent feeding in stabled horses was highly negatively correlated with time spent in abnormal behaviour (Marsden, 1993). A questionnaire based study found that the risk of Thoroughbred horses performing abnormal behaviour increases as the amount of forage offered falls below 6.8 kg day^{-1} (McGreevy et al., 1995). A study by Malpass and Weigler (1994) found that an environmental enrichment device that stimulated foraging behaviour in laboratory housed horses was effective in reducing behavioural problems such as coprophagy.

This study describes the effect on behaviour of a foraging device, which delivers food rewards to an individual horse in response to being pushed. The aims of this study were firstly, to determine whether horses would use the foraging device and if so, how they use it, both quantitatively and qualitatively. Secondly, to assess whether there was any effect on the overall time budget of the horse before, during and after the introduction of the foraging device, as it was hypothesised that the device may encourage more species-specific foraging behaviour in the stabled horse.

2. Animals, materials and methods

The animals used in the experiment were five Standardbred horses (Table 1). They were individually housed in loose boxes (minimum size 4 m × 4 m), in which both physical and visual contact with other horses were possible at all times. Four of the five animals were bedded on a thick layer of straw and the fifth on wood shavings; all were cleaned out twice daily. All horses were fed morning (Horses 1–4 between 07:00 h and 08:00 h and Horse 5 between 08:00 h and 09:00 h) and evening (between 18:00 h and 19:00 h). Horses 1–4 were fed 'Spillers coarse mix' concentrates (available from Dalgety Agriculture Ltd., Aztec Way, Bristol, UK) and Horse 5 was fed hydroponic grass barley, all according to individual needs. The level of feeding remained constant over the three test periods for each animal and the diets met the horses nutritional requirements. Timothy hay and water were available ad libitum for the duration of the experimental period. Differences in housing and management between Horses 1–4 and Horse 5 were due to the fact that Horse 5 belonged to a different owner from Horses 1–4, who had her own management and housing preferences.

For each day of the test period, the horses were stabled between the hours of 19:00 h and 12:00 h the following day. They were turned out to pasture between consecutive experimental days (i.e. for a total of 7 h per day).

2.1. The Edinburgh Foodball for horses

The enrichment device used was a modified version of the 'Edinburgh Foodball' (British patent no. 9200499.3). It comprises a cylindrical casing, covered with rubber and with plastic hemi-spheres attached to either end, so the ball could be easily manoeuvred (Fig. 1). It also encompassed an internal food store and a number of holes for dispensing food. The exact mechanics of the Foodball have been described by Young et al. (1994).

2.2. Experimental protocol

The horses were individually exposed to three consecutive test periods, which will be described below.

Baseline (B: Days 1–3). The animal under observation was stabled between the hours of 19:00 h and 12:00 h under the management practices previously described.

Foodball (F: Days 4–8). At 18:00 h on Day 4, the animal under observation was trained to use the foraging device. For this purpose, the Foodball was filled with a

Table 1
Description of horses

Horse	Sex	Age (years)
1	Gelding	5
2	Gelding	18
3	Mare	18
4	Filly	1
5	Gelding	12

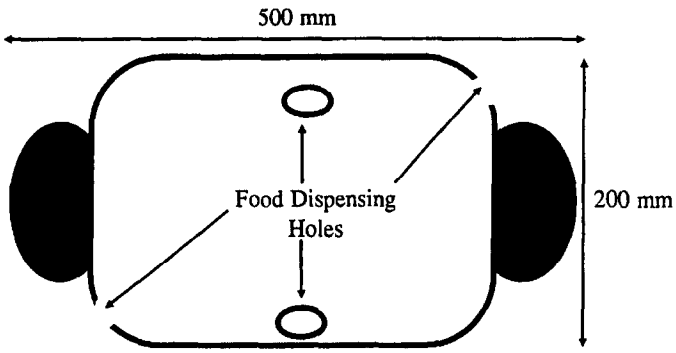

Fig. 1. The 'Edinburgh Foodball' modified for horses.

pelleted food and placed directly in front of the horse. Each kilogram of the food contained 100 g of protein, 200 g of fibre, 27.5 g of oil and 85 g of ash; this food was additional to the concentrates and timothy hay that was offered. A handful of pellets was then shown to the animal and placed underneath the Foodball, the purpose of which was to encourage the horse to push the ball, hence receiving a food reward. This process was continued until the animal began to push the Foodball without assistance and training was concluded when the horse had received four consecutive food rewards. At 19:00 h the test period started. The Foodball was refilled morning (approx. 07:00 h) and evening (approx. 18:30 h) with 4 kg of the pelleted food.

Post enrichment (P: Days 9–11). The Foodball was removed from the stable and conditions returned to those in Days 1–3. This period was considered necessary in order to determine whether any observed changes happened with time, rather than as the result of exposure to the Foodball.

2.3. Data recording

The horses were filmed with a time lapse video recorder (24 h mode) throughout the experimental period. Behavioural data were collected by time sampling every 2 min onto check sheets and placed into the categories in Table 2.

During the Foodball test period (Days 4–8) bouts of using the Foodball were also determined. A bout was taken to be from the time that contact was initially made with the ball until the time which foraging ended. Foraging was only counted as having finished at that instant prior to which the animal engaged in another behavioural activity for four consecutive minutes.

2.4. Statistical analysis

All data collected were converted to proportions of observations per day that the animal engaged in each activity. The proportions were then averaged across test periods within horses. Each behavioural category in Table 2 was analysed by a repeated measures analysis of variance, using a within horse analysis and two factors test period

Table 2
Ethogram of mutually exclusive behaviours (Adapted from Caanitz et al., 1991)

Category	Description of activities
Ingest hay	Prehending, masticating or swallowing hay
Ingest concentrates	Prehending, masticating or swallowing concentrates
Drink	Self explanatory
Move	Movement of one limb or more
Stand	Self explanatory
Lie sternally	Lying down on the sternum, legs folded under the body
Lie laterally	Lying on the side, with legs outstretched
Manoeuvrefoodball	Pushes directed at Foodball, using either the nose or the foreleg, whilst standing or moving
Foodball forage	Investigation of fallen substrates from the Foodball during a Foodball bout, whilst standing or moving
Nose bedding	Foraging within the bedding whilst standing or moving
Eliminate	Defecate or urinate
Others	Self grooming (consists of the horse using its incisor teeth to take short firm nips at the skin and hair; the use of a hind limb to scratch; or the use of a post or some other stationary object to scratch against); Mouthing (chewing wood of stalls, chewing feed buckets); Playing with feed bucket

(with three treatment levels: Baseline, Foodball and Post enrichment) and hour (with 15 treatment levels; Genstat 5, Lawes Agricultural Trust, 1987). The within horse analysis was used to detect whether there were any significant differences due to differences in housing and management of the horses. Significant differences between the three test periods were then subjected to post-hoc comparisons by paired *t*-tests (Ryan et al., 1985). The proportions of observations in each behavioural category were analysed by analysis of variance to determine hour effects and test period * hour interaction effects (Genstat 5, Lawes Agricultural Trust, 1987). Finally, the mean Foodball bout length per hour was calculated for each individual horse over the five day period in which the Foodball was present (see Fig. 2). There were some missing data, which affected the number of degrees of freedom.

To meet the requirements for parametric statistics the variables: ingest concentrates, move, drink, lie laterally, eliminate and nose bedding were square root transformed whilst ingest hay, stand and lie sternally required no transformation.

3. Results

All horses consumed most of the food on offer from the Foodball; this meant that they consumed approximately 8 kg of food from this source per day.

The within horse analysis of the analysis of variance found no significant differences between horses and therefore differences in housing and management did not affect the animals' behaviour. Analysis of variance revealed that the following behaviours; ingest concentrates, moving, standing and nose bedding showed significant test period differences ($F = 4.60$; 6.72; 6.10 and 4.17; all df = 2,47; $P < 0.05$; $P < 0.01$; $P < 0.01$ and

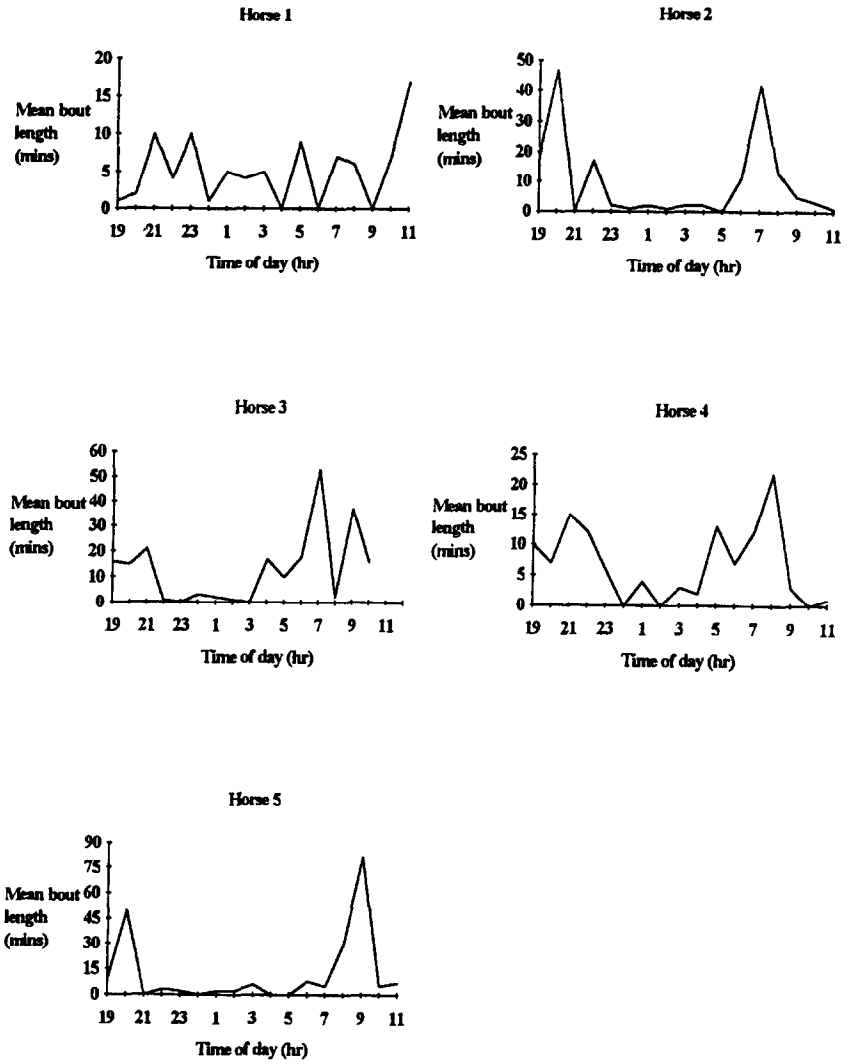

Fig. 2. The relationship between time of day and mean duration of a bout of using the Foodball by individual horses (sunset ocurred at 21:00 h and sunrise at 04:00 h).

$P < 0.05$ for ingest concentrates, moving, standing and nose bedding respectively; see Table 3). Post-hoc comparisons of these four behaviours show that the differences in ingesting concentrates are due to the Post enrichment horses ingesting concentrates for more observations than the Foodball horses (Table 4). Moving was significantly lower in the horses during the Foodball period than during both the Post enrichment and Baseline periods (Table 4), whilst the difference in standing behaviour was due to horses standing for more observations during the Baseline period than the Foodball period (Table 4). Finally, comparing the behaviour, nose bedding across each of the three test periods by a

Table 3
Mean (± SEM) proportions of observations spent in each behavioural category

Category	Test period		
	Baseline	Foodball	Post enrichment
Ingest hay	0.280 ± 0.015	0.240 ± 0.011	0.265 ± 0.017
Ingest concentrates	0.034 ± 0.007	0.024 ± 0.005 [a]	0.040 ± 0.008 [a]
Move	0.0360 ± 0.003 [b]	0.021 ± 0.002 [b c]	0.027 ± 0.003 [c]
Drink	0.017 ± 0.004	0.011 ± 0.001	0.014 ± 0.005
Stand	0.388 ± 0.018 [d]	0.286 ± 0.013 [d]	0.343 ± 0.020
Lie sternally	0.150 ± 0.014	0.157 ± 0.011	0.164 ± 0.015
Lie laterally	0.054 ± 0.008	0.061 ± 0.007	0.077 ± 0.012
Foodball forage	N.A.	0.121 ± 0.121	N.A.
Foodball manoeuvre	N.A.	0.022 ± 0.022	N.A.
Eliminate	0.003 ± 0.001	0.003 ± 0.001	0.003 ± 0.001
Nose bedding	0.017 ± 0.003 [†]	0.048 ± 0.004 [†]	0.061 ± 0.010
Other	0.021 ± 0.003	0.006 ± 0.001	0.006 ± 0.002

The same letter superscript indicates which test periods were significantly different from one another, for a particular behaviour, when analysed in a pairwise manner by post-hoc paired *t*-test. [†] Indicates that these two test period were nearly significantly different ($P < 0.1$) from one another. N.A., Not applicable.

Table 4
Post-hoc (paired *t*-test) comparisons between test periods

	Test period comparisons (*t*-values)		
Category	B vs. F	B vs. P	F vs. P
Ingest concentrates	−1.48	−1.34	2.93 *
Move	−4.29 *	−1.05	2.91 *
Stand	−4.29 *	−0.81	1.43
Nose bedding	2.63 [a]	1.06	0.24

All df = 4; * $P < 0.05$; B, Baseline; F, Foodball; P, Post enrichment; [a] $P < 0.1$.

paired *t*-test, showed no significant difference. This probably reflects individual difference for this behaviour, although the difference between the mean proportion of time horses spent nose bedding during the Baseline and Foodball periods were almost significant ($P < 0.1$).

An analysis of variance on the effect of hour of day on behaviour revealed that all the behaviours in Table 2, except for eliminate, are highly significantly affected by time of day (Table 5). The same analysis for test period * hour effects, shows that the following behaviours; ingest concentrates, move and stand are significantly affected by test period across each hour of the experimental period (Table 5).

Except for Horse 1, there are two prominent peaks in mean bout duration of the Foodball with time, during each day of the Foodball period (Fig. 2). The first of these lies between 19:00 h and 21:00 h, and the second between 07:00 h and 09:00 h. Horse 1 is seen to use the Foodball for fairly consistent short periods of time throughout the entire Foodball period with no obvious peaks. Horses 2–5 all show a similar pattern of

Table 5
Analysis of variance results for hour effects and test period * hour interaction effects

Category	Test period * Hour	Hour effects
	F-value	*F*-value
Ingest hay	0.90	4.39 ***
Ingest concentrates	2.23 ***	19.5 ***
Move	1.53 *	2.50 ***
Drink	1.10	4.40 ***
Stand	1.48 *	5.56 ***
Lie sternally	1.14	19.89 ***
Lie laterally	0.83	17.75 ***
Eliminate	1.31	1.31
Nose bedding	1.3	2.83 ***

Hour effects: df, 16,176; Test period * Hour interaction effects: df, 32,176; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

use with bout duration being higher in some individuals than others (Fig. 2). Horse 1 was also seen to manoeuvre the Foodball in a somewhat different manner than the other individuals, by using a foreleg rather than the nose, which was the preferred method for Horses 2–5.

4. Discussion

The results from the present study show that stabled horses will use a foraging device containing a high fibre, pelleted diet for more than 0.14 of their total time budget. Each horse used in this experiment was found to have its own individual style of manoeuvring the Foodball. However, except for Horse 1, the nose was used in some manner to push the ball, thereby mimicking species-specific foraging behaviour.

The use of the Foodball was associated with a significant effect on the following behaviours: ingest concentrates, move, nose bedding and stand. The significant reduction in the proportion of time spent ingesting concentrated food during the Foodball period, compared with the Post enrichment period was surprising, since all of the horses were fed consistent amounts of concentrates throughout the experimental period, none of which was found to be wasted at any time. Presumably, this was due to the animals consuming their food at a faster rate when the Foodball was present in the stable, suggesting that they were highly motivated to use the foraging device. From casual observations, it was noted that in the majority of instances; the horses would direct foraging at the Foodball immediately post feeding, rather than consuming hay, which was always available ad libitum. This contrasts with the other two periods when the Foodball was absent, as the horses immediately started eating hay once they had finished eating concentrates. These observations support the suggestion put forward by Young et al. (1994) that food motivated animals will direct foraging behaviour towards the substrate with the highest incentive value (see Lawrence and Terlouw, 1993). This would suggest that the pelleted food contained in the Foodball had a higher incentive

value than the hay, but only directly after feeding, since at other times of the day, eating hay was seen to take precedence over directing foraging towards the Foodball. Since the nutritional content of the pelleted food is very similar to that of hay (personal communication, Jane Hurley, Horse Nutritionist, Dalgety Agriculture Ltd., Aztec Way, Bristol, UK) it appears that using the Foodball was the important factor.

A significant reduction in moving occurred during the Foodball period compared with the other two periods. The explanation for this apparent anomaly is that in the present study; the activities 'Manoeuvre Foodball' and 'Forage from Foodball' incorporated both standing and moving into their description.

In the present study, during the Foodball period the horses were able to perform more complex foraging behaviour directed towards the Foodball. However, when the Foodball was absent from the stable, except for the small increase observed in nosing the bedding during the Post enrichment period, foraging behaviour was restricted to eating hay and concentrates. Foodball use was associated with a significant reduction in time spent standing by the horses compared with the Baseline period, reflecting an increase in activity when the horses were able to use the Foodball. During the Post enrichment period, the proportion of time spent standing did not return to Baseline levels, presumably due to the continued search for food dropped by the Foodball in the previous period. The fact that the horses were more active should have positive consequences for their physical fitness.

Peaks in the mean duration of Foodball use, except for Horse 1, were seen to occur at similar times of the day, although the duration varied, which could either be a reflection of each horse's motivation to perform foraging behaviour or an indication of their individual nutritional requirements. Horse 4 demonstrated the smallest maximum bout duration, which provides evidence for the latter explanation, since she was the smallest of the five horses used. The peaks in mean bout duration appeared to occur immediately post feeding; the apparent lag in the second peak occurring in the morning for Horse 5 being accounted for by the slightly later feeding time of this animal in the morning only. The pattern shown by Horses 2–4 could possibly be explained by heightened feeding motivation after feeding, due to positive feedback (Lawrence and Terlouw, 1993). It could be argued that the peaks also coincide with the Foodball being refilled, however, on no occasion was it found to be entirely empty, suggesting that this is probably not a valid explanation.

Interestingly, the two peaks are seen to coincide with sunrise and sunset (see Fig. 2), which indicates a crepuscular activity cycle (Aschoff, 1986). This suggests that the horses use the foraging device as a substitute for performing grazing behaviour, which in free ranging animals is largely confined to the daytime, with onset of active grazing being closely related to the onset of sunrise (Fraser, 1992). However, some scientists have observed domestic equids grazing at night (Keiper and Keenan, 1980; Keiper et al., 1980; Cromwell-Davis et al., 1985).

5. Conclusions

The Foodball appears to be associated with a change in the time budget of the horses that is more comparable to that of their free-ranging counterparts since total time spent

foraging was increased and time spent standing was decreased (see Boy and Duncan, 1979). This fulfills one of the criteria laid down to indicate good animal welfare; that is, animals having a similar time budget to their 'wild' counterparts (Bayne et al., 1992).

Although none of the horses used for the experiment were seen to perform stereotypic behaviours, the Foodball could have a possible role for their treatment or prevention. The circumstances in which stereotypies are usually shown in the horse are those in which there is confinement, social isolation, lack of exercise and inadequacy of diet (Broom and Kennedy, 1993; McGreevy et al., 1995; Winskill et al., 1995) and this study has shown that the Foodball reduces time spent standing and increases foraging time. Further research is obviously needed to see the effect of introducing a Foodball to horses, which perform stereotypic behaviours. A foraging device similar to the Foodball has been found to be effective at reducing behavioural problems, such as coprophagy, in laboratory housed horses (Malpass and Weigler, 1994).

This study has shown that stabled horses will use a modified version of the 'Edinburgh Foodball' as a foraging device, in a manner and pattern resembling normal grazing behaviour. Thus, the Foodball appears to be a useful behavioural enrichment device for stabled horses.

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