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Pre-feeding behaviour in UK leisure horses and associated feeding routine risk factors

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Abstract

Many horses display unwanted behaviour prior to receiving concentrate feed or forage. These behaviours have received relatively little scientific attention as a distinct group of equine behaviour problems and risk factors for their performance have not been quantified. The objective of this study was to generate data on the diet of UK leisure horses, the feeding practices employed by their carers, and the prevalence of behaviour problems seen prior to feeding. A convenience sample of leisure horse carers were surveyed via a self-administered internet survey. Each carer provided data for only one horse, and to minimise recall bias was asked to report details of their horse's feeding routine over the week prior to completing the survey. Recruitment was spread over twelve calendar months. The survey was completed by 1,324 respondents, each reporting data for an individual horse in their care. Pre-feeding behaviour problems were common within the sample and were reduced by Principal Components Analysis into three components labelled: aggression; frustration; and stereotypies. While the specific risk factors associated with these problems differed, they fell into four distinct themes: how the horse is fed; the use of nutritional supplements; exercise and stabling; and the performance of oral investigative behaviour. The risk factors for pre-feeding behaviour problems identified in this study raise concerns about the way domestic horses are currently fed and managed. In conjunction with published empirical evidence they indicate that the welfare of domestic horses may be improved by adopting a feeding regime and management system more suited to their physiological and behavioural needs.

Keywords: *animal welfare, diet, horse, management, nutritional supplements, stereotypies*

Introduction

Horses evolved to consume large amounts of low quality forage by trickle feeding for approximately 16–18 h per day (Davidson & Harris 2002; McGreevy 2004) and they rarely fast voluntarily for longer than 3–4 h (Ralston 1986; Davidson & Harris 2002). Yet many domestic horses are fed restricted amounts of forage supplemented by high energy/low fibre cereal-based feeds provided as large, discrete meals (Davidson 2002). The disparity between the horse's evolutionary requirements and the feeding practices for domestic equines can compromise the welfare of domestic horses at both a physical and psychological level (Ralston 1986; Davidson & Harris 2002).

Feeding large quantities of cereals, intermittent feed deprivation and an imbalance of concentrates and forage have been implicated in the development of physical conditions such as laminitis, gastric ulcers, colic and other gastrointestinal disturbances (Rowe *et al* 1994; Murray & Eichorn 1996; Tinker *et al* 1997; Davidson 2002; Archer & Proudman 2006). Subtle behavioural changes may result from the pain associated with these conditions and the horse may show increased sensitivity to touch or changes in responsiveness, and become depressed or cantankerous (Davidson & Harris 2002). Diet can also have a more overt effect on the behaviour of domestic horses (Harris 2005) and inappropriate feeding practices have been implicated in the development of oral stereotypies (McGreevy *et al* 1995; Waters *et al* 2002), wood chewing (Marcella 1988) and excitable or unwanted behaviour when the horse is ridden (Holland *et al* 1996; Kronfeld *et al* 1999; McGreevy 2004).

The arrival of food becomes a very exciting and rewarding event for stabled horses, and consequently feed times are periods of high arousal and frustration (Mills & Clarke 2002). The unnaturally high energy content and palatable taste of many concentrate feeds may also act as super-stimuli giving rise to high levels of anticipation prior to feeding (Goodwin *et al* 2005). This anticipation may be expressed in the form of repetitive redirected behaviour, eg kicking the stable door (Flannigan & Stooky 2002), behaviour signifying excitement and arousal, eg pawing (Collery 1974) and stereotypies such as weaving (Cooper *et al* 2000; McAfee *et al* 2002; Clegg *et al* 2008).

The level of expression of anticipatory behaviours may also be indicative of an animal's overall welfare. Their use as a welfare indicator has been explored by researchers in The Netherlands, the premise being that an animal's sensitivity to reward reflects past experiences; with negative experiences positively correlated with reward sensitivity and therefore increased anticipatory behaviour (Spruijt *et al* 2001; Van der Harst & Spruijt 2007). Research to further our understanding of the relationship between anticipatory behaviour and welfare has been undertaken in farmed mink (*Neovison vison*) (Hansen & Jeppesen 2006) and more recently in horses (Peters *et al* 2012) with promising results.

That said, pre-feeding behaviour problems, as a distinct category of behaviour problem, have received relatively little research attention (Cooper & McGreevy 2002) and have been considered as ritualised pre-feeding behaviours rather than as behaviour problems *per se*. Yet, aggressive or destructive pre-feeding behaviour problems can be of great concern for leisure horse owners, as illustrated by the regularity with which these problems are featured in the help pages of popular equestrian publications. Furthermore, it is unknown whether these problems share risk factors with those identified for feeding-related stereotypies or if they have different aetiologies altogether. As these behaviours have the potential to be used as indicators of equine welfare, it would also be beneficial to understand more about them and their expression prior to feeding, and to consider what their performance, at any level, may tell us about the welfare of horses.

The aims of this study were to quantify and describe the feeding practices employed for UK leisure horses and the prevalence of specific pre-feeding behaviours, and to identify risk factors associated with these behaviours.

Materials and methods

The survey

The survey was one of a series of three online surveys exploring the husbandry and welfare of UK leisure horses (Hockenhull 2010). The study and surveys used received ethical approval from the Departmental Ethics Committee for the Department of Psychology at the University of Chester, UK.

The survey homepage provided some instructions to the participants as well as assuring them of their anonymity and right to withdraw from the study. Participants were asked to complete the survey for one horse in their care, but were not given any instructions on how to choose which horse this was. The survey included 23 questions concerned with the horse's diet and feeding routine, including the type of concentrate feed (defined as any hard/additional feed provided on top of the horse's daily forage ration) and forage provided, the way both were fed and the use of dietary supplements. (For full survey, see the supplementary material to papers published in *Animal Welfare* section at the UFAW website, www.ufaw.org.uk). Basic information on the time the horse spent stabled, out at grass and in work was also requested. To reduce recall bias, respondents were instructed to provide data reflecting their routine in the week prior to completing the survey.

Respondents were asked to rate the frequency their horse displayed nine pre-feeding behaviour problems (barging [ie roughly pushing people], kicking/banging the stable door, pulling faces, pawing, aggression towards humans, aggression towards other horses, weaving, box-walking and head bobbing) prior to receiving concentrate feed or forage in a matrix question using a 1–5 scale anchored at the endpoints (1 = never, 5 = often) the meaning of which was not defined. The behaviour problems chosen were identified from the problem pages of popular UK equestrian publications. The terminology used in the survey was the same as that included in these magazines to facilitate the participants' understanding of the survey questions. 'Pulling faces' was a commonly reported concern and encompassed behaviours including the horse putting its ears back, baring teeth and threatening to bite. Pilot testing revealed that respondents felt more comfortable rating their horse's behaviour than when required to commit to a present/absent binary answer. A not applicable option was provided to minimise item non-response in cases where the horse did not have the opportunity to display a particular behaviour. The survey was online for a full calendar year (2006–2007) to help account for seasonal variation.

Survey sample

Data were generated from a convenience sample of UK leisure horse owners. Recruitment was ongoing throughout the year and strategies were employed to maximise the likelihood that the sample obtained would be representative of the wider leisure horse population. These included online strategies, such as invitations in internet discussion forums, links from equestrian websites and emails to riding clubs, and offline strategies including notices in local press and equestrian magazines, postal mailshots containing information on the surveys to livery yards and leaflet distribution.

Demographic data on both the respondents and their horses collected by the first survey in the series were comparable to other data sources, including the National Equine Database, indicating that the survey sample was representative of the wider UK leisure horse population (Hockenhull & Creighton 2013).

Statistical analysis

To minimise the impact of individual interpretation of the 1–5 scales used to rate the frequency of pre-feeding behaviour problems, the scale responses were reduced into binary scores depicting whether the behaviour was absent (rated as 1 or not applicable) or present (rated 2–5). Not applicable and never (1) responses were combined after respondent response patterns indicated that a large number of respondents used these options interchangeably. It was considered safer to combine these scores and risk type II error than overestimate the prevalence of problems. The behaviour problems were then entered into a Principal Components Analysis (PCA) using an oblimin rotation. Each horse received a score for each component denoting whether it performed behaviour represented by the component or not. The resulting binary data for each component were used for the subsequent analyses.

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Table 1 Distribution of responses to the question how often the horse shows any of the following behaviour before being fed hard feed or forage.

Pre-feeding behaviour problem	Percentage (%) of horses							
	Never				Often	Total % showing behaviour	Sample size	Median (IQR)
	1*	2	3	4	5			
Pawing	66	18	5	5	6	34	877	1 (1–2)
Kicking/banging door	73	15	5	2	5	27	874	1 (1–2)
Weaving	93	3	2	< 1	1	7	865	1 (1–1)
Box walking/pacing/circling	83	11	3	2	1	17	868	1 (1–1)
Aggression towards people	92	5	2	< 1	< 1	8	874	1 (1–1)
Aggression towards horses	75	14	6	3	2	25	873	1 (1–1.5)
Barging	84	11	3	1	< 1	16	867	1 (1–1)
Head bobbing/nodding	69	13	8	5	5	31	873	1 (1–2)
Pulling faces	73	15	5	3	4	27	862	1 (1–2)
Whinnying/nickering	24	19	15	15	27	76	883	3 (2–5)

* N/A and 1 (never) scores were combined to create a true 1–5 scale.

The data were filtered for logistic regression analyses exploring associations between pre-feeding behaviour problems and feeding routine risk factors to only include those horses that received concentrate/hard feed. This was to prevent redundancies in the data affecting the outcome of the models. Independent variables associated with a behaviour problem component at $P < 0.25$ in the univariate analysis (Hosmer & Lemeshow 2000) were tested for multicollinearity and rejected where Spearman's correlation matrices were $r \geq 0.4$ or collinearity diagnostics showed tolerance values ≤ 0.1 and variance inflation factor values ≥ 10 (Field 2005; Pallant 2007). Where covariance was found, variables relating to the horse's feeding routine were preferentially retained.

Twenty-four of the feeding routine variables were screened for associations with each of the three pre-feeding behaviour components using univariate logistic regression analyses. When the variables meeting the $P < 0.25$ criteria for each component were tested for multicollinearity, evidence of correlations between independent variables was found and as a result time spent stabled and time spent turned-out were excluded from inclusion in the multivariate models. Time spent stabled and time spent turned-out were both correlated with two of the feeding routine variables (frequency horse receives hard feed and horse's forage routine) which remained in the analysis as they were more important to the study objectives. The variable time spent working per day was excluded from the multivariate analysis due to redundancy issues when included with the variable number of times horse worked over the last week. In the end, fourteen feeding variables were put forward for the final multivariate models.

The selected independent variables were entered into multivariate logistic regression models for each behaviour problem component using the forced entry method and goodness-of-fit was assessed using the Omnibus Test of Model Coefficients ($P \leq 0.05$) and the Hosmer and Lemeshow Test ($P \geq 0.05$).

Independent variables that contribute significantly to the model have P-values ≤ 0.05. Effect sizes of feeding routine risk factors are expressed as odds ratios (OR). Odds ratios greater than one reflect an increase in odds of the horse having a behaviour problem; odds ratios less than one reflect a decrease in odds of that outcome (Tabachnick & Fidell 2007). The logistic regression results' tables specify which category of the variable formed the reference category (R) against which the other categories were compared. All statistical analyses were conducted using SPSS version 14 for Windows (SPSS Inc, USA).

Results

The survey generated data on 1,324 individual horses. A faulty software upgrade resulted in responses to matrix format questions not being recorded over a three-month period (between March–June 2007). This combined with item non-response and the automatic skip rules within the survey have lead to the variation in item totals reported here.

Pre-feeding behaviour problems

Behaviour data were generated for 890 horses, 89% (788/890) of which showed some form of pre-feeding behaviour problem. The distribution of respondents' responses for each behaviour variable is presented in Table 1. The not applicable (N/A) and 1 (never) categories were combined to create a total number of horses that do not display the behaviour for each behaviour problem variable.

Table 2 Distribution of responses to questions relating to the horses' concentrate diet and feeding routine.

Factor	Number (%)
Type of concentration feed provided	
None*	78 (7)
Low energy feed (DE 8–10.5 MJ kg^{-1})	882 (74)
Medium energy feed (DE 10.6–12.5 MJ kg^{-1})	197 (17)
High energy feed (DE 12.6–15 MJ kg^{-1})	26 (2)
Frequency concentrate feed is provided	
As a titbit (not every day)	29 (3)
Once a day	342 (32)
Twice a day	624 (59)
Three times a day	47 (4)
More than three times a day	10 (1)
Other	8 (1)
How the horses is fed concentrates in relation to other horses	
At the same time as other horses	690 (65)
At different times to other horses	289 (27)
There are no other horses present	52 (5)
Other	27 (3)
Number of dietary supplements provided (of eleven listed)	
None	64 (8)
One	126 (15)
Two	212 (25)
Three	190 (23)
Four	125 (15)
Five	64 (8)
Six	35 (4)
Seven to eleven	17 (2)

* These respondents automatically skipped the survey questions on concentrate feeding regime.

The decision was taken to exclude whinnying from subsequent analyses. Whinnying was included in the survey to encourage owners to think about how their horse behaves at feed times rather than due to any evidence that it is considered a problem by owners. In addition, it failed to load highly (> 0.3) onto any component during the following PCA. When whinnying was excluded, 70% (623/890) of horses performed some type of pre-feeding behaviour problem.

Three components were extracted from the PCA, with all constituent behaviours loading > 0.3, which together explained 57.1% of the variance in the data. One variable (barging) cross-loaded between two of the components, however, as it fitted equally well with both components biologically it was included in both components for all further analyses.

The first component was labelled aggression and consisted of the behaviours aggression towards people: pulling faces; aggression towards horses; and barging. The second contained behaviours indicative of frustration: barging; kicking/banging the door; and pawing. The last component consisted of the stereotypic behaviours weaving, box-walking/pacing/circling and head bobbing/nodding.

The percentage of horses reported by their owners to display behaviour represented by each component was 44% (386/879) for aggression, 49% (431/884) for frustration behaviour and 39% (346/879) for stereotypic behaviour.

Diet and feeding routine

Table 2 details the distribution of survey responses related to the horses concentrate diet, feed supplements and feeding routine.

Supplements were provided predominantly as a preventative rather than a curative measure, with the exception of calming supplements and those marketed to benefit joint and hoof health (Figure 1).

Thirty-one percent (376/1,228) of horses lived out or had constant access to forage when stabled, 29% (354/1,228) were outside for part of the day and had constant access to forage in the stable, 35% (440/1,228) were outside for part of the day and had measured amounts of forage when stabled and 5% (58/1,228) of horses were kept stabled and received forage only at set times.

Table 3 details the distribution of survey responses related to the horses' forage diet and feeding routine.

Respondents were asked to rate the frequency their horse performed five oral investigative behaviours during their interactions. The horse was given a present/absent score for each behaviour depending where it was scored on the 1–5 scale. Horses rated 1 (never) were coded as 'behaviour absent' and those rated 2 or above were coded as 'behaviour present'. Licking hands was reported for 77% (662/860) of horses, nipping hands for 21% (179/851), gently searching clothing 81% (700/864), roughly searching clothing 23% (195/848) and bites at clothing 23% (197/857). An overall score was also calculated, denoting the horse's response across all five behaviours. If the horse scored 'present' for any of the five behaviours, it was given a score of 1 overall (92% [799/869]). Only horses coded 'absent' for all five behaviours could score 0 for this variable (8% [70/869]).

Respondents who reported that their horse was not ridden (n = 133) were automatically grouped into a 'horse not ridden' category for the question on the frequency the horse worked over the previous week. The horses in the sample were worked a median (interquartile range [IQR]) of four (2–6) times over the week prior to the survey being completed, for a median of between 30 min and 1 (30 min–1 h 30 min) h per day (Table 4).

The median (IQR) time spent stabled was 9–12 (0–16) h per day and 9–12 (5–24) h per day were spent turned-out. Twenty-eight percent (333/1,172) of horses were not stabled at all during the week prior to the survey being completed and 3% (40/1,175) were not turned-out at all over that period (Table 5).

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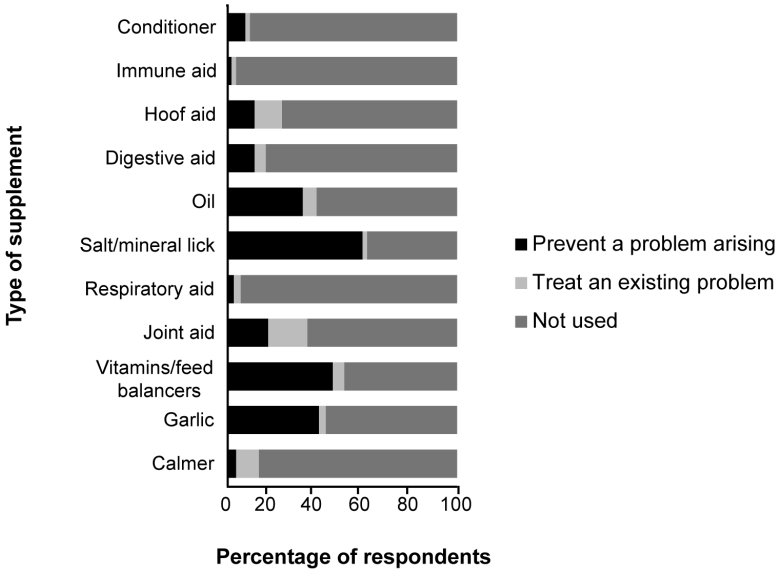
Figure 1

Respondents' use of eleven feed supplements for UK leisure horses.



Feeding routine risk factors associated with pre-feeding behaviour problems

The results of both the univariate and multivariate logistic regression analyses are presented below for each of the three pre-feeding behaviour components.

Aggressive pre-feeding behaviour

The univariate logistic regression analyses revealed ten feeding variables associated with aggressive pre-feeding behaviour that met the $P < 0.25$ criteria for inclusion in the multivariate model. The association was significant for four of these variables: number of dietary supplements given, use of dietary calmer, number of times the horse worked over the last week and whether the horse performs any of the five oral investigative behaviours during interactions.

Significant associations were also found between the variable time spent turned-out per week and four of the five individual oral investigative behaviour variables, however these were not eligible for the multivariate analysis.

Significant associations between aggressive pre-feeding behaviour and the feeding routine variables are shown in Table 6. Three of the feeding routine variables retained their direction of effect and significance from the univariate analyses. The fourth significant variable was associated with a reduction in aggressive pre-feeding behaviour if the horse spent part of the day at grass and had constant access to forage when stabled.

Pre-feeding frustration behaviour

Nine feeding routine variables met the criteria for inclusion in the multivariate model after the univariate logistic regression analyses. The association with pre-feeding frustration behaviour was significant for three of these variables, forage routine, number of times worked over the last week and whether the horse performs any of the five oral investigative behaviours during interactions.

Table 3 Distribution of responses to questions relating to the horses' forage diet and feeding routine.

Factor	Number (%)
Type of forage provided	
Hay	731/1,279 (57)
Soaked hay	308/1,279 (24)
Haylage	546/1,279 (43)
Straw	68/1,1279 (5)
Lucerne/alfalfa	248/1,279 (19)
Silage	12/1,1279 (1)
Number of forage types provided	
One	304 (24)
Two	534 (42)
Three	344 (27)
Four	79 (6)
Five	13 (1)
Six/seven	5 (< 1)

The multivariate logistic regression found five significant associations between pre-feeding frustration behaviour and feeding routine variables (Table 7). Four of these were also significant in the univariate analyses and showed the same direction of effect. The fifth risk factor, the horse worked five times over the previous week, was not significantly associated with a reduced risk of pre-feeding frustration in the univariate analyses, although it was approaching that level ($P = 0.055$).

Table 4 Distribution of responses to questions relating to the horses' work routine.

Factor	Number (%)
Number of times ridden/worked over the last week	
Horse not in work	133/1,179 (11)
Once	130/1,179 (6)
Twice	124/1,179 (10)
Three times	157/1,179 (13)
Four times	177/1,179 (15)
Five times	226/1,179 (20)
Six times	213/1,179 (18)
Every day	82/1,179 (7)
How long horse spent working each day (on average)	
Horse not in work	133/1,177 (11)
< 30 min per day	102/1,177 (9)
30 min–1 h per day	448/1,177 (38)
1–1 h 30 min per day	338/1,177 (29)
1 h 30 min–2 h per day	101/1,177 (9)
2–2 h 30 min per day	24/1,177 (2)
2 h 30 min–3 h per day	14/1,177 (1)
More than 3 h per day	17/1,177 (1)

Table 5 Distribution of responses to questions relating to the horses' housing routine.

Amount of time (h)	Time spent stabled (n [%])	Time spent turned out (n [%])
Horse not stabled/turned out	333/1,172 (28)	40/1,175 (3)
1–4 h	109/1,172 (9)	/1,175 (5)
5–8 h	88/1,172 (8)	/1,175 (18)
9–12 h	291/1,172 (25)	/1,175 (26)
13–16 h	238/1,172 (20)	/1,175 (9)
17–20 h	64/1,172 (6)	/1,175 (4)
21–24 h	49/1,172 (4)	/1,175 (35)

Stereotypic pre-feeding behaviour

Six feeding routine variables were significantly associated with stereotypic pre-feeding behaviour in the univariate logistic regression analyses, and a further five variables met the criteria for inclusion in the multivariate logistic regression model.

Significant univariate associations were also found between the variables time spent stabled per day and time spent turned-out per day, although these variables were not eligible for the multivariate model due to multicollinearity issues.

The multivariate logistic regression identified nine significant associations between feeding routine risk factors and the occurrence of pre-feeding stereotypies (Table 8), only two of which, 'receiving hard feed once per day' and 'working six times over the last week', were not significant in the univariate analyses.

Discussion

The prevalence of pre-feeding behaviour problems

Pre-feeding behaviour problems were reported for 70% of UK leisure horses sampled in this survey. This may have implications for the welfare of these horses if the behaviours indicate excessively heightened reward sensitivity. They can also, as indicated by the comments left by respondents, have further implications including verbal and physical punishment, keeping both the upper and lower stable doors bolted to prevent the horse from interacting with the environment outside the stable, and not feeding that horse until last on the yard or not at all to 'teach it a lesson'.

PCA reduced the nine behaviours to three components of related behaviours. Barging was the only behaviour that cross-loaded between components. While three distinct themes emerged, aggressive behaviours, frustration behaviours and stereotypies, it is likely that the behaviours represented by all three components have some degree of anticipation and frustration underlying their performance due to the context in which they are seen, although the way they are expressed may differ between individual horses. There was only a 10% variation in the percentage of horses displaying the behaviour represented by each component, ranging from 39% of horses performing pre-feeding stereotypies to 49% displaying behaviour indicative of pre-feeding frustration, which may further illustrate the similar aetiologies of these problems.

The association between pre-feeding stereotypies, particularly weaving, and feeding routine has perhaps received more research attention than the behaviours included in the two remaining components. Weaving, box-walking and head nodding are typically at their most prevalent around feed time (Cooper & McGreevy 2002), and consequently are unusual amongst stereotypies in that their performance prior to receiving feed can result in them becoming a conditioned response to feed-related cues (Houpt 1986). The learnt constituent of these stereotypies can be demonstrated by the decline in performance that accompanies a change in feeding routine or pre-feeding cues (Cooper & McGreevy 2002). That these three behaviours formed their own component during analysis indicates that there may be a functional difference between these behaviours and those loaded onto the other components and horses may express all or one of these problems in response to the same issue. Pre-feeding stereotypies were the least frequently reported pre-feeding behaviour, reportedly displayed by 39% of horses sampled.

Kicking/banging and pawing are amongst the repetitive behaviours primarily expressed in association with feeding. While they have been described by some authors as stereotypic in nature (Cooper & McGreevy 2002), they did not load on the component with the true stereotypies. Instead these behaviours loaded on the component with other behaviours indicative of pre-feeding frustration, and were reported in 49% of horses sampled. Cues from the owner predicting the arrival of food may elicit and reinforce these anticipatory, and/or frustrated behavioural responses (Auty

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Table 6 Significant feeding risk factors for the performance of aggressive pre-feeding behaviour identified using a forced entry multivariate logistic regression model (n = 717).

Feeding routine variable	*P*-value	OR (95% CI)
*Use of dietary calmer (*R = *not used/horse does not receive hard feed)*		
To prevent a problem arising	0.011*	3.117 (1.292–7.523)
*Horse's forage (*R = *lives out or constant access to forage when stabled)*		
Part day at grass and constant access to forage when stabled	0.014*	0.571 (0.365–0.894)
*Number of times the horse worked per week (*R = *horse not in work)*		
Six times over the last week	0.010*	0.450 (0.245–0.829)
*Horse shows any of the five oral investigative behaviours (*R = *no)*		
Yes	0.038*	2.094 (1.041–4.209)

R = Reference category.
Significance levels: * $P \leq 0.05$.
The model classified 61.1% of cases correctly and met the assumptions of the two goodness-of-fit tests (Omnibus Test of Model Coefficients $P < 0.05$; Hosmer and Lemeshow Test $P > 0.05$).

Table 7 Significant feeding risk factors for the performance of 'pre-feeding frustration behaviour' identified using a forced entry multivariate logistic regression model (n = 719).

Feeding routine variable	*P*-value	OR (95% CI)
*Horse's forage routine (*R = *lives out or constant access to forage when stabled)*		
Part day at grass and measured access to forage when stabled	0.041*	1.519 (1.017–2.269)
Kept in and receives forage at set times	0.012*	2.639 (1.238–5.624)
*Number of times the horse worked per week (*R = *horse not in work)*		
Five times over the last week	0.045*	0.560 (0.318–0.988)
Six times over the last week	0.006**	0.440 (0.245–0.793)
*Horse shows any of the five oral investigative behaviours (*R = *no)*		
Yes	0.014*	2.254 (1.177–4.316)

R = Reference category.
Significance levels: * $P \leq 0.05$; ** $P \leq 0.01$.
Overall the model classified 59.4% of cases correctly and met the assumptions of both goodness-of-fit tests used.

1998; Nicol 2005). Both pawing and kicking/banging may be triggered by the extreme arousal that surrounds feeding, the effects of which may be heightened by inadequate environmental conditions and management practices (Zeitler-Feicht 2004). Barging in this context may also be an expression of the horse's heightened arousal and frustrated motivation, leading them to disregard the owner's personal space in their attempt to reach the food.

The third component contained aggressive pre-feeding behaviours, reported in 44% of horses sampled. Aggression is relatively uncommon in horses, and when it does occur it is often over limited resources such as food (Kiley-Worthington 1987). Aggression between horses is often at its peak prior to concentrate feeding, when levels of arousal are high, and may be aggravated by insufficient space between individuals resulting in some animals overtly defending their ration from the advances of others (Zeitler-Feicht 2004). Face pulling associated with feeding may incorporate agonistic responses, such as threats to bite or actual bites, as well as ritualised elements of horses' normal social communicative behaviour (Cooper & McGreevy 2002). Barging has also been interpreted as an agonistic response (McGreevy 2004). Intraspecific aggression outside of feeding times has been attributed to feed-related frustration (McGreevy *et al* 2001). Aggression may also be a result of pain (Waring 2003; Ashley *et al* 2005) or sub-optimal environments (Kiley-Worthington 1987), and consequently, the cause of abnormal aggressive responses should always be investigated.

Risk factors for behaviour on all three components encompassed aspects of feeding routine, as well as factors outside feeding, and four common themes emerged: how the horse is fed, the use of supplements, the performance of oral investigative behaviour during interactions with people, and exercise and stabling. The remaining results will be discussed in respect of these themes.

Table 8 Significant feeding risk factors for the performance of 'stereotypic pre-feeding behaviour' identified using a forced entry multivariate logistic regression model (n = 718).

Feeding routine variable	*P*-value	OR (95% CI)
Frequency horse is given hard feed (R = *as a titbit/not every day)*		
Once a day	0.036*	0.363 (0.141–0.935)
How fed in relation to other horses (R = *fed at the same time as other horses)*		
There are no other horses present	0.017*	0.336 (0.137–0.822)
Number of dietary supplements (R = *none/horse does not receive hard feed)*		
Two supplements given	0.046*	2.094 (1.013–4.324)
Three supplements given	0.012*	2.593 (1.238–5.432)
Five supplements given	0.002**	4.006 (1.649–9.735)
Six or more supplements given	0.021*	2.868 (1.172–7.015)
Number of times the horse worked per week (R = *horse not in work)*		
Once over the last week	0.019*	0.361 (0.154–0.844)
Six times over the last week	0.036*	0.519 (0.281–0.959)
Horse shows any of the five oral investigative behaviours (R = *no)*		
Yes	0.002**	3.826 (1.649–8.875)

R = Reference category.
Significance levels: * $P \leq 0.05$; ** $P \leq 0.01$.
The multivariate logistic regression identified 65.9% of cases correctly and met the assumptions of the goodness-of-fit tests.

How UK leisure horses are fed

The data on feeding practices generated by this survey provide a snapshot of how UK leisure horses were fed in 2006/2007. The majority of horses sampled (93%) received some form of concentrate/hard feed. This exceeds levels reported in earlier surveys of UK horse owners, although the data presented in these surveys are divided by type of concentrate feed (Mellor 1997) and season (Hotchkiss *et al* 2007) making a true comparison difficult. However, there has been an increase in the use of pre-mixed or manufactured compound feeds over recent years (Harris 1999) and the high number of owners feeding concentrates reported in this survey may reflect this trend. As the survey was online for a full calendar year, the findings also suggest that additional feeding was not solely implemented over winter to help the horse maintain condition, but was practised throughout the year; perhaps as a vehicle for the provision of dietary supplements (Davidson & Harris 2002).

Providing a large number of concentrate meals spread throughout the day has been linked to an increased performance of anticipatory behaviours such as weaving (Houpt 1995; Cooper *et al* 2005). This is supported by the findings of this study whereby feeding the horse concentrates only once per day reduced the risk of these pre-feeding stereotypies. McBride and Hemmings (2009) suggest that neurological changes in stereotypic horses enhances their motivational state for goal-directed behaviours and activities that stimulate this neurochemical pathway may be associated with the performance of these behaviours. Because highly palatable concentrate/hard feeds are so far removed from the feedstuffs horses evolved to eat they act as a form of psychostimulant creating horses with a hypermotivated reward-seeking phenotype (McBride & Hemmings 2009). Feeding the horse only one concentrate meal per day will consequently reduce the number of events that elicit these behaviours.

Feeding the concentrate meal when no other horses are present also reduced the risk of pre-feeding stereotypies, perhaps through reducing the level of arousal at feed times as the horse has no misleading cues when neighbouring horses were being fed and no other horses to stimulate it. There may be a perceived reduction in competition for feed when there are no other horses present and horses fed alone may also receive their feed sooner after the initial pre-feeding cues from the owner than when there are a number of horses to be fed.

All respondents reported feeding their horse at least one type of forage. The median (IQR) number of forage items fed was 2 (2–3), the most common combination being grass and hay, suggesting that the majority of horses only received basic forage rations and were not provided with a range of forage types to relieve dietary monotony or for enrichment purposes (Goodwin *et al* 2001; McGreevy 2004; Thorne *et al* 2005). The reduced risk of abnormal behaviour associated with feeding a range of forages reported by McGreevy *et al* (1995) was not found in this study.

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Sixty percent of horses had constant access to forage, either through living out at grass or being fed *ad libitum*. The remainder of horses had controlled access to forage or received forage only at set times, although only a small percentage (5%) of these were stabled full time. As there are no comparison data available from published studies, there is no evidence to indicate that these levels of access to forage may be outside the norm.

Providing constant access to forage when stabled was associated with a reduced risk of aggressive pre-feeding behaviour. Zeyner *et al* (2004) found a similar reduction in pre-feeding aggression for horses with a higher hay intake in their experimental study. The freedom to eat as and when the horse chooses may both satisfy its motivation to feed and the requirements of its digestive physiology, and allow it some degree of control over this aspect of its environment which has positive connotations for welfare (Morgan & Tromborg 2007).

A further hypothesis for the association between constant access to forage and reduced risk of pre-feeding aggression relates to aggressive behaviour as an indicator of pain in horses (Waring 2003; Ashley *et al* 2005). Horses continually secrete acid into their stomach and under natural conditions this is buffered by the saliva the horse produces whilst grazing (Davidson & Harris 2002). Intermittent feed deprivation and the feeding of high energy/low fibre meals may lead to insufficient saliva being produced resulting in a poorly buffered, acidic stomach environment leading to abdominal discomfort and the development of gastric ulcers (Murray & Eichorn 1996; Davidson & Harris 2002; McGreevy 2004). A recent study found gastric ulceration to be highly prevalent within a leisure horse population, with 53% of apparently healthy horses exhibiting some degree of ulceration (Luthersson *et al* 2009a). Providing forage meals more than 6 h apart was associated with an increased risk of non-glandular ulcers in these horses (Luthersson *et al* 2009b). Constant access to forage will allow the horse to neutralise any excess stomach acid through the saliva produced as it masticates (Hastie 2001; Mills & Clarke 2002; McGreevy 2004; Moeller *et al* 2008), alleviating pain from gastric ulcers or stomach acidity.

Restricted access to forage was the only true feeding practice risk factor associated with pre-feeding frustration behaviour. Receiving measured amounts of forage when stabled, or being kept stabled and provided with forage at set times were both associated with increased risk of these behaviours being displayed when compared to horses that live out or have constant access to forage when stabled. Owners often inadvertently reinforce pre-feeding behaviour problems by delivering food when the horse is displaying them (Houpt 1986). Feeding forage, as well as concentrates, as discrete meals may serve to facilitate this process by increasing the opportunity for the horse to learn the (unintentional) association between their behaviour and the arrival of food.

The use of nutritional supplements

The majority of respondents reportedly fed various dietary supplements in addition to their horse's basic ration. Previous data regarding the frequency supplements are fed in the UK equine population have varied considerably. Many supplements have not received adequate research into their efficacy or how they interact with each other when taken together (Davidson & Harris 2002). This means that some horses may be at risk from overdosing on some key nutrients, which are already provided in optimal levels in compound feed, while the uptake of other minerals may be inhibited (Harris 1999; Davidson & Harris 2002) unless supplements are used with caution. The majority of respondents reported feeding supplements as a preventative measure rather than to cure an existing problem, raising further questions about their necessity.

The use of two, three, five or six or more dietary supplements was associated with an increased risk of pre-feeding stereotypies in the multivariate model. Restless behaviour, repetitive head movements and stereotypic behaviour can be expressions of pain (Houpt 1986; Marsden 2002; Ashley *et al* 2005; Bussières *et al* 2008) and it is possible that horses exhibiting pre-feeding stereotypies have underlying painful physical conditions that may necessitate the use of dietary supplements designed to benefit these. However, these factors are confounded and we cannot draw any firm conclusions regarding their relationship from these data. Providing the horse with additional dietary supplements with the intention of preventing all manner of health and behavioural problems arising may be one example of trying to do what is best for the horse by extrapolating from human health practices without considering the implications for the horse.

The use of nutritional calming supplements, either to prevent a problem arising or to treat an existing problem, was significantly associated with pre-feeding aggression and frustration. This finding suggests that calming supplements do not eliminate behaviour problems and improved understanding of what triggers the behaviour and the use of habituation to alter the horse's behaviour in aversive situations may be more effective in addressing any problems (Malmkvist & Christensen 2007). There is little scientific evidence for efficacy of calming supplements for horses and low doses of those containing the active ingredient L-tryptophan may have even have an excitatory effect (Grimmett & Sillence 2005; Malmkvist & Christensen 2007; Hothersall & Nicol 2009).

The survey respondents' use of supplements that are intended to modify behaviour reflects a trend towards owners having a 'quick-fix' attitude when it comes to solving behaviour problems. This is of concern as owners should first attempt to alter their horse's diet, management or training regime or take the time to work through the problem with the horse (Davidson & Harris 2002; Harris 2005).

Performing oral investigative behaviours during interactions with people

Expression of any of the five oral investigative behaviours (licking hands, nipping, gently searching clothing, roughly searching clothing and biting at clothing) was associated with an increased likelihood of the horse displaying pre-feeding behaviour problems from all three components. The relationship between these two forms of behaviour, oral investigative behaviours and pre-feeding behaviours, is unknown. The oral investigative behaviours reported may be learned behaviours, their performance having been inadvertently reinforced by the owners (Hockenhull & Creighton 2010). They may also reflect the horse's high motivation to perform foraging behaviour or indeed thwarted foraging attempts. If the oral investigative behaviours are indicative of the horse's generic response to food and level of arousal in feeding situations, these behaviours, alongside pre-feeding behaviours, may have potential use as welfare indicators in equines.

Exercise and stabling

Being engaged in some form of work six times a week reduced the likelihood of pre-feeding aggression and stereotypies, possibly because of the opportunities for increased exercise and time out of the stable. This finding is supported by the experimental study of Freire *et al* (2009) who found that spending 1 h per day on turn-out or engaged in some form of exercise significantly reduced unwanted behaviour during handling. Exercise has also been associated with a reduction in wood-chewing in stabled horses (Krzak *et al* 1991). McGreevy (2004) has suggested that there is no evidence linking exercise routine to stereotypic behaviour. However, the findings of this study imply that this is not the case, although the mechanism of the interaction between them is yet to be investigated.

While the variables describing stabling and turn-out regime could not be entered into the multivariate models due to multicollinearity issues, they were significantly associated with all three behaviour components in the univariate analyses. Time spent stabled was associated with an increased risk of pre-feeding stereotypies and frustration behaviour compared to horses that were not stabled, and spending time turned-out was associated with a reduced likelihood of aggression and frustration compared to horses that did not have this opportunity.

Animal welfare implications

Pre-feeding behaviour problems were common within this sample of the leisure horse population. Associations between different features of the horses' feeding routine and each of these components revealed four key themes which can be used in conjunction with published evidence to inform recommendations for owners on how to reduce the performance of these behaviours. From their association with all three pre-feeding behaviour problem components, it is speculated that the expression of oral investigative behaviours may be indicative of individuals susceptible to feeding or environmental deficiencies. This is an entirely new direction of study, and one that would be interesting to pursue in light of the possibility of using anticipatory behaviours as welfare indicators. If oral investigative behaviours are also indicative of wider concerns they may have potential as welfare indicators themselves.

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