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Behavioural changes in stabled horses given nontherapeutic levels of virginiamycin

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Summary

Abnormal behaviour commonly develops in intensively managed horses. A possible cause is the change in diet occurring when the horse is stabled. An experiment was performed to examine this possibility by manipulating the diet with the feed supplement virginiamycin, as Founderguard. During 4 weeks, 18 horses were fed diets ranging from hay alone to concentrate plus hay in the ratio of 3:1. The rations of half the horses given concentrate were supplemented with Founderguard. Horses eating high concentrate rations displayed abnormal oral behaviours at a higher frequency than those eating only hay. The incidence of these behaviours was reduced when diets were supplemented with Founderguard. The drop in faecal pH of animals on concentrate diets was also reduced by Founderguard. Animals on concentrate diets had an average of 21 kg less gut fill *post mortem*. Dietary supplementation with virginiamycin as Founderguard apparently lessens some behavioural problems associated with management of stabled horses and the intake of grain. It may allow concentrate to be fed at higher levels than customary without adverse behavioural side effects. The suggested mechanism for the improved behaviour due to Founderguard supplementation is reduced fermentative acidosis in the hindgut.

Introduction

Large numbers of horses are kept under intensive management worldwide. Concerns about their performance and welfare arise because a considerable number display behaviours regarded as abnormal because they are rarely seen in unrestrained animals. Depending on which behaviours are included, how they are defined, and the sample studied, the incidence has been estimated at between 7% (Canali and Normando 1993) and 30% or more (McGreevy *et al.* 1995a) of intensively managed horses. The behaviours causing concern are mostly repetitive activities without apparent function, which are therefore usually regarded as 'stereotypies', common ones being 'crib-biting', 'wind-sucking' and 'weaving'.

Despite their prevalence, stereotypic behaviours have not often been studied in horses and little is known about their causes or remedies (Lawrence and Rushen 1993). Stereotypic behaviour has been attributed to a lack of environmental stimulation (Houpt 1986) and to a frustration of natural behavioural drives (Lawrence and Rushen 1993). Horses in stables, for example, may be driven to compensate for inadequate environmental stimulation by self-stimulating, repeated activity. A common belief is that such abnormal behavioural practices are learnt by imitation (Fraser and Broom 1990); however, proof of this has not been given. It has also been proposed that stereotypic behaviours are partly inherited, but this too is difficult to ascertain because of the need to distinguish inherited effects from those learnt from older animals (Vecchiotti and Galanti 1986).

The most common explanations offered for abnormal horse behaviour implicate inadequate physical and social environments. However, intensive management of horses also involves a change in the animals' diet. On being stabled, horses are usually offered hay or chaff with a supplement of grain to replace lost access to pasture. In physiological terms, this dietary change alters oral stimulation, the pattern of ingestion and digestive function. Singly or collectively these could contribute to the development of abnormal behaviours (Houpt 1987; Rushen *et al.* 1993). Effects on horse behaviour of changing digestion have been studied by Willard *et al.* (1977) who found that animals fed a pelleted diet spent more time chewing wood, being coprophagous and searching their stable than those fed hay. Furthermore, neutralising the acidity of the hind-gut of such animals by administering sodium carbonate to the caecum lowered the incidence of stereotypic behaviour, suggesting that acidity in the lower gut may be a stimulus to such behaviour.

The availability of the nontherapeutic antibiotic virginiamycin as the feed supplement Founderguard[1] allows the effect of gut acidity on stereotypic behaviour to be investigated further. Virginiamycin suppresses lactic acid production in the rumen of sheep (Godfrey *et al.* 1995) and in the hind gut of sheep (Godfrey *et al.* 1993) and horses (Rowe *et al.* 1994). The aim of this work was to examine the effect of Founderguard on the behaviour of horses fed a concentrate supplement high in cereal grain; it was hypothesised that a relationship might exist between behavioural responses and pH of the hindgut.

Materials and methods

Animals

Two duplicate trials each involved 9 Standardbred or Thoroughbred horses. The animals were mares or geldings, age

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4–10 years, weighing 400–500 kg. They were purchased after checks for 'soundness' and a verbal assurance of no behavioural problems. After purchase and before the experiments began, animals were monitored in the field for 1 h/day for 7 days to detect behavioural abnormalities. No abnormal behaviour was observed at this stage in any animal.

Feeding

Each duplicate trial involved feeding groups of 3 horses 1 of 3 dietary regimes for 4 weeks. In the first regime, oaten hay alone was fed at 8 kg/day throughout. The other 2 regimes involved feeding decreasing amounts of hay and increasing amounts of concentrate in successive weeks. Each day each animal received 8 kg hay in the first week, 6 kg hay plus 2 kg concentrate in the second week, 4 kg hay plus 4 kg concentrate in the third week, and 2 kg hay plus 6 kg of concentrates in the fourth week. Furthermore, the rations of one of the concentrate fed groups were supplemented daily with Founderguard (containing 1% virginiamycin) during weeks 2, 3 and 4, while the other group received no Founderguard.

The concentrate was a commercial horse supplement[2] containing 43% wheat, 42% barley, 9.3% lupinseed meal, 2% molasses, 3.5% minerals and 0.2% mineral/vitamin premix. The estimated digestible energy (for pigs) was 12.6 MJ/kg, crude protein 12%, and crude fibre 5.5%. Founderguard was added to the feed at 22.5g per day. The daily ration was fed in 2 equal parts, at 0700 h after the first hour of observation, and at 1500 h before the second hour of observation.

Stabling

Horses were housed singly in adjacent wooden stables measuring 4 m square, with walls 1.5 m high over which they could see other animals. In an attempt to limit crib-biting to a single site in each stable, wooden edges except the top of the stable half-door were covered with metal mesh ('Weldmesh', 4 mm diameter steel bars welded at 150 mm centres). An index of crib-biting was set up using the method of Willard *et al.* (1977); a pine board (1140 mm long) bolted to the top of each stable half-door was removed each week and weighed to record the mass of wood removed by biting.

Behavioural observations

Behaviours monitored were based on those described by Fraser (1992) and defined as:

Grasping: biting an object with the incisor teeth, but without removing material or swallowing air.

Wood-chewing: grasping wood and at least briefly chewing it.

Cribbing: biting an object and apparently swallowing air with a gulp; sometimes only the upper incisors are involved with the animal pulling down on these thereby opening the soft palate and sucking air into the stomach (see McGreevy *et al.* 1995b); grasping is often followed by cribbing.

Wind-sucking: apparently sucking air into the stomach without first grasping onto an object; often the neck is arched and the horse performs a nodding motion before seeming to gulp air.

Behaviour was recorded by an observer experienced with horses (J.T.) who limited direct contacts with the animals, did not feed the animals and touched them only when collecting blood and faeces and when weighing them.

Observations were made indoors and outdoors each day. Indoors, stabled horses were observed from a platform 4 m above the stables for 1 h before the morning feed at 0700 h, and for 1 h after the afternoon feed at 1500 h. Each of the 9 animals was observed every 4 min, and note taken of instances of the activities defined above plus others not so defined, which included bed-eating when an animal was seen with hay from the stable floor in its mouth, and stall-licking when a horse had its tongue touching part of the stable.

Outdoors, the handling characteristics of the horses were assessed as they were lead around a set path after morning and afternoon feeds. Behavioural categories were set up to record whether the horses walked or jogged, moved ahead of or behind the handler, and reared or pulled on the lead rope. Checks were also made at these times for lameness.

Measurements of faecal pH, blood parameters and gut fill

Each morning after feeding, horses were weighed and had faeces removed from the rectum. The pH of faeces was measured immediately, by moistening with 1 ml of distilled water and recording the pH with a glass electrode. On the same occasion, 10 ml of blood were collected from a jugular vein via a 19 G needle, once in the first week, twice in the second week, three times in the third week and daily in the fourth week. The animals showed no outward sign of disturbance during these daily checks. Part of each blood sample was subject to standard haematological analysis, while the remainder was frozen and later analysed for D-lactate as described by Rowe *et al.* (1994).

The day after each trial finished, all animals in the group were slaughtered by rifle shot followed by exsanguination. The viscera were weighed to provide an index of gut fill, the viscera being the gastrointestinal tract from oesophagus to anus plus the penis of geldings or the uterus of mares.

Statistical analyses

The data were analysed using the Kruskal-Wallis test to determine overall significance of the treatments in each week. Where significant effects were found the means were compared using the Mann-Whitney U test combined with the Bonferroni procedure whereby the critical probability level ($P<0.05$) was adjusted to compensate for the increased probability of finding a significant result when mutiple comparisons are made (Krauth 1988). Body weights were compared using Student's paired t test and visceral weights were compared by ANOVA. All analyses were done using Statview 4.5 for the Macintosh computer (ABACUS Concepts, California, USA).

Results

Feed intake

Within each 24 h period, all horses ate their entire ration. Horses supplemented with Founderguard were noted to eat their food more slowly; however, eating rates were not quantified.

Body weights

Changes in bodyweight from the first to last days of the 2 trials were +1.0 ± 3.4 kg (mean ± s.e.), -7.7 ± 4.8 kg and -3.0 ± 4.8 kg

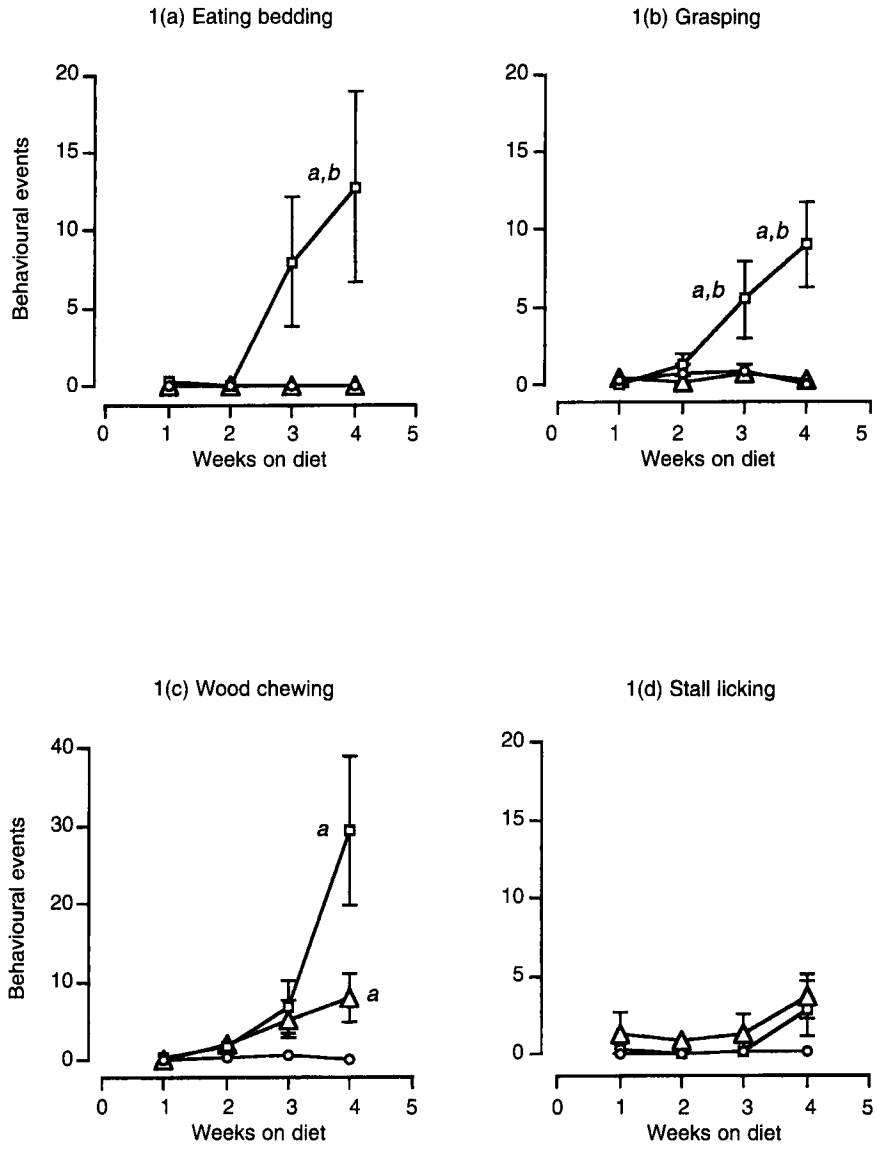

Fig 1: The influence of diet on the behaviour of stalled horses; hay only (○), hay plus concentrate (□) and hay plus concentrate and Founderguard (△). 1(a) Eating bedding; 1(b) Grasping; 1(c) Wood chewing and 1(d) Stall licking. Behavioural events indicate the mean (± s.e.) weekly sum of observations for 2 h every day of the week for the 6 horses in the treatment group. The proportion of concentrate in the ration increased over the 4 week period to finish at 75% in week 4. [a]significantly different to hay P<0.05; [b]significantly different to hay plus concentrate and Founderguard P<0.05.

for the hay, hay plus grain, and hay, grain and Founderguard groups, respectively. These changes were not statistically significant (P>0.05).

Behaviour

During 108 h observation in the 2 trials, 770 instances of categorised behaviour were recorded. The most common were wood-chewing (41%), eating of bedding (17%), grasping (14%), aggression (14%) and stall-licking (8%). In 97 of the 104 observations of aggression, the interactions occurred between 2 particular horses, and the other 7 all involved another particular animal. Aggression was, therefore, treated as the individual behaviour of these specific animals, and no further analysis was made of it. Similarly, analyses were not made of the other 6% of recordings which comprised stall-walking, pawing, stall-kicking and tail-rubbing.

The occurrences of eating bedding, grasping, wood-chewing, and stall-licking are shown in Figure 1. The inclusion of concentrates in the diet significantly elevated the incidence of each behaviour, except stall licking, after 3 and 4 weeks of feeding when the level of concentrates was 50–75% of the diet. Stall licking was a relatively minor behaviour. The inclusion of Founderguard with the concentrate diet prevented the occurrence of eating bedding and grasping, and there was also a clear trend to reduce the incidence of wood chewing.

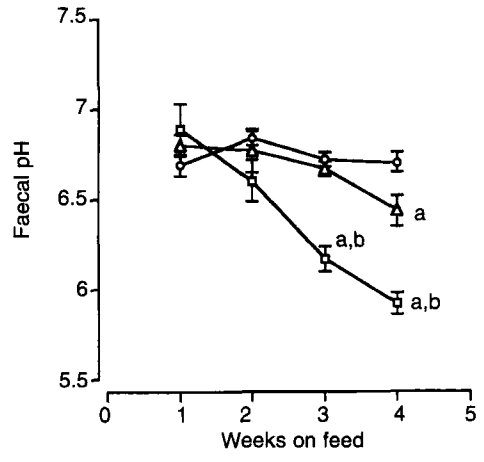

Fig 2: The influence of diet on the mean (± s.e.) weekly faecal pH; hay only (○), hay plus concentrate (□) and hay plus concentrate and Founderguard (△). The proportion of concentrate in the ration increased over the 4 week period to finish at 75% in week 4. [a]significantly different to hay P<0.05; [b]significantly different to hay plus concentrate and Founderguard P<0.05.

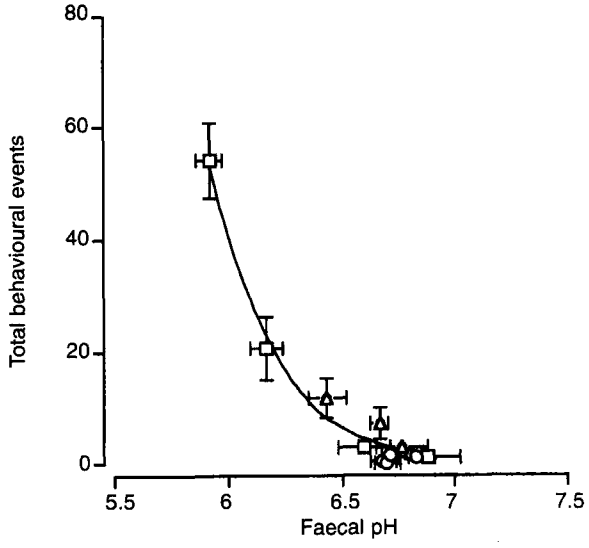

Fig 3: The relationship between the mean weekly faecal pH and total behavioural events of stalled horses; hay only (○), hay plus concentrate (□) and hay plus concentrate and Founderguard (△). Total behavioural events (eating bedding, grasping, wood chewing and stall licking) represent the weekly sum of all such observations during 2 h every day of the week. The relationship between total behavioural events and faecal pH can be described by the third-order polynomial equation shown, with $r^2 = 0.98$.

Quantification of wood-chewing by recording weight loss of pine boards on the stable doors was unsuccessful. There were teeth marks where the animals had been biting, but there was no visible wood loss or recordable weight change. The horses chewed some parts of the stable that were uncovered by mesh, and from there apparently removed some wood.

Outdoors, all horses were equally easy to handle and always walked where guided by the handler. There were no grounds for allocating them to different categories.

Faecal pH

The faecal pH decreased progressively as the inclusion of concentrates increased over the 4 week period with the decline being significant in weeks 3 and 4 (Fig 2). The inclusion of Founderguard prevented this decline at week 3 when the diet contained 50% concentrates. As the level of concentrates increased to 75% (week 4), the inclusion of Founderguard significantly reduced the decline in faecal pH compared to when concentrates alone were fed.

There was a close and negative curvilinear relationship ($r^2 = 0.98$) between the mean weekly faecal pH and the total number of behavioural events recorded each week (Fig 3). A decrease in faecal pH below about 6.2–6.3 was associated with a rapid rise in the incidence of behavioural abnormalities.

Gut fill

The weights of viscera *post mortem* were significantly (P<0.0001) higher for hay-fed horses, at 18.3 ± 0.3 % body weight (mean ± s.e.; absolute weight 86.8 kg), than for horses fed concentrates with or without Founderguard, at 14.0 ± 0.4% (65.8 kg). This represents a difference of 21 kg between hay-fed and 75% concentrate-fed animals. There was no significant effect of Founderguard on visceral weight.

Blood Samples

The concentration of D-lactate was either low or not detectable (<20 μmol/l) in all of the dietary treatments and there was no evidence of any pathophysiological change in haematology.

Discussion

Abnormal behaviours

These observations on stabled horses show that diets low in roughage are associated with increases in behavioural activities that can be considered abnormal viz. wood chewing, grasping, bed-eating and stall licking, which are far less common or absent in free ranging horses. The particular behaviours displayed all had some component of oral stimulation. Locomotor abnormalities such as weaving were not displayed. Whether this is biologically significant is uncertain.

Wood chewing, grasping and bed-eating all increased progressively over the 3 or 4 weeks of the trial. This was apparently due to the increasing levels of concentrate provided (25, 50 and 75%) and not associated with learning or the time in stalls since there was no change in behaviour of animals fed hay only. The effect of feeding duration on abnormal behaviour remains unclear. Founderguard treated animals were subjectively noted to take longer to consume their ration and it is probable that the horses fed hay only also spent longer feeding. These apparently longer feeding times could have led to greater saliva production which could contribute to the recorded neutralisation of gut acidity, however an effect of saliva on hindgut pH seems improbable. The possible shorter feeding time of the horses fed concentrate without Founderguard might also have allowed more nonfeeding time in which to develop abnormal behaviours; more

extensive observations would be needed to establish this.

Effects of Founderguard

Administration of Founderguard led to a dramatic reduction in abnormal behaviour. No other effects were evident; animals ate all their ration, and their demeanour was unaffected.

The most obvious explanation of the effects is that suggested by the work of Willard et. al. (1977), that is, reduced acidosis in the hindgut. The primary mechanism of virginiamycin, the active ingredient of Founderguard , is to suppress lactic acid production from starch fermentation in the hindgut (Godfrey *et al.* 1993). Lactic acid is the primary determinant of a reduced pH during fermentative digestion and the increased faecal pH of horses fed concentrates with Founderguard confirms that the production of lactic acid was reduced in such horses in this experiment. How the reduction in gut acidity could affect behaviour has not been elucidated. It could be simply due to less visceral discomfort with less acidity, or more indirectly to changes in digestive products or in hormones released (Gillham *et al.* 1994) during or following digestion.

A report by McGreevy *et al.* (1995b) indicates that horses do not swallow air when wind sucking. The common reports that wind sucking induces colic, poor condition and interference with feed satiety due to the ingested air, therefore, can no longer be sustained. Perhaps wind sucking, as for the wood chewing, grasping and stall-licking documented here, is a behaviour induced by the lower gut acidosis associated with high grain diets.

Related dietary effects

The effect of Founderguard in reducing abnormal oral behaviour in horses on high concentrate diets suggests, but does not demonstrate unequivocally, that horses can have normal well regulated hindgut fermentation on such diets so long as Founderguard is included. Longer trials, including close monitoring for laminitis are required. Earlier studies (Rowe *et al.* 1994) have already shown that Founderguard can prevent laminitis on diets high in starch.

The consequences of having horses able to live and work on rations containing 75% concentrate could be considerable because of reduced gut fill. Visceral weights of horses eating concentrates were on average 21 kg less at slaughter than those of animals eating hay, though total body weight differences between the groups up to the previous day were less than this. A reduction in gut fill arising from eating a high-concentrate diet could have significant consequences for exercise performance.

In conclusion, this work suggests that when horses are fed diets high in starch the control of hindgut acidosis with Founderguard can reduce the incidence of abnormal behaviours.

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Manufacturers' addresses

[1]Vet Search International, North Rocks, NSW 2151, Australia.
[2]Glen Forrest Stockfeeders, Western Australia.

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