The horse's behavioural and welfare needs for optimal foraging opportunities

Horses are herbivores and are designed to eat a diet high in fibre and low in starch, obtained through freedom of movement to select and forage from a diverse range of plants in the company of other horses. Forage fed to domesticated horses is often provided in various devices designed to replicate more natural feeding patterns, but can result in frustration behaviours even though horses are adept at learning to manipulate such devices to surmount feeding challenges. Because domesticated horses are often required to perform in a range of spheres, which in turn requires higher energy output, many horses have their fibre rations restricted in favour of feeding high-starch substrates. This can lead to significant changes in the microbial environment of the gut, which compromises gastrointestinal health and can cause a range of undesirable behaviours. Diet-related disorders such as gastric ulcers are commonly seen when restricting forage rations and/or overfeeding starch in the horse, and behavioural consequences include frustration-related behaviours, aggression and oral and locomotory stereotypies, all of which compromise the horse's welfare. Meeting the behavioural needs of the horse by giving them agency to access the 3 Fs – friends, forage and freedom – is inextricably linked with their natural feeding behaviour. It is fundamental to ensure that horses are provided with the opportunity for positive feeding experiences to improve both physical and mental welfare.

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All horses have a range of behavioural needs that must be met for adequate homeostasis, both for physiological and mental wellbeing. The Five Domains model (Mellor et al, 2020) acknowledges the wealth of research available to discuss the impact of behavioural interactions and nutritional conditions on animal welfare. It recognises both positive and negative emotional states with regards to whether caretakers meet the animal's needs through the minimum standard of care, or proactively seek to enhance welfare by making small changes to their management. The 3 Fs – access to friends, forage and freedom, originally discussed by Fraser (2012a; 2012b; 2012c) – are now a popular term that focuses on three of the top behavioural priorities of horses. These are reiterated within the Five Domains model (Mellor et al, 2020), in that horses need to have opportunities for adequate nutrition, as well as positive experiences in the ability to chew for prolonged periods of time and gastrointestinal comfort (Mellor et al, 2020). All too often, forage rations are limited, and horses may experience a range of gastrointestinal issues as a result (Hesta and Costa, 2021). Having agency over free movement to explore their environment and engage in social behaviour with conspecifics, such as socially facilitated periods of foraging (Mellor et al, 2020), are key aspects of ensuring that the 3 Fs are provided for. This article discusses the impact of modern feeding practices on the behaviour and welfare of horses.

Nutritional vs behavioural needs

Horses have evolved to consume large amounts of forage and are therefore highly motivated to eat (Baumgartner et al, 2020). Naturally, horses would spend a large portion of their day engaged in the search for food and its subsequent consumption, although these opportunities are often restricted in the domesticated horse (Benhajali et al, 2009). Although most rations are carefully balanced to meet the horse's nutritional requirements, modern management strategies may not consider the behavioural elements of feeding and thus represent a welfare challenge (Horseman et al, 2016), by limiting the horse's access to the 3 Fs. This is because of changes to the type, amount and rate of food availability, as well as horses being stabled for long periods of time with restricted

access to forage and grazing. Horses that are regularly stabled and fed large amounts of starch-rich concentrate meals are likely to be frustrated and lack stimulation, the effects of which may be difficult to differentiate from those of thwarting their behavioural needs (Hothersall and Nicol, 2013). These topics are further discussed in this article.

Many horses and ponies have restricted access to forage, particularly grazing and reduced turnout time. While the key aim is to maximise forage availability to meet the minimum recommended daily intake of 1.5% of bodyweight in dry matter per day (Harris et al, 2017) to avoid gastrointestinal issues and behavioural frustration, simply providing forage is not enough. Ponies given ad libitum access to short-chopped forage showed a reduced rate of intake when compared to those on restricted diets (Dugdale et al, 2010), while horses fed low-fibre pelleted diets were more motivated to work for hay and the opportunity to increase their chewing rates (Elia et al, 2010). Turnout on grass offers the ability for horses to graze, move and potentially socialise, thereby accommodating the 3 Fs in a low-cost, low-labour management system. In a study by Weinert et al (2020), horses with 24-hour access to either pasture or hay spent approximately 3 hours longer eating when on grass than hay, and also demonstrated a higher chew rate and increased movement.

In a survey generating behaviour data for 890 horses in the UK, feeding-related behavioural problems were demonstrated in 70% of horses, including frustration behaviour (49%), aggressive behaviour (44%) and stereotypic behaviour (39%) (Hockenhull and Creighton, 2014a). Horses kept stabled with restricted access to forage were more likely to show frustration behaviour than horses that had unrestricted access to forage when stabled or horses that lived out. Despite the increased behavioural opportunities that turnout provides in terms of the 3 Fs, turnout options are limited in many equestrian settings as a result of a lack of (suitable) land available, and potentially the anthropomorphic tradition and preference for humans to want to house their horses in stables, seen as places of safety and comfort (Hockenhull and Furtado, 2021). Stables socially isolate horses, inhibit their options for free choice-decisions over feed intake, restrict their movement and vastly limit behavioural opportunities (Chaya et al, 2006). Socially isolated horses with no access to grazing turnout or social contact are seen as having suboptimal welfare (Horseman et al, 2016) so horse caretakers need to reconsider their views of stabling and which other management options may better provide for their horse's behavioural needs and welfare.

While many caretakers are concerned that social turnout may increase the risk of aggression-associated injuries (Hartmann et al, 2009), this can be avoided by reducing the risk of resource-guarding agonistic behaviours. In contrast to domestic horses, resource-guarding behaviours are rarely seen in feral and free-roaming horses as food is typically unrestricted (Fureix et al, 2012). Benhajali et al (2009) observed reduced agonistic behaviour in densely grouped mares kept in a paddock when given the opportunity to forage ad libitum, as well as an increase in positive social interactions such as allogrooming. Hartmann et al (2009) saw reduced aggression in newly introduced horses that had been pre-socialised in neighbouring stables, but noted that they had adequate space and unrestricted resources. Therefore, it is possible to minimise the risk of injury by ensuring unrestricted access to forage during turnout, so that horses do not feel frustrated or the need to aggressively protect limited resources. If forage needs to be supplemented during turnout to compensate for inadequate grazing, or for horses on alternative turnout surfaces such as dry lots or track systems, it is important to ensure that the extra forage is available at all times, in sufficient quantities and in multiple locations relative to stocking density. Hartmann et al (2009) also observed that the horses showed clear individual differences in aggression levels, and it is worth remembering that, although providing unrestricted access to forage may help mitigate aggressive behaviour, this is not the only possible cause of aggression in horses.

Choice and control

Domestic diets are far removed from those of free-ranging horses, where they would be grazing for up to 81% of the day on a diet of low-quality forage (Boyd and Keiper, 2005), although there is much variation in natural feeding patterns in different horse populations depending on several factors as reviewed by Ellis (2010). The diversity of the species grazed and browsed would be high as a result of the horse's freedom to move, choice to select what they consumed and ability to control their intake volume to satisfy their energy requirements and gut fill. Most modern diets provide little variety and lack the options for the horse to select from to satisfy different sensory qualities. Thorne et al (2005) found that horses provided with a variety of forages to choose from spent longer foraging and indicated individual preferences for specific forages, suggesting that the opportunity for choice and control of intake was enriching.

Other studies have investigated the effects of different flavours on the consumption choices of both water (Mars et al, 1992) and feed (Cairns et al, 2002; Goodwin et al, 2005; van den Berg et al, 2016a), with some horses indicating a preference for novel flavours provided by fruits, herbs or spices. Therefore, organoleptic characteristics of forages such as taste, odour and texture do appear to be of importance in the selection of forages for consumption (van den Berg et al, 2016b) and extends to other substrates, which is a valuable tactic to consider when catering for horses with a reduced appetite.

Presentation and restriction of feed

Foraging behaviour itself involves movement to search for preferred foods, as well as apprehending the food and consuming it (Goodwin et al, 2002). The natural grazing behaviour of the horse is to take a few bites of grass then take one or several steps and repeat the searching and eating pattern (Elia et al, 2010), in which horses have the choice over which direction they take and which plants they select to eat. As well as grass, horses will also ingest trees and other wooden substrates, especially when fed high concentrate/low forage diets (Willard et al, 1977), during feed restriction (Curtis et al, 2011), or when stabled with no exercise or turnout (Krzak et al, 1991). van den Berg et al (2015) undertook a survey looking at the habits of domesticated Australian horses. They found that 73% of horses browsed various parts of trees, shrubs and vegetation other than grasses and legumes, although

it was unclear whether this was as a result of reduced food availability or a preference for variety in the diet. The authors state that this is the first study to document this behaviour in domesticated horses, although various studies discuss browsing of a wide variety of plant species in feral and free-roaming horses.

Presentation of forage

Presentation of forage has an influence on consumption rates and behaviour in horses given rationed forage, as this often reduces the choice and control that horses have over natural foraging behaviours. Feeding hay from the floor was the preferred feeding position indicated by horses in a study by Webster and Ellis (2010), where hay was placed loose on the floor and an equal amount above that in a haynet. Horses did also eat from the net, showing alternating preferences in feeding height, or potentially allowing for better visual opportunities while feeding, as suggested by the authors. There are many slow-feeder devices available for a variety of feeds that aim to prolong time spent eating a restricted forage ration, through increasing opportunities for movement and challenges for manipulating the forage from the device. However, not all of these methods provide opportunities for selection of preferred forages, unless horses are offered cafeteria-style feeding options, as studied by Goodwin et al (2002), whose results showed that multiple feeding stations increased time spent foraging and feeding through varied selection of preferred substrates.

Above ground forage devices

Devices designed for long stem forages, such as hay, haylage and straw, include haynets, bags and less flexible hay mangers, as well as an increased range of more recently marketed large volume forage holders often termed 'slow-feeders'. Research into various devices has given insight into whether these options increase foraging opportunities and promote an improved range of desirable behaviours, but have also found that there are some adverse effects that mean these devices should be used with careful consideration. Haynets prolonged consumption time when hay was presented in nets with smaller hole sizes (Ellis et al, 2015a), or when hay was presented in multiple double-layered haynets (Ellis et al, 2015b) and reduced total forage consumption when haynet hole size was reduced (Glunk et al, 2014). This is especially important when considering the findings of Luthersson et al (2009) – that the risk of non-glandular gastric ulcer development increases when the interval between forage feeding is more than 6 hours. Horses would naturally not interrupt feeding for more than 3–4 hours (Ellis, 2010); therefore, ensuring that forage rations provide sufficient opportunity to allocate time to feeding behaviour is vital for optimal health and welfare. However, such devices require learning and often force in their manipulation to access the forage within, and may be linked to an increase in frustration and discomfort behaviour.

Rochais et al (2018) found that horses spent more time feeding but displayed higher levels of discomfort behaviours such as frustration directed at the device, pawing, yawning and vacuum chewing when eating from hay bags than when eating hay presented in a more natural feeding position from the floor. Using slow-feeders increased time spent eating and reduced the expression of stereotypic and frustration behaviours. Correa et al (2020) evaluated the effect of a slow-feeder, the design of which resembled a cross between a hay bag and a haynet, oblong in design with a solid fabric back and square holes at the front. They found that horses spent longer eating and also had to alter the way in which they manipulated the hay from the bag; the authors suggested that this simulated grazing behaviour. Horses were observed to shake the bag during initial feeding sessions, which could be seen as frustration, but the authors also suggested that this was a more insightful behaviour enabling the horses to shake the hay through the holes for easier manipulation. These are interesting interpretations, and horses do appear to be capable of adapting their behaviour to manipulate food from challenging device designs. Horses have to operantly manipulate hanging devices such as haynets and hay feeders to find an appropriate hole to pull the food from, which may increase frustration depending on whether or not they are successful in obtaining forage with these efforts. Some horses may adapt their behaviour quickly and be reinforced by success, while unfruitful attempts could be seen as negative punishment, which can lead to frustration. Horses who were unsuccessful in completing visible and invisible displacement tasks had higher heart rates and performed more behaviours indicative of frustration than successful horses (Rørvang et al, 2021). The authors suggested that increased frustration and arousal could lead to a negative feedback loop and affect motivation in future efforts.

Haynets and hay bags provide forage above ground and thus encourage eating in an abnormal position, affecting the horse's posture and increasing the force required to extract forage from the haynet, which may negatively impact the dental and musculoskeletal systems (Hodgson et al, 2022; McAteer et al, 2023). Devices have also been designed for pelleted forages (such as alfalfa, grass and hay) and combined forages; these are often small, plastic objects with a single or multiple holes which can dispense pellets when manipulated by the horse. Such devices can also be filled with short stem forages such as chaff, and any other hard feeds and foodstuffs that have a small enough particle size, promoting trickle feeding of more palatable feeds that are often consumed rapidly.

Goodwin et al (2007) compared the use of round, square or polyhedral foraging devices containing high fibre pellets. Noted effects on behaviour included the ability to manipulate the devices, and frustration in doing so, observed through pawing and biting the devices. The devices were confined within feed bowls or mangers, and thus were perhaps not able to be as easily manipulated as they would be free on the floor of the stable. Several horses did knock them out of the manger, perhaps through frustration or manipulation as identified by the authors, or potentially as a solution to increase the chance of obtaining food, or even to be able to move the device more freely and use the space in their environment. The dimensions of a typical stable would limit the amount of movement horses could reasonably achieve in recreating natural foraging movement, and while many foraging devices are designed as 'stable toys', their use in turnout situations should also be researched to determine the potential for a greater range of locomotory effects. The greatest frustration was observed when the device was empty, suggesting the horses were not satiated or perhaps were frustrated that the activity ending was beyond their

control. The duration of the study was not mentioned, but long-term studies may find that horses learn to associate the change in sound of the object being empty and therefore stop manipulating it, as observed by Henderson and Waran (2001), who found that horses disengaged with a feeding device once it was empty, only moving it periodically as if to check if it had been refilled. This indicates that they understood whether or not it still offered reinforcing opportunities, and that novelty alone was not sufficient to promote interaction. Henderson and Waran (2001) studied horses using an Equiball (a large oval-shaped food-dispensing device) filled with high-fibre pellets, and determined that the device encouraged several feeding patterns: using the ball immediately until empty, alternating between using the ball and eating hay or eating all hay first followed by use of the ball to obtain the pellets. This suggests differing patterns of motivation for two different types of forage-based feeds, as discussed by Elia et al (2010).

In a study by Kutzner-Mulligan et al (2013), horses were given feed in buckets with balls added to simulate adding rocks to feeds to slow consumption, and in another design the bottom of the bucket had small 2.5 cm deep wells that the horses had to manipulate feed from. The researchers observed an increase in time spent feeding for both treatments, but over the study period of 4 days, this time decreased, indicating that the horses were adapting their feeding behaviour to be able to apprehend the food more efficiently. Similar results were seen by Carter et al (2012) who appraised the use of the Pre-Vent Feeder, a bucket with 8.9 cm deep wells in the bottom. Of nine horses in the study, three showed some pawing behaviour which the authors proposed could have been as a result of frustration or to help shake the food loose from the wells, similar to the problem-solving behaviour suggested by Correa et al (2020). Frustration may have been apparent, as this bucket design required horses to obtain the food using their tongues and lips in a different way to feeding from a flat-bottomed bucket as they were accustomed to, although they quickly adapted and obtained food more quickly with repeated trials.

More long-term studies to measure the duration of apparent positive and negative effects of novel feed devices on feeding efficiency and frustration behaviour are warranted in feeding devices designed for both long-stem forages and pelleted feeds. Frustration is likely to result in undesirable behaviours such as conflict, displacement and aggression (Pannewitz and Loftus, 2023), but these may be hard to link to causes such as feeding position and restriction, whereby observation of behaviours before, during and after eating could give insight into the relevant emotions associated with feeding and the consequences for the horse. Ricci-Bonot and Mills (2023) identified more subtle facial characteristics indicative of the negative emotional states such as frustration and disappointment during a series of feeding tests. Blinks, nostril lifts, tongue shows, chewing and licking the feeder were associated with signs of disappointment, while eye white increases, rotating ears, turning the head left and biting the feeder were more likely to be seen when horses were frustrated. When given a feed device, horses have control to access the food when they choose to, but their attempts may be frustrated depending on the complexity of the device and how quickly they can learn to successfully manipulate it.

Grazing muzzles

Grazing muzzles have been demonstrated to decrease grass intake by 29% (Glunk et al, 2012) and 83% (Longland et al, 2011a). Restrictive methods to reduce grass intake may lead to the adaption of intake behaviour, seeing rebound effects in horses. Horses and ponies were observed to adapt their grazing behaviour and eat more quickly when turnout time was restricted than when allowed to graze ad libitum (Longland et al, 2011b; Glunk et al, 2012), with ponies increasing their consumption rate and ingesting nearly 50% of their daily requirement in only 3 hours (Ince et al, 2011). Ponies also adapted to the restriction of a muzzle over time and increased their consumption rate leading to weight gain after only 2 weeks of wearing a muzzle for 10 out of 23 hours access to grazing, indicating either adaptation to grazing through a muzzle or compensatory eating when unmuzzled (Longland et al, 2016).

Grazing muzzles may also affect the behaviour of horses and ponies through the association with wearing a muzzle. Anecdotally, owners reported difficulty catching horses when turned out to fit muzzles for periods of time, evasive behaviour when putting muzzles on, and horses frequently damaging or removing muzzles, all of which may indicate a negative association with the experience of wearing a muzzle, potentially as a result of discomfort and/or frustrated feeding attempts. Davis et al (2020) did not document any aversion to muzzle fitting in the miniature horses in their study until 3 weeks into the trial. Physiological findings in this study suggested reduced stress over this time period, indicating that horses were not physiologically stressed by wearing the muzzle, but perhaps showed behavioural aversion to having the muzzle applied for other reasons. Longland et al (2016) documented one pony modifying the opening in the muzzle and having to replace it frequently, and resentful behaviour when having the muzzle fitted in another pony in their study. They also noticed a change in the second pony's behaviour when muzzled, spending more time resting or engaging in non-feeding directed behaviour. This pony also lost weight and did not show the compensatory post-inhibitory grazing behaviour shown by others in the study, suggesting a possible reduced motivation to attempt to eat as a result of a negative feedback loop from frustrated attempts, as discussed by Rørvang et al (2021).

Davis et al (2020) found that wearing a grazing muzzle decreased locomotion and affected resting behaviour. Resting behaviour increased when muzzled for 10 hours per day, but decreased when muzzled for 24 hours per day. Horses also foraged less when only muzzled for 10 hours than they did when muzzled for 24 hours, showing that horses adapt their behavioural time budgets to different situations to favour essential maintenance behaviours in order of priority, with foraging being more important than rest and movement here. This also suggests that horses learn to adapt to routines, putting less effort into trying to forage when muzzled, which is indicative of learned helplessness, and readjusting their time budgets accordingly. Davis et al (2020) also found that after initial weight loss, ponies gained weight several weeks into the trial, supporting the evidence that horses can learn to adapt their feeding behaviour when wearing restrictive devices as found by Longland et al (2016). This shows behavioural flexibility and enables horses to learn to predict consistent management

routines and as such adapt their behaviour throughout the day to meet their behavioural needs.

Potential links between diet, gastrointestinal disorders and behaviour

Diets which are high in rapidly fermentable carbohydrates that reach the hindgut, such as starch and sugar, have a major impact on the balance of microbiota in the hindgut (Julliand and Grimm, 2017; Garber et al, 2020). Of key concern is the effect of increasing populations of harmful lactic acid-producing bacteria and the reduction in overall bacterial diversity (Hansen et al, 2015; Warzecha et al, 2017). Although the benefits of feeding fibre to replace starch has been well documented to promote gastrointestinal health and welfare, many horses are still fed a high-starch diet which can cause significant changes in the equine gut environment (Raspa et al, 2022). High levels of starch disrupt the hindgut, leading to acidosis, decreased microbial diversity and unstable colonies of bacteria (Al Jassim and Andrews, 2009; Julliand and Grimm, 2017), whereas high fibre diets have the opposite effects (Hansen et al, 2015; Julliand and Grimm, 2017). The microbiota in the horse's gut can affect physical and mental wellbeing, with mental stress potentially affecting the gut–brain axis (Mach et al, 2020). Horses fed low-fibre/high-starch diets show altered composition of the gut microbiota and increased behavioural reactivity, including hypervigilance and alertness (Bulmer et al, 2019; Destrez et al, 2019; Mach et al, 2020).

Mach et al (2020) also determined that oral and locomotory stereotypies, aggression and withdrawal behaviours were related to the composition of faecal microbiota in 185 sport horses evaluated in their study. All horses were housed individually, with no turnout, fed a concentrate and hay diet and in varying levels of training for their discipline, with some experiencing travel to competition, representing the management of many animals in the sport horse population. In a systematic review by Homer et al (2023), changes in microbial population were correlated with aggression and fear in research on pigs, dogs and horses. Homer et al (2023) identified a difficulty in distinguishing between cause and effect in relation to microbial population shifts and undesirable behaviour: does abnormal behaviour alter the microbiome, do changes in the microbiome influence the expression of abnormal behaviour, or is there another confounder affecting horses displaying abnormal behaviour that impacts the microbiome? Garber et al (2020) reviewed a wide range of environmental and biological factors affecting the equine microbiome, including the effects of nutrition and management, medication, age, disease and stress, and many studies are providing clearer links to elucidating the relationship between diet, the microbiome and equine behaviour.

Reduced microbial diversity is also associated with a higher predisposition to pathogens (Hesta and Costa, 2021), putting these horses more at risk of gastrointestinal dysfunction and discomfort. Equine gastric ulcers, as well as colic, insulin dysregulation, equine metabolic syndrome, laminitis, pituitary pars intermedia dysfunction and developmental orthopaedic disease, may be caused and exacerbated by diets high in starch as well as other risk factors (Nadeau et al, 2000; Archer and Proudman, 2006; Hoffman, 2009; Scantlebury et al, 2015; Andrews et al, 2017; Banse and Andrews, 2019; Hewetson and Tallon, 2021). Horses with restricted access to continuous grazing are more likely to develop gastric ulcers (Videla and Andrews, 2009).

Low-forage diets are commonly implicated in the development of stereotypic behaviours (McGreevy et al, 1995; Lesimple et al, 2016; Rochais et al, 2018). In a systematic review by Seabra et al (2021), the authors identified several themes related to the 3 Fs implicated in stereotypy development and prevalence. These included providing high levels of concentrate feed, reduced feeding time, confinement, not having access to pasture or paddock, limited roughage and social isolation. The results were dependent on multiple environmental and biological factors, with varying results documented in the 18 studies reviewed as a result of differences in experimental design.

Both weaving and cribbing behaviours are likely to be observed in every hour of a 24-hour period of observation, with cribbing rates typically higher than those seen in weaving horses (Clegg et al, 2008). It is more common to see weaving behaviour performed pre-prandially in anticipation of the arrival of food (Clegg et al, 2008), triggered by stimuli such as other horses eating or cues indicating the arrival of food (McBride and Hemmings, 2005), thus indicating frustration because of food restriction (Hockenhull and Creighton, 2014b). Weaving usually ceases to be performed once the horse is provided with the means to meet their behavioural needs (such as food arrival and ingestion) (Roberts et al, 2017). Cribbing behaviour may be seen in anticipation of food and is often exacerbated by the arrival and consumption of food (Clegg et al, 2008), indicating a different motivational process, whereby cribbing is a self-reinforcing behaviour that becomes habitual and therefore harder to stop by simply providing food (Roberts et al, 2017).

Various studies discuss the potential link between cribbing behaviour and gastric ulcers. Gastric ulcers were found in a group of cribbing foals (Nicol et al, 2002), and Waters et al (2002) observed that concentrate feed stimulated cribbing behaviour and coincided with the development of gastric ulcers in foals. It was reported that cribbing horses produced less saliva than non-cribbing controls (Moeller et al, 2008). Therefore, these horses could perform the repetitive action of cribbing in order to stimulate greater saliva production and buffer gastric acid that is implicated in the irritation of gastric ulcers (Nicol, 1999), subsequently alleviating the discomfort caused by gastric ulcers and reinforcing the cribbing behaviour. However, Houpt (2012) found no difference in the saliva production in cribbers vs non-cribbers, concluding that while cribbing did not stimulate saliva production, the stimulation of gastric secretions was likely to lead to ulcer formation. Wickens et al (2013) observed an increase in gastrin production following concentrate meals consumed by horses that crib bite, but found no difference in gastric ulcer prevalence between cribbing and non-cribbing horses. Daniels et al (2019) found no difference in gastric anatomy in cribbers and non-cribbers, and suggested that it was more likely that similar environmental and physiological stress links gastric ulcers and cribbing. While it is difficult to bring together these differing findings, it remains a fact that cribbing and gastric ulcers are commonly seen in horses, and that links to an inadequate diet and other potential stressors are well documented

KEY POINTS

- Horses have evolved to feed on a high-fibre/low-starch diet.
- Gastrointestinal health and welfare are compromised when starch is fed at rates that the equine gastrointestinal tract cannot cope with.
- Domestic diets often do not replicate those of free-ranging horses.
- If the behavioural needs of the horse are not met through their diet and how food is provided, emotional wellbeing is compromised and undesirable behaviours may develop as a way of coping with the deficit.
- Diet-related gastrointestinal disorders (such as microbial disruption and gastric ulcers) increase stress, compromise welfare and may result in undesirable behaviours such as frustration-related behaviours, aggression and stereotypies.
- Feeding management should aim to increase behavioural opportunities through enriching the horse's environment to meet their behavioural needs and enhance welfare.

in both of their causations. By increasing the opportunity to forage and prolonging time spent on foraging activities it may be possible to decrease stereotypies, thus improving welfare (Seabra et al, 2021).

In order to reduce starch levels and still provide an energy-dense ration for performance horses, commercial formulations that are high in fat and rapidly fermentable fibres (and thus provide similar energy levels) are becoming a popular choice for horses with gastric ulcers and other feed-related disorders. Replacing high starch levels in diets with high levels of fibre and/or fats has shown benefits on behaviour, which include engaging in more relaxed locomotory and continued grazing behaviours, with reduced vigilance and behavioural reactivity to arousing stimuli (Nicol et al, 2005; Bulmer et al, 2015), and a reduction in coprophagy and aggressive behaviour (A Zeyner, unpublished dissertation, 2002). These findings may be relevant to the horse in other situations where behavioural reactivity has been exacerbated by a high starch diet, and as such reducing starch and increasing fibre rations should be considered for horses with behavioural problems as well as gastrointestinal challenges.

Conclusions

There is a large amount of research available on natural feeding behaviour, the efficacy of devices designed to replicate these behaviours and the impact of diets containing high-starch/low-fibre rations on gastrointestinal health. Lack of forage appears to be the biggest issue at the foundation of both gastrointestinal and behavioural problems, with some findings highlighting the possible frustration and discomfort associated, particularly when accessing forage is challenging. More research to determine the effect of physical discomfort on the emotional wellbeing and behaviour of the horse will help to further clarify these links and causal factors. Although modern feeding practices are starting to reflect the research regarding improved feeding strategies for horses with a compromised gastrointestinal tract, the aspects of natural feeding behaviour that are required to fulfil the behavioural needs of the horse may not always be so well reflected in these methods. Thinking about the 3 Fs is one of the simplest ways to consider behavioural wellbeing in the horse – not only must equine caregivers meet their nutritional requirements for good health, they must do it in a way that will offer positive opportunities for horses to experience good welfare. This can be done by ensuring adequate choice of forage, prolonging feeding time and using strategies to mimic natural behaviours in a low stress way, in conjunction with providing the horse with freedom to move and locate these resources in the company of conspecifics. EQ

Conflicts of interest

The author declares that there are no conflicts of interest.

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