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An investigation into restricted grazing techniques in the UK and their impact on equine welfare

An Investigation into Restricted Grazing Techniques in the UK and their Impact on Equine Welfare

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Abstract

Most domestic horses in the UK are grazed on pasture cultivated for production animals, which have contrasting energy requirements to horses. Health issues (e.g. obesity, laminitis) can develop due to excessive energy-rich grass consumption, therefore horses may require restricted grazing. Little research exists on restricted grazing methods' (RGMs') efficacy at managing health issues or on potential welfare implications. An online questionnaire was distributed via social media resulting in 503 responses. Strip grazing was tried most frequently (67.6%). Respondent perception of welfare impact differed significantly between methods ($P<0.001$), with strip grazing considered to negatively impact welfare least and stabling most. Perceived welfare impact was not associated with the methods being used by respondents, suggesting owners may be unable to use their preferred method. Indeed, 24.0% reported yard restrictions determined how they managed their horses, while ease of implementation influenced the initial decision of which method to use for 52.3%. Next, the behavioural impact of two forms of strip grazing was evaluated in an intervention trial of 11 ponies (control n=4, condition 1 n=3, condition 2 n=4). There was no significant difference in the overall percentage of scans ponies in any condition were observed grazing, though time of day ponies grazed most varied between control and strip grazed conditions. Ponies in the strip grazed conditions were recorded grazing new grass (available daily once strip moved, not available to control ponies) during the greatest percentage of scans, as opposed to grass in other areas of the field ($P=0.002$). There was no difference in performance of stress-related behaviours between conditions, though this was a small trial and a larger sample may have yielded differences. Further research is required to establish whether scientific evidence supports owner-reported effectiveness or negative impacts of different RGMs, so the best advice can be made available and equine welfare optimised.

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Author’s Declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's *Regulations and Code of Practice for Research Degree Programmes* and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

SIGNED: DATE: 06/04/20

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List of Abbreviations

ANOVA	Analysis of Variance
BHS	British Horse Society
CI	Confidence Interval
DEFRA	Department for Environment, Food and Rural Affairs
DMI	Dry Matter Intake
EGUS	Equine Gastric Ulcer Syndrome
EMS	Equine Metabolic Syndrome
HSD	Honest Significant Difference
IBM	International Business Machines
MCQ	Multiple Choice Question
MD	Mean Difference
NEWC	National Equine Welfare Council
NRG	Non-restricted Grazer
NSC	Non-structural Carbohydrate
PPID	Pituitary Pars Intermedia Dysfunction
RG	Restricted Grazer
RGM	Restricted Grazing Method
SPSS	Statistical package for the Social Sciences

1. Introduction

1.1. Background

The grass most domestic horses are kept on has been cultivated as cattle pasture, meaning it is much more energy rich than the forage diet horses have evolved to eat, especially for native ponies, most of which were bred in regions of sparse vegetation (Eustace 1992). Contrastingly, grass species bred for the cattle industry have been selected for increased nutrient density and extended grazing period, with the aim being to increase milk and meat production (Watts 2004). Therefore, horses may need their access to grass restricted to prevent health problems, the primary examples being laminitis and obesity, which are both prevalent and serious issues faced by the UK leisure horse population (Pollard *et al.* 2019a; Robin *et al.* 2015), with laminitis being the second biggest killer of horses in the UK (Harrison & Murray 2016). This painful and sometimes life-threatening condition may result in chronic lameness (Harris *et al.* 2006), while Luthersson *et al.* (2017) found 30% of horses diagnosed with laminitis had been euthanised within twelve months of diagnosis due to associated reasons. It is thought that approximately 90% of cases of laminitis have an underlying hormonal cause, of which the metabolic disorders Pituitary Pars Intermedia Dysfunction (PPID) and Equine Metabolic Syndrome (EMS) are examples (Karikoski *et al.* 2011). These conditions result in abnormal hormone levels and insulin resistance, making horses more at risk should they be allowed to consume excessive carbohydrates (e.g. concentrate feed or energy-rich grass), as this can result in a carbohydrate overload which in turn can trigger laminitis (Pollitt 2001). Furthermore, insulin resistance can reduce glucose availability to the laminae, the tissue supporting the pedal bone in the hoof (Treiber *et al.* 2006), leading to the inflammation and separation of these tissues (laminitis) (Pass *et al.* 1998). Grasses cultivated for cattle tend to have a high non-structural carbohydrate (NSC) concentration, examples being fructan and other simple sugars, which have been implicated in the causation of laminitis (Watts 2004). Constant access to pasture can also lead to obesity (Longland *et al.* 2016b), and the prevalence of this disease in the UK leisure horse population is estimated between 27.08% and 35.41% depending on season (Giles *et al.* 2014). Obesity is a risk factor for laminitis and other health conditions such as osteoarthritis (Wyse *et al.* 2008) and insulin resistance (Hoffman *et al.* 2003).

Improved forage management can reduce the risk of horses developing laminitis (Kane *et al.* 2000); prevention is more effective and cheaper than treating the condition once it occurs and will spare horses from unnecessary pain (Redden 2004). Common methods used to try and prevent laminitis include the use of grazing muzzles, stabling, strip grazing, 'starvation' paddocks, crew yards and track systems, all of which work by limiting horses' access to grazing. Owners may also limit their horses' access to grass as a method of pasture management, for example to prevent overgrazing or the

pasture becoming churned up during periods of wet weather which causes damage that can have long recovery times (Beukes *et al.* 2013). However, despite the scale of the issue given potential implications of allowing excessive pasture access, research on how best to limit grazing and tackle this issue is greatly lacking. Furthermore, as the cattle industry funds the majority of research into grazing science (Watts 2004) and there is a lack of research funding into the requirements of leisure horses, this is unlikely to change. Much of the research that is carried out into equine nutrition is also funded by the performance horse industry, but these horses are likely to have much greater energy needs than the general equine population which includes retirees, companions and horses ridden for recreation (Watts 2004). To better understand the implications of restricting access to grazing on equine welfare it is important to recognise how horses have evolved to live and feed naturally.

1.2. Natural Behaviour

Horses are trickle feeders, naturally grazing 16-18hrs/day (Cooper *et al.* 2005) and rarely voluntarily going without eating for more than 3hrs (Ellis *et al.* 2015). Horses able to continuously graze at pasture have a decreased prevalence of equine gastric ulcer syndrome (EGUS) compared to those fed intermittently, as during grazing there is a continuous flow of saliva and ingesta that buffers stomach acid (Videla & Andrews 2009). Horses only produce saliva when they chew (Moeller *et al.* 2008). When feed is withheld from horses, gastric pH drops rapidly, and the non-glandular mucosa is exposed to an acid environment (Murray & Schusser 1993). This poses a problem for owners trying to restrict their horse's grazing, as they must not do this to such an extent that other health issues are caused. Additionally, horses would naturally get exercise whilst foraging, with Hampson *et al.* (2010) finding feral horses travelled an average of 17.9km/day. Several restricted grazing techniques tend to involve limiting space, which should be considered especially if weight loss is the goal as horses' ability to exercise independently will also be restricted.

Furthermore, horses are a highly social prey species whose main defence mechanism is flight (Goodwin 1999). Motivation to seek out and spend time with conspecifics is high as evolutionarily group living was an essential part of the horse's survival strategy (Goodwin 1999); domesticated horses have not lost any of the social behaviour shown by wild ancestors (Christensen *et al*. 2002). Horses have a subtle method of communication where visual signals and body language are very important (Goodwin 1999), as is touch (Gourlay 2014), and can recognise conspecifics based on unique visual, olfactory and auditory information (Proops *et al.* 2009). Social integration between unrelated females can increase foal birth rates and survival, as well as reduce harassment by males (Cameron *et al*. 2009), demonstrating social bond formation has direct fitness advantages other than just decreasing risk of predation (Goodwin 1999). Pair bonding, where two horses spend much time in close proximity to each other, following each other and engaging in mutual grooming more often

than with other herd members (Goodwin 1999), is very common. Pair bonds are usually formed between horses of around the same age and rank within the herd (Kimura 1998). Mutual grooming promotes coat care and social affiliation (Crowell-Davis *et al*. 1986) and is a form of communication based on bonds between individuals (Kimura 1998). It can also reduce heart rate (Feh & Mazieres 1993) and is thought to reduce social tension between group members as well as providing reassurance after social conflict (van Dierendonck & Goodwin 2005). Some restricted grazing techniques may limit horses' ability to express natural social behaviour, and therefore have the potential to impact their psychological welfare, for example muzzles may limit mutual grooming while stabling may prevent physical contact.

1.3. Grazing Muzzles

Sixteen percent of UK horse carers report using muzzles (Sinclair *et al.* 2018), which only allow horses to eat through a small hole or slots, reducing the amount of grass that can be consumed. Grazing muzzles were also reportedly used on 77.5% of overweight equids in a survey of licensed horse operators in Maryland, USA (Jaqueth *et al.* 2018). Together these studies suggest that the use of grazing muzzles is not uncommon. The 2019 National Equine Survey estimates the horse population in Britain to be 847,000 (British Equestrian Trade Association 2019) and so a large number of horses could potentially be affected by their use in both the UK, as well as abroad. Published research into muzzles is limited, but studies have found they are effective, decreasing pasture dry matter intake (DMI) by 30% (Glunk *et al.* 2014*)* and 83% (Longland *et al.* 2011). Although these studies report contrasting figures, factors including time of year, grass length and type, muzzle design and individual differences in horses could contribute to this.

Longland *et al.* (2016b) found wearing a muzzle for 10hrs/day for 3 weeks effectively decreased overall bodyweight gain compared to horses given free access to pasture for 23hrs/day in 4/5 ponies. However, the fifth pony gained weight whilst muzzled at the rate of ponies in treatment freegraze, indicating that despite being an effective tool for weight management in most horses, muzzles may not be appropriate for all. In general, the other four lost weight in week 1 but gained weight in weeks 2 and 3, suggesting ponies were engaging in compensatory eating in weeks 2 and 3, consuming a disproportionate amount whilst unmuzzled to make up for not being able to eat as much whilst muzzled (Longland *et al.* 2016b). Davis *et al.* (2019a; b) found horses muzzled for 24hrs/day for 3 weeks lost weight, while when unmuzzled or muzzled only 10hrs/day they gained weight. This again suggests compensatory eating was a factor and that muzzling may only be effective if used in certain conditions. Therefore, owners must take care when using muzzles, as it may not be suitable for all horses to be allowed free access to pasture after a muzzle has been removed. Further, owners should keep track of body condition to ensure muzzles are having the desired effect. How owners

implement muzzling is currently unknown, for example how long horses tend to be muzzled and whether they are allowed free access to grass on its removal. These factors are likely to impact the success of muzzling to manage health issues, and owners may be discouraged from continuing muzzle use if the way in which they are implementing it does not give the desired results. Jaqueth *et al.* (2018) found yard managers were not very satisfied with muzzles, rating them 3.1/5, and suggested this was due to the requirement of increased input from the manager. It is not known how satisfied horse owners are with muzzles or other methods, which is information that could be useful in improving guidance available regarding restricted grazing.

In theory, muzzles reduce grass intake while meeting horses' needs to trickle feed (Longland *et al.* 2016a) and have social contact, which some other methods of restricted grazing may not allow. However, there are factors which may prevent muzzles working as they are intended. Longland *et al.* (2016a) found muzzled ponies had considerable difficulty eating swards of grass >10cm in length, which may mean when horses are turned out muzzled on long grass, they are unable to consume enough to prevent EGUS. Horses may also struggle to eat very short grass through the muzzle and attempting to do this could also cause abnormal wear and tear on the incisors (NEWC 2015a). Furthermore, in their study of 5 ponies Longland *et al.* (2016b) described one pony as becoming 'increasingly resentful' at having the muzzle fitted; by week 3 spending long periods muzzled without grazing. Although this was not seen in other ponies, if some horses behave in this way whilst muzzled, they will not be trickle feeding and so be at risk from EGUS. Furthermore, the pony may have refrained from grazing as it struggled to eat whilst muzzled which would lead to a frustrated motivation to feed (McGreevy *et al.* 1995), meaning it would also be suffering from poor psychological welfare. It is possible horses unable to eat effectively may experience learnt helplessness (Hall *et al.* 2008) and give up on trying to graze at all whilst muzzled.

The National Equine Welfare Council (NEWC) (2015a) offers guidance on muzzle use and considers potential associated welfare implications. There are behavioural restrictions imposed by wearing one, for example horses cannot groom themselves or engage in mutual grooming, an important part of creating and maintaining bonds (Sigurjónsdóttir *et al.* 2003). This may cause frustration, as well as changing the herd dynamic. The NEWC (2015a) advises initially observing muzzled horses with their herd mates to ensure they are accepted as rejection is a possibility. Furthermore, when wearing the muzzle, horses' communication may be impeded. Wathan *et al.* (2016) found horses gain social information from facial expressions, using them to regulate social interactions. Agonistic interactions tend to follow a pattern of escalation to decrease the chances of a highly aggressive interaction resulting in injury, and facial cues ranging from nose wrinkling and escalating to bite threats and biting are used (Goodwin 2007). These kinds of facial cues may be obscured by the muzzle and not picked up on by other horses. This could lead to aggression in situations where it would otherwise be diffused. However, there are no published data on the likelihood of this occurring, limiting the

evidenced-based advice that can be given to owners on this matter. Concern over aggression may discourage owners from trying grazing muzzles; conversely, not taking it into account may lead to poor herd dynamics or injury.

Longland *et al.* (2016b) observed 'pasture damaging' behaviours in two ponies, digging into pasture with their forefeet during the muzzle treatment but not treatment freegraze. Hockenhull & Creighton (2014b) identified pawing, a similar behaviour, as an indicator of frustration in horses, so it is possible this may also drive 'pasture damaging' behaviour. Pawing was also observed in muzzled horses by Fowler *et al.* (2017), as was rubbing the muzzle, which may indicate frustration and attempts to remove it, suggesting horses found wearing them aversive. However, in this study closed bottom muzzles were used which allowed drinking but not eating. Horses should not be prevented from eating completely for extended periods and these are not the standard muzzles available on the market. It is not clear whether horses may have displayed these behaviours if they had been able to eat small amounts, as most muzzles are designed to allow. However, performance of these behaviours decreased after 2 weeks, suggesting horses may have adjusted to wearing the muzzles, or developed learnt helplessness (Hall *et al.* 2008) from being unable to remove them. The NEWC (2015a) highlights the importance of introducing muzzles gradually so it is a positive experience for the horse, and the muzzle is not associated with fear. The importance of acclimatisation appears to be understood by researchers, with Longland *et al.* (2016b) spending 2 weeks before the study acclimatising ponies to grazing and drinking through the muzzle, although the methods used are not described and it is not clear how the period of 2 weeks was decided upon. There have not been any studies investigating the optimum technique or length of time for muzzle acclimatisation, and if acclimatisation methods used during research do not successfully habituate horses to wearing muzzles prior to the study commencing, results may be affected. Successful acclimatisation may be able to reduce initial frustration and allow horses to trickle feed more easily, increasing equine welfare. Therefore, this is an area that requires investigation.

1.4. Stabling

Horses can be stabled to keep them off grass completely either as a management technique or as part of treatment for laminitis or obesity. Horses suffering from acute endocrinopathic laminitis should be removed from pasture and put on box rest, using deep bedding to provide foot support and minimise pedal bone rotation (Menzies-Gow 2018). Stabling also greatly reduces the risk of horses evading the method of restricted grazing being practised, for example a horse may be able to remove a muzzle in the field or break through temporary fencing or jump out of a starvation paddock or strip grazed section. If this would result in immediate serious health implications for the horse then stabling may be the safest option, especially if the horse is unlikely to be discovered for a long

period if this occurred. It is also recommended that obese insulin resistant horses are removed from pasture into a stable or crew yard for example, so diet can be restricted and controlled (Geor & Harris 2009). The typical diet advised for obese horses is hay fed at the equivalent of 1.5% of the horse's ideal body weight (Dixon 2014; Frank *et al.* 2010). Owners may be recommended to split this ration and feed it on several occasions throughout the day (Dixon 2014), this minimises the chances of the horse being left without forage for long periods. However, this may not always be done, for example if owners are only able to visit their horse twice a day, before and after work. Luthersson *et al.*'s (2009) study into EGUS found being without forage for >6 hours to be a risk factor associated with the development of non-glandular ulcers. If this time period is regularly exceeded for horses stabled on restricted hay rations, they may be at risk of EGUS. This may also be an issue when using starvation paddocks and crew yards.

Stabling may also pose other issues as it is likely horses will be socially isolated and prevented from displaying many natural, highly driven behaviours, which has the potential to compromise welfare. Stereotypies have been implicated as indicators of poor welfare because they tend to develop under stressful conditions, such as when social contact, locomotion or feeding are restricted (Sarrafchi and Blokhuis 2013). Stereotypic weaving in stabled horses was found to decrease the more windows were opened (up to 4, 1/wall), which may have been due to horses gaining some social interaction from neighbours or horses in the field, or being less stressed when able to see conspecifics nearby (Cooper *et al.* 2000). Though a variety of stable designs exist it is still common for horses to only have windows on the front wall, providing a limited view of the surrounding yard or fields and not allowing physical contact with neighbours. Additionally, horses may be stabled alone on the yard for large parts of the day and depending on layout may be unable to see other horses in the fields. Yarnell *et al.* (2015) found that physiological indicators of stress were higher in single housed horses unable to make physical contact than singly housed horses able to make partial contact, or those able to make full contact in pairs or groups. In contrast, the lowest levels of physiological stress were recorded in group housed horses able to make full contact, that were also significantly easier to handle, supporting the argument that individual stabling can negatively impact welfare.

Boredom may also be a problem for horses stabled for long periods. Although toys can be provided to alleviate boredom (Harrison 2016) many available on the market may be unsuitable for horses on restricted grazing regimes as they are based on the horse receiving a food reward. Stables may be enriched without the use of food, although Bulens *et al.* (2013) found non-commercial items that did not offer a food reward (a bottle filled with sand, and a rope) to offer only limited enrichment, as they did not encourage expression of natural behaviour and it appears possible that rather than decreasing abnormal behaviour, horses just redirected abnormal behaviour towards the items provided. Furthermore, exercise will be restricted which can be an issue especially if the horse is not being worked, as a combination of exercise and calorific restriction is likely to be more effective for

weight loss than using one or the other alone (Geor & Harris 2009). Exercise may be especially important for older horses suffering from arthritis, to prevent them becoming stiff, as well as benefitting circulation and gut health, therefore stabling for most of the day may be unsuitable for these horses (Blue Cross 2016).

1.5. Starvation Paddocks and Crew Yards

Starvation paddocks are fields that have been grazed down so there is very little grass available in them. Horse carers may choose this method as it allows horses to still be turned out in groups and consume some grass. Despite the name, horses should not be starved when this method is being used and if they cannot obtain sufficient forage from the grass available, they should be provided with another source such as hay so not to risk EGUS. Crew yards are based on a similar concept to starvation paddocks, allowing horses to be turned out together but this time on a completely grass-free area, which may be a concrete yard or other suitable space. Alternatively, horses may be turned out in sand schools, or an area of the field can be covered with a deep layer of wood chips to prevent access to grass (Geor & Harris 2009). As there is no source of forage, hay or another source that is high in fibre but with a low NSC content must be provided in a restricted ration (Geor & Harris 2009) as it would be in stabled horses. In the USA the term 'dry lot' is used to describe any turnout area void of vegetation, and one survey of horse operators in Maryland found 67.4% of overweight equids were housed in these, though as with muzzles yard managers were not that satisfied with them (3.7/5) (Jaqueth *et al.* 2018). Starvation paddocks and crew yards offer benefits over stabling as horses will have a larger area so increased exercise opportunities, and the ability to be turned out with companions. When turned out in groups horses tend to be more mobile than when alone, and in addition time spent socialising is time spent not eating (Short 2018). Crew yards also have the advantage over starvation paddocks that forage intake can be completely controlled, as in a stable.

Traditional starvation paddocks may not be suitable for some horses as they could still allow significant grass intake, as well as carrying a risk of sand or soil ingestion due to horses attempting to graze very short grass (Durham 2011). This is also a risk when feeding hay from the ground in a starvation paddock or sand school and may lead to sand colic (Schramme 1995), as ingestion and intestinal accumulation of sand can lead to abdominal pain and gastrointestinal tract obstruction (Ragle *et al.* 1989). Furthermore, short stressed grass, which occurs when grass is overgrazed and so likely to be found in starvation paddocks, may have a higher NSC concentration as the stem base is a storage organ for NSC (Watts 2004). Overgrazing can also increase the selective pressure for high NSC grasses as these tend to be able to withstand more intensive grazing (Watts 2004), which questions the suitability of starvation paddocks for the management of laminitis, obesity and related diseases. Varying weather conditions may also affect growth rate and NSC content of grass (Watts

2004), meaning starvation paddocks may have to be managed more carefully than grass-free turnout options.

Another potential issue with crew yards, and starvation paddocks if there is insufficient grass, is that forage must be provisioned, and as with stabling horses may finish this quickly and be left at risk of EGUS. Group turnout may result in some horses getting a greater share of the forage ration than others or may cause competition when forage is limited, for example Ingólfsdóttir & Sigurjónsdóttir (2008) found more dominant horses achieved greater access to provisioned hay, and gained weight, than subordinates, who lost weight. Lack of forage availability may also result in horses trying to escape their restricted grazing by jumping out or breaking temporary fencing, which could result in access to lush pasture or injury. Moreover, there could be a large variety in the way these methods are implemented by different horse carers. For example, just because these methods provide the option for horses to be turned out with companions and to have a large area to live in it does not mean this will necessarily be the case. Owners may choose or have no other option but to turnout their horse alone, and if kept in a sand school or crew yard this could potentially be away from other horses in the field. The size of turnout provided with these methods may also be small depending on space available at the yard, and so may not allow much more exercise than a stable would. However, if the area is large enough the forage ration may be split up to encourage movement (Short 2018).

1.6. Strip Grazing

When carrying out true strip grazing horses will be grazed on a section of grass for a period of time and then the paddock area will be moved (usually by moving 2 mobile fences) up the field, so that the new section comprises of some fresh ungrazed grass and some previously grazed grass (Dyke n.d.). Grass that has previously been grazed but is no longer in the section horses have access to is said to be 'recovering' (Dyke n.d.; Undersander *et al.* 1993). There are common variations of this used, for example moving only one fence so each time access to fresh grass is allowed the paddock size increases (Inside-Out Hoofcare n.d.). Some people may also move both fences so the paddock is made up entirely of new grass each time rather than a combination of grazed and ungrazed, though this is a form of rotational grazing, where animals are rotated between several paddocks giving each paddock a chance to recover after it has been grazed (Cardoso *et al.* 2019). Again there is a lack of research into this method regarding reducing weight and grass intake of equines, with the majority being carried out on cattle and other production animals with the aim of finding ways to increase nutrient intake and so production of milk or muscle growth (e.g. Gregorini *et al.* 2006), the opposite of the aim when strip grazing horses to manage weight or prevent laminitis. However, Arriaga-Jordan and Holmes (1986) found strip grazed cows had lower herbage intakes, bodyweights and grazing times than continuously grazed cows. Therefore, it may also be possible to use strip grazing to reduce

the bodyweight and grass intake of horses, though it will likely depend on the exact way the method is implemented.

Some horse carers may prefer strip grazing to other methods as it may be seen as a more 'natural' way of keeping horses than other restricted grazing techniques as horses are still able to graze as well as be turned out with conspecifics. Although, having access to this much grass may not be suitable for all horses requiring restricted grazing, and Dyke (n.d.) recommends using another method alongside, e.g. muzzling or stabling, in times of rapid grass growth. One risk with this method is that once the strip has been moved horses may binge on the fresh grass available which may make colic or laminitis more likely (Freeman & Redfearn 2007), and also grazing it down rapidly so they have little left for the rest of the duration until the strip is moved again, putting them at risk of EGUS. A benefit of strip grazing is that it can be used creatively with the aim of increasing exercise, for example by fencing the field into a shape which means the water trough is at one end and the gate at the other (Short 2018). However, this may not be possible in all fields and is likely to be more labour intensive than having a straightforward rectangular strip. Strip grazing may also generally be more labour intensive than other methods, due to the time and effort required to move the fencing when it is time to allocate more grass. Another issue is that, at least in part likely due to a lack of guidance available, owners often rely on guesswork when deciding the size of the strip and how much and how often to move the fences. This could result in the method being used ineffectively, for example by in fact not sufficiently limiting grazing so horses are left at risk of laminitis or weight gain. Conversely, space or grass could be limited excessively, posing a risk to welfare in other ways. However, as previously discussed, there is no real evidence base with which to generate guidance.

Using strip grazing incurs some of the same potential issues as with starvation paddocks and crew yards. There is a risk horses may try to jump out of the strip or break through temporary fencing, reduced space could reduce exercise or increase competition, and although it has the benefit of allowing horses to be turned out together and socialise there may not be others at the yard with similar needs, and so horses may end up being separated from their social group.

Studies have shown grasses contain a higher concentration of NSC in the afternoon and evening than the morning, and this difference is also retained once grass is cut for hay, meaning hay harvested in the afternoon will have a higher NSC concentration (Mayland *et al.* 1998). Fisher *et al.* (1999) found cattle, goats and sheep prefer afternoon cut hay which contains higher NSC concentrations and so is of higher nutritive value, and Mackay *et al.* (2003) also confirmed the same preference in horses. In a study of strip grazed beef heifers, it was found that those given access to new herbage in the afternoon had greater gains in bodyweight and condition than those given access to new herbage in the morning, and that afternoon herbage allocation resulted in longer and more intense grazing bouts (Gregorini *et al.* 2006). There are no comparable data published on horses but given that, like

cattle, they prefer afternoon cut hay it is highly likely they will have a similar preference for grass available in the afternoon over that available in the morning. Therefore, it is possible that horses may show similar behaviour to cattle with longer and more intense grazing bouts if the strip is moved in the afternoon or evening and may also be more likely to gain/less likely to lose weight when the strip is moved in the afternoon. This is an area which requires researching as it could have serious implications for the implementation of strip grazing for managing horses with diet related health issues, as the time the strip is moved to allow access to fresh grass may impact its success as a method of restricted grazing.

1.7. Track Systems

The concept of track systems originated from Paddock Paradise, a method devised by Jaime Jackson, who first published a book on this in 2006 with the aim of developing a boarding system where horses live as closely as possible to how they would in the wild (Jackson 2016). He was a practising farrier and now a natural hoof care specialist based in the USA, who spent time travelling with horses living in the wild, and has also published books on laminitis, hoof care and natural horse behaviour (Jackson 2016). Jackson (2016) describes a 'template' designed (Figure 1.1.) to aid readers in developing their own Paddock Paradise, which consists of a track being created around the perimeter of the field using electric fencing; this is the part the horses will live on. According to Jackson (2016),

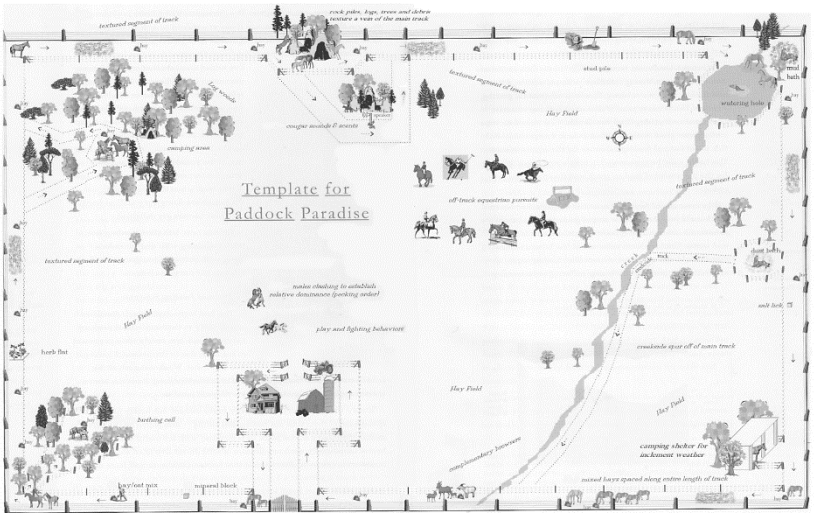


Figure 1.1. Diagram of a template Paddock Paradise (Jackson 2016).

ideally the track will be grass free and have a range of surfaces e.g. gravel, sand, rock, hard earth that the horses will walk over, as well as sections where horses have access to shelter, a watering hole (either natural or artificial) that allows bathing, a sandy/dusty area for rolling and feeding stations with a variety of hay types fed from hay nets. There should be other herbs and vegetation growing that horses can eat to get additional nutrients and salt licks provisioned. Horses should live on the track as a small herd, the number of horses the track is suitable for will depend on its size. The idea is that the track design will keep horses moving as they travel between feeding stations and other

areas, helping to keep them fit and aid in weight loss, as well as having no or little access to grass which decreases the risk of associated diseases. (Jackson 2016). Jackson (2016) claims having a range of hard surfaces which horses are walking over as well as a suitable diet will keep hooves in good condition and can even remove the need for trimming at all. However, some track systems created may consists purely of fencing the perimeter of a field for horses to live in (Chubbock n.d.; Dyke n.d.) with none of the other Paddock Paradise features suggested by Jackson (2016) included.

Jackson (2016) includes some case studies of track systems which have been effective in achieving the goals described above. One example is the Paddock Paradise set up at the Association for the Advancement of Natural Horse Care Practices Field Headquarters in Lompoc, California (of which Jackson is the founder) which is a mile long in total following a range of inclines and declines and surfaced mostly with gravel. According to Jackson as a result of living on this track the horses have athletic bodies and strong hooves that have not required trimming in several years. The other example is of an attendee of one of Jackson's talks on Paddock Paradise who had a laminitic mare. A track was created around the perimeter of their 4-acre field, which is scraped weekly with a tractor and box blade to keep it grass free. It is reported that the mare suffering from laminitis is now healthy; both her and the other horse have lost weight and have healthier hooves. There are also positive testimonies from others in the book who have created their own track system. (Jackson 2016). However, there are no published scientific data available to confirm these claims and results reported in Jackson's book are likely to be biased, meaning studies must be conducted to validate the potential benefits of a system such as this.

Although track systems are increasing in popularity in the UK it is not known how many people use them. Furthermore, many UK horse carers are unlikely to have the facilities to set up a mile-long track, or even as much as 4 acres to use unless they own land. Horse carers are likely allocated paddocks at livery yards which may be too small for a track system, while yard owners may be reluctant to allow a track to be set up, and even more reluctant to allow the removal of grass. Plus, horses turned out together may have different owners who will likely have to agree together on how to manage the field. Some livery yards are set up as a track system which all horses will live on, though these do not appear to be common in the UK. A track system may also be time consuming and labour intensive to set up and maintain, especially if weekly grass removal were required, though this may not be necessary as horses are likely to overgraze the track and may still benefit from increased movement (Dyke n.d.). Jackson (2016) also emphasises that it is the use of space that is important rather than the actual size of the field, as the track could be weaving back and forth across the field to make use of all of the space, rather than around the perimeter for example. He suggests any field/property larger than one acre could be used, though many UK horse carers will not even have access to an acre they can manage without restrictions as most UK horses are not kept on the owners own land (Boden *et al.* 2013). If an attempt to create a track system in a very small field or

with too many horses is made this could cause issues; a horse could be confined by the narrower track and unable to move away/flee from other horses if necessary, which may result in increased aggression (Waring 2003). Additionally, as with some other methods there may be a risk of horses attempting to jump out or break through fencing if sufficient space and forage are not provided within the track. Having horses constantly walking back and forth along the same paths could also cause the ground to become very muddy and churned up during wet weather especially in areas of poorly draining soil types like clay (Mickan 2011). The weather and terrain in California where Jackson set up a Paddock Paradise system is likely very contrasting to that in most of the UK, which may make conditions in the UK less suitable.

1.8. Research Aims

Overall, there has been little research into these common methods of restricted grazing, with some receiving almost no research interest at all. There is evidence demonstrating muzzles can be an effective way of managing bodyweight and reducing DMI in certain situations, but comparable studies have not been carried out into the other methods, therefore it is unclear how effective these methods are at preventing and treating laminitis and obesity. Furthermore, as well as knowing efficacy it is important to understand how many owners are using these RGMs and the ways in which they are implementing them, so we can build an idea of how many horses are being affected and the ways in which welfare may be impacted. Factors influencing owners' decision making on which methods to use and how to use them are important to understand as it is ultimately down to owners to choose how they manage their horses; if methods are found to be effective but owners do not like using them then studies will not be having the desired impact on equine welfare. Another highly important aspect is that we do not know the impact of these methods on equine psychological welfare, and if bodyweight is successfully decreased but the horse is highly distressed other health and behavioural issues are likely to develop instead. Current research still leaves many questions unanswered, and these must be addressed so restricted grazing practices that are effective but have minimal negative impact on other aspects of welfare can be promoted.

The aim of this project was to answer some of these questions so that restricted grazing practices can be better understood. The first study employed a questionnaire to investigate which RGMs are being used and horse carers' opinions on them, the reasons horse carers are restricting grazing and how they are implementing methods, and horse carers' experiences of trying to restrict grazing and manage associated health problems. The second study uses behavioural observations of horses being used in a strip grazing intervention trial to explore the impact of strip grazing on grazing behaviour, equine time budgets and welfare.

2. What methods are used to limit horses' grazing in the UK and what are horse carers' opinions on these?

2.1. Materials and Methods

This study was granted ethical approval by the University of Bristol Faculty of Health Sciences Research Ethics Committee.

2.1.1. The Questionnaire

An online cross-sectional questionnaire was used to collect data on UK horse carers' opinions on different restricted grazing practices, which methods they used, and how they implemented these. The questionnaire was built using Online Surveys and was online from the 8th March to 1st April 2019. It comprised of a combination of 60 multiple choice and free text questions split into five main sections, the basic structure of the questionnaire is shown in Figure 2.1. A large proportion of the questionnaire (40%) was made up of free text questions due to the fact many of the questions had not been asked before in a research context, and so the possible range of answers that may be given was unknown. Therefore, it was undesirable to influence respondents' answers by providing multiple choice question (MCQ) options in some contexts and valuable to gain detailed accounts of methods used and the reasons horse carers held the views they did. The full questionnaire can be found in Appendix A.

Respondents did not have to answer all the questions, only those in the sections applicable to them. The first section gathered general background information on participants, and from then on respondents who had and had not practised restricted grazing were sent down different paths. Those who had not used restricted grazing before answered one section which asked about their understanding of the practise and gathered their general opinions on different methods. It also aimed to discover what, if any, alternatives to restricted grazing they used and which, if any, RGMs they would try in the future if the need arose. The other three main sections were for those who had restricted a horse's grazing in the past. The first asked about their general experiences and opinions: which methods they had used or tried and why, what restrictions or barriers affected which methods they could use and how they rated each method in terms of welfare and why. It also asked which methods they would use again or not, and which they would try in the future or not and the reasons for this. The other two sections were for respondents who had used specific methods, strip grazing and grazing muzzles, and explored respondents' experiences with these in more detail. These two methods were chosen to focus on as anecdotally they were thought to be two of the most commonly

used methods of restricted grazing, while both having little research conducted into them. Stabling to restrict grazing is also thought to be common, but though stabling has received little research attention regarding restricted grazing, research has been undertaken in other contexts that is also relevant to restricted grazing (e.g. Yarnell *et al.* 2015; Erber *et al.* 2013; Visser *et al.* 2008). The questions asked how exactly they were implementing these methods, as there are a variety of ways both methods can be carried out. It was hoped that understanding how these methods are being implemented would provide a better idea of what their potential welfare implications may be.

Participants were not required to complete all questions to move through the survey, though responses to some were 'required', but they did have to press the 'finish' button at the end for their responses to be recorded.

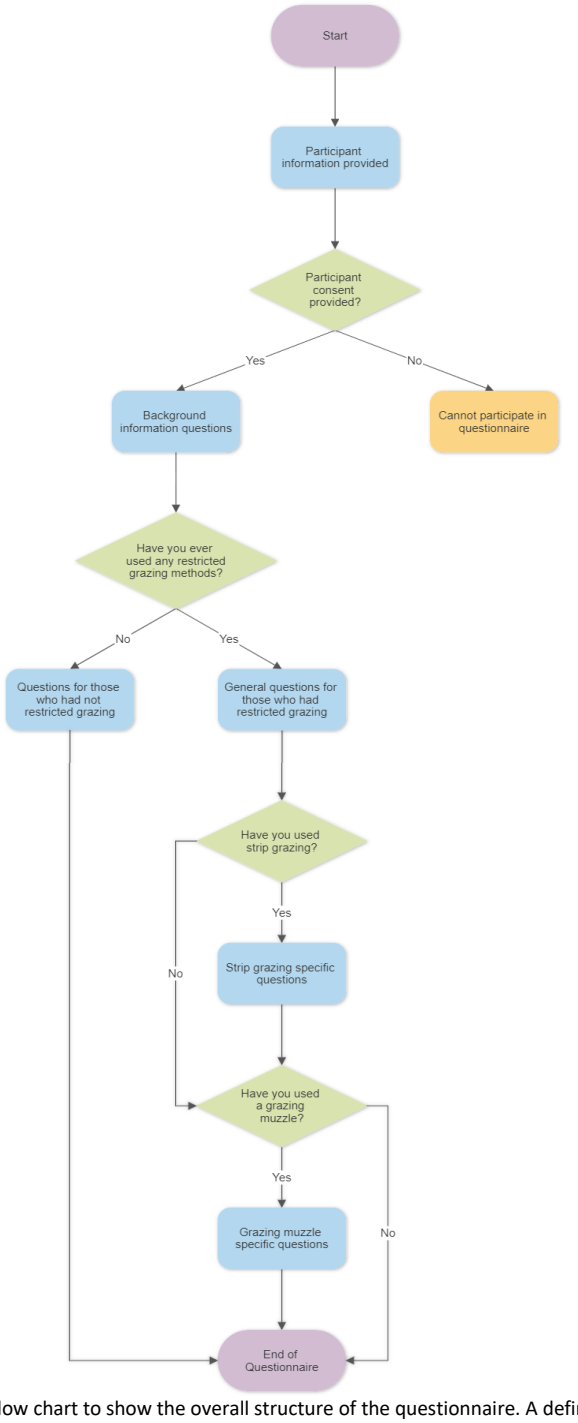


Figure 2.1. Flow chart to show the overall structure of the questionnaire. A definition of restricted grazing was given in the participant information.

2.1.2 Pilot

Two rounds of piloting took place to refine the questions included; participants were gathered from a convenience sample. A variety of styles were used, with some respondents filling in the survey alone and then providing feedback, and others completing it over the phone or in person and providing commentary on each question as they came to it. After piloting it was decided to exclude 'track system' as one of the multiple choice options when asking what methods people had used or heard of, as the majority of respondents had not heard of this method or had heard of it but did not know what it was. There are a wide range of ways in which track systems can be implemented which also makes the method hard to accurately describe. It was thought that those who used this method would state this in 'other'. The questionnaire took approximately 20 minutes to complete. It was a slight concern that this length of time may put people off from completing the questionnaire. However, pilot respondents said although it was fairly long with quite a few free text questions, they were invested in the research topic and so did not feel they would have been put off from answering or stopped without completing the survey. However, as several of the pilot respondents were connected to the researcher this may have led to a bias towards more positive comments and respondents being more invested in completing the questionnaire.

2.1.3. Sample

Anyone aged 18 or over who had owned/loaned/shared/cared for a horse in the UK, either currently or in the past, was eligible to answer the questionnaire, not just those who had used restricted grazing in the past. Those who had not restricted grazing were asked about their knowledge of and opinions on these practices, the aim being to gather a range of perspectives on the issue. However, the main target group was leisure horse carers who had restricted grazing. Horses kept as pets or for leisure are least likely to be used for regular exercise and most likely to be at risk of laminitis or obesity (Robin *et al.* 2015). This group of horses is also least likely to be registered with an equine industry body but may account for up to 60% of the UK equine population (Boden *et al.* 2012). There is currently no existing sampling frame to draw from, and though some previous studies have gathered their sample from veterinary practices and their clients (e.g. Hotchkiss *et al.* 2007), not all horses may be registered with a practice and so would be excluded (Boden *et al.* 2013). Those who have owned horses in the past but do not currently would also be excluded. Therefore, a convenience sample of UK horse carers was gathered through social media, via email and with physical posters displayed around the Bristol Vet School. Emails were sent to researchers at Bristol Vet School, equine colleges, and riding schools and livery yards whose contact details were found on the British Horse Society (BHS) website. However, the main avenue used was Facebook; a page was created for the project and the survey link was shared into relevant equine groups and pages,

including equine charity pages (listed in Appendix B). In some cases, individuals or pages also shared the questionnaire to other Facebook groups/pages or their own timelines. Social media has been an important recruitment avenue for other online equine questionnaires (Boden *et al.* 2013; Jaqueth *et al*. 2019). It was thought an online questionnaire was likely to yield the greatest number of respondents due to the convenience for respondents (Boden *et al*. 2013), though those without internet access would not be able to participate.

This was an exploratory survey; it was not known how many horse carers had used restricted grazing so this data could not be used in a sample size calculation. As the survey was exploratory and aimed to collect a lot of data it was fairly long, and it was known this may discourage people from responding. A sample size of 400-500 responses was aimed for, as it was decided this would be realistic within the project time frame and allow simple statistical analysis. Other fairly long online questionnaires about equine health gained similar numbers of respondents e.g. Allison et al 2011.

2.1.4. Analysis

The term 'non-restricted grazers' ('NRGs') is used to refer to all respondents who answered 'no' to the question asking if they had restricted grazing, and answered the section of the questionnaire intended for those who had never practised restricted grazing. 'Restricted grazers' ('RGs') refers to all respondents who answered yes to this question.

MCQs were analysed in IBM SPSS Statistics 24. Descriptive statistics were used to describe the distribution of responses to different questions. Non-parametric tests were used to explore relationships as data from closed questions were categorical so not normally distributed. Friedman tests and post hoc Wilcoxon tests with a Bonferroni adjusted alpha value of 0.005 (as a total of 10 Wilcoxon tests were carried out in each case) were used to compare the welfare ratings given to each of the listed RGMs. This process was carried out separately for respondents who had and had not restricted grazing, as both groups rated welfare of the RGMs. Friedman tests were used because for this type of question one group of participants was tested at 5 points, i.e. each participant in a group gave 5 welfare scores, which yielded ordinal data. Mann Whitney U tests were used to compare the welfare scores given by RGs and NRGs for each method, as ordinal values were being compared for two independent groups of respondents. A total of 5 Mann Whitney U tests were done, as there were scores from 5 RGMs to compare.

Responses to MCQs are displayed as graphs, showing the number of respondents who selected each answer, followed by the percentage in parenthesis. Multi-answer MCQs, where respondents were able to select more than one answer, are indicated as such below the graph.

Free text questions underwent content analysis using NVivo 12 to identify common themes in the answers. Answers to each question were categorised into themes and subthemes and the number of respondents who mentioned each theme and subtheme in their answer was recorded.

Responses to free text questions have been categorised and displayed in tables. Tables display the question, with the response category in the first column, followed by the number of respondents whose answer covered that category in the next column, and in some cases followed by the response subcategories in the final column with the number of respondents who mentioned each item in parenthesis. One answer from a single respondent could cover items in multiple categories and subcategories in most cases, meaning the sum of respondents who mentioned all items may be greater than the number of respondents who answered the question. Some free text questions were not answered by all participants, the number of responses received for each question is shown in parenthesis next to the question.

2.2. Results

2.2.1. Overview

In total, 503 participants responded to the questionnaire, 468 of which (93%) reported using restricted grazing practices either currently or in the past while 35 (7%) reported they had not. However, 12 of those who indicated they had not used restricted grazing when asked went on in a later question to describe using a method of restricted grazing. The majority of respondents were horse owners or carers (92%) (Figure 2.2.) and had >25 years' experience in the horse world (58%) (Figure 2.3.).

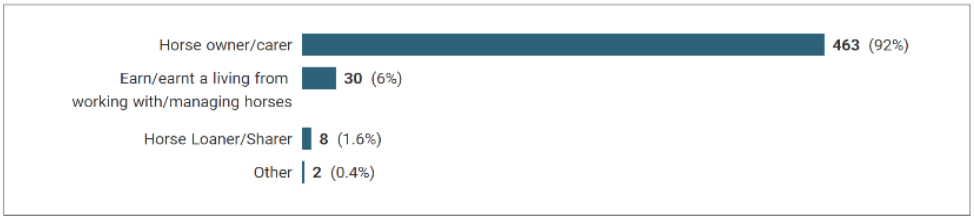


Figure 2.2. Response to question: What is your main stake/interest in the horse world?

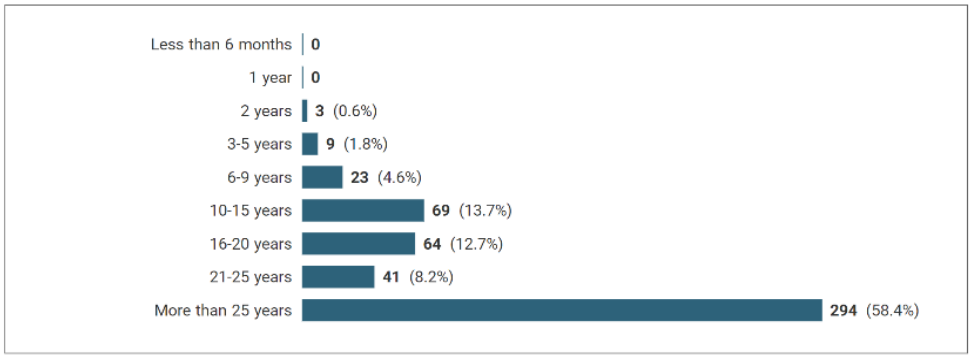


Figure 2.3. Response to question: How long (approximately) have you been involved in the horse world?

2.2.2. Non-Restricted Grazing Section

Thirty-five respondents were directed to this section of the questionnaire having declared that they never used RGMs. It was most common for respondents to keep their horse at a livery yard (51%), followed by their own land (26%) (Figure 2.4.). For 23% there were restrictions at the place their horse was kept, limiting how they were able to manage their horse; these restrictions are outlined in Table 2.1.

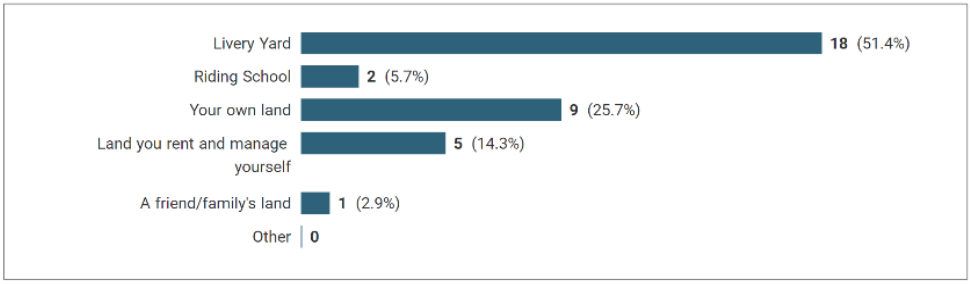


Figure 2.4. Response to question: Where is/was your horse kept?

Table 2.1. Categorised responses to the open question: Are there any restrictions on how you can manage your horse due to rules or the situation at the place you keep/kept your horse? (N=35)

Yard Restriction	Number of Respondents	Descriptions
Turnout Restrictions	5	Limited or no turn out during winter/bad weather **(5)**
Limited due to Routine, Facilities or Setup at Yard	3	Set fields for horses e.g. all managed together as a herd, separate mare and gelding fields **(2)** Unable to change fields to rest them **(1)**
Yard Rules	1	Not allowed to add objects or substrates e.g. sand to field **(1)**
Space Related	1	Not enough space for the number of horses at the yard **(1)**
No Restriction	27	

The remainder of the questions in this section asked for respondents' knowledge and opinions of restricted grazing. Most respondents had heard of grazing muzzles and strip grazing (Table 2.2.).

Table 2.2. Categorised responses to the open question: What methods of restricted grazing have you heard of? (N=35)

Method	Number of Respondents
Grazing Muzzle	26
Strip Grazing	22
Starvation Paddocks or Similar	12
Stabling	10
Track system	8
Crew Yard or Similar	7
Other	4
Had not heard of any methods	1

The majority had also taken measures to manage their horse's pasture (Table 2.3.). Twelve answers included descriptions of practices classified as restricted grazing under the definition provided to the respondents.

Table 2.3. Categorised responses to the open question: Have you ever had to take measures to manage your horse's pasture e.g. to stop it becoming too churned up, to preserve grass? (N=33)

Response	Number of Respondents	Descriptions
Yes: RGM described	12	Limiting turnout time **(8)** Muzzling **(1)** Crew yard/bare paddock **(1)** Reducing field size with temporary fencing **(1)** Other **(1)**
Yes: Non-RGM described	21	Rotating and resting pastures **(8)** Re-sow grass **(3)** Mud or 'throw away' winter paddock **(2)** Roll fields **(2)** Poo picking regularly **(1)** All weather surface round gates etc. **(1)** Harrowing **(1)** Watering **(1)** Mulching **(1)** Not allowing over grazing of a field **(1)**
No	10	

Just over half of NRGs had cared for a horse with a condition for which one of the main interventions is adjusting feed and grazing practices (Figure 2.5.).

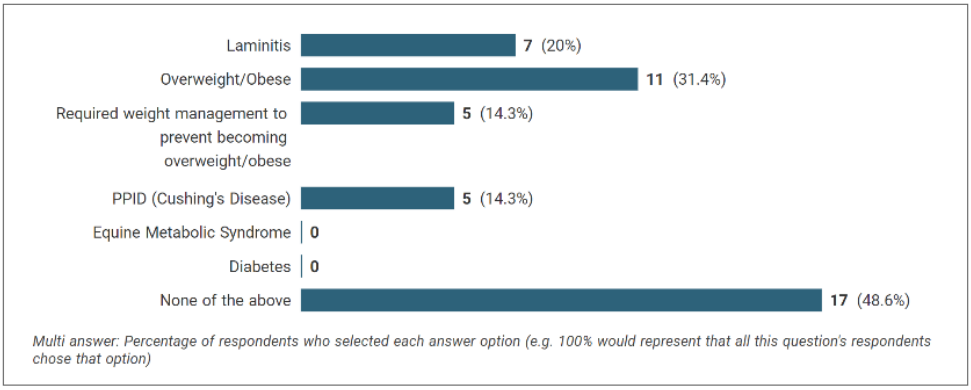


Figure 2.5. Response to question: Have you ever cared for a horse with any of these conditions?

Respondents described the methods they used to manage these conditions, and 12 described methods classified as restricted grazing under the definition given at the beginning of the questionnaire (Table 2.4.).

Table 2.4. Categorised responses to the open question: If you selected one of these conditions, what methods do/did you use to help manage it/them? (N=18)

Response	Number of Respondents	Descriptions
RGM described	12	Limiting turnout time **(4)** Starvation paddock **(3)** Muzzling **(1)** Strip grazing **(1)** Other **(2)** Future plans **(1)** – newly diagnosed horse, had not yet used the RGMs described
Non-RGM described	13	Change in provision of hay e.g. soaking, using slow feeder, different type, reducing/increasing amount fed **(8)** Reducing/using lower calorie/sugar feed **(8)** Increased exercise **(7)** Medication **(4)** Stop rugging **(1)**

When asked which RGM NRGs would try first if it was necessary to use one, a range of answers was given without there being one clear choice (Table 2.5.).

Table 2.5. Categorised responses to the open question: If in the future a horse you cared for required its access to grass to be restricted for any reason, what method(s) do you think you would try first? (N=32)

Restriction Method	Number of Respondents
Starvation Paddock	7
Grazing Muzzle	6
Strip Grazing	6
Track System	6
Stabling/Limited Turnout	4
Crew Yard or Similar	3
Further Research Required to Make Decision	1
Non-RGM Described	1
Other	4

Respondents were asked to rate how good they thought grazing muzzles, stabling, starvation paddocks, crew yards and strip grazing were in terms of welfare on a Likert scale from very bad to very good. They were told to assume that in each case the horse would have at least some access to forage e.g. some provision of hay in starvation paddocks and stable. Only participants who gave a rating to every method were included in analyses. For analysis, the Likert scale descriptors were given numerical values from 1 to 5, with very bad being given a value of 1 and very good being given a value of 5. Figure 2.6. shows the approximate overall welfare rating of each method on the Likert scale and the average welfare score (/5) calculated during analysis. Respondent perception of welfare impact differed significantly between methods, Friedman test: χ^2 (4, N=34)=30.22, P<0.001, with strip grazing considered to have the least negative impact on welfare and stabling the most. Wilcoxon tests (using a Bonferroni adjusted alpha value of 0.005) were used to carryout pairwise comparisons between each method. After the Bonferroni correction was done four tests revealed a significant difference. For each test N=34. Muzzles were rated significantly lower for welfare than strip grazing: Z=-3.274, P=0.001, and crew yards: Z=-2.929, P=0.003. Stabling was also rated significantly lower for welfare than strip grazing: Z=-4.212, P<0.001, and crew yards: Z=-3.069, P=0.002.

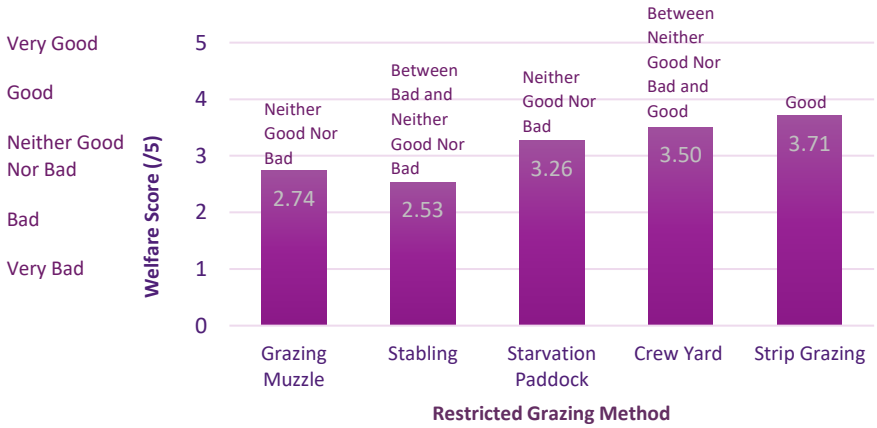


Figure 2.6. Graph to show approximate welfare rating (based on Likert scale values) and average welfare score /5 (calculated during analysis) given to each restricted grazing method by respondents who indicated they had not restricted grazing before (N=34).

Respondents were asked to explain why they rated the methods as they did, this has been broken down into positive, neutral, and negative responses for each method (Table 2.6.).

Table 2.6. Categorised responses to the open question: Please explain the reasons you gave each method the welfare rating you did (N=23) (In each cell N represents the number of respondents who gave either a positive, negative or neutral rating to each method.)

Method	Positive Responses	Neutral Responses	Negative Responses
Grazing Muzzle	N=4 Horse can be turned out/exercise **(3)** Horse Can be with companions **(1)** Still allows some access to grass **(1)**	N=1 Depends on the individual horse **(1)**	N=14 Negative psychological welfare e.g. stress/frustration **(7)** Prevents social interactions e.g. mutual grooming **(3)** Causes abnormal dental wear **(2)** Horses can remove them easily **(1)** Compensatory eating/gorging on removal of muzzle **(1)** Increase cortisol, bad for insulin resistance **(1)** Impacts drinking **(1)** Other **(2)**
Stabling	N=0	N=2 Depends on the individual horse **(2)**	N=20 Not enough space/reduces exercise **(11)** Negative psychological welfare e.g. stress, boredom **(7)** Social isolation **(4)** May be left for long periods without forage **(3)** Other **(2)**
Crew Yard	N=12 Horse can exercise/move freely **(6)** Can be with companions **(4)** Allows better control of diet/forage intake **(1)** Positive psychological welfare **(1)** Other **(1)**	N=2 Depends on the individual horse **(1)** Had not heard of this method **(1)**	N=5 Limits exercise/activity **(2)** Arenas – bad for airways/causes sand colic if done regularly **(1)** Horse may be in isolation **(1)** May be left for long periods without forage **(1)**
Starvation Paddock	N=11 Horse can be turned out/exercise **(6)** Can be with companions **(2)** Still allows some access to grass **(1)**	N=0	N=9 Limits exercise/activity **(3)** Horse may be in isolation **(2)** Negative psychological welfare e.g. stress, boredom **(1)**

Table 2.6. Categorised responses to the open question: Please explain the reasons you gave each method the welfare rating you did (N=23) (In each cell N represents the number of respondents who gave either a positive, negative or neutral rating to each method.)

Method	Positive Responses	Neutral Responses	Negative Responses
Starvation Paddock (Continued)	Allows better control of diet/forage intake **(1)** Positive psychological welfare **(1)** Other **(3)**		Ingestion of soil/sand etc. **(1)** May be left for long periods without forage **(1)** Other **(1)**
Strip Grazing	N=8 Horse can be turned out/exercise **(3)** Can be with companions **(3)** Still allows some access to grass **(2)** Positive psychological welfare **(2)** Other **(1)**	N=1 Had not heard of this method **(1)**	N=8 Short/stressed grass **(3)**

2.2.3. Main Section: General Restricted Grazing Questions

2.2.3.1. General Information

A total of 468 respondents were directed to this section of the questionnaire because they use or had used restricted grazing practices. The majority of respondents were the main person responsible for caring for their horse (89%) (Figure 2.7.) and kept their horses at livery yards (34%), their own land (33%) or land they rented but manged themselves (24%) (Figure 2.8.).

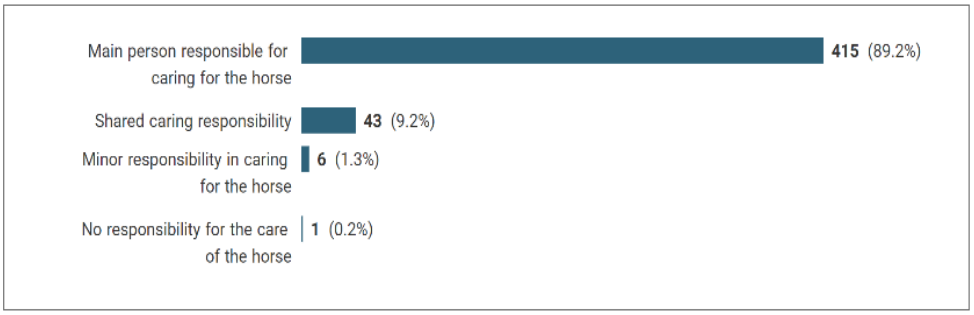


Figure 2.7. Response to question: What role do/did you have in the day to day care for this horse?

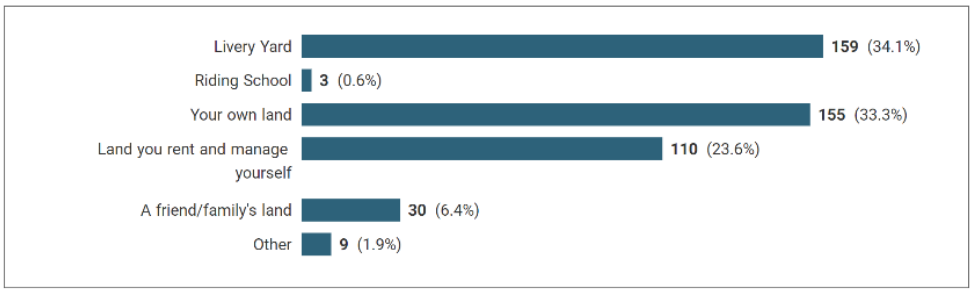


Figure 2.8. Response to question: Where is/was your horse kept?

Laminitis prevention or management was the most common reason restricted grazing had been practised (81%), followed by preventing a horse becoming overweight (76%) (Figure 2.9.).

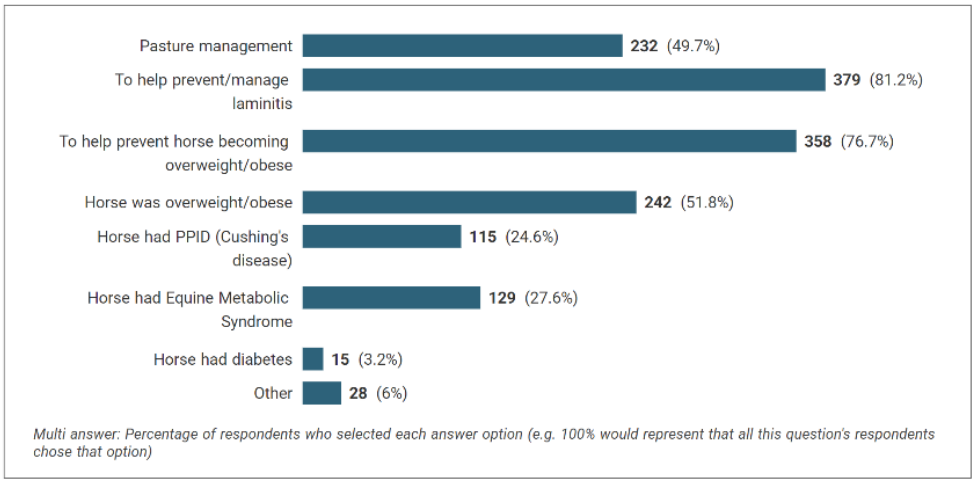


Figure 2.9. Response to question: Why have you practised restricted grazing?

These respondents used non-RGMs alongside restricted grazing to manage their horses' health problems, although there were differences in the methods most used depending on whether they were managing laminitis/PPID/EMS or bodyweight/condition (Figure 2.10.).

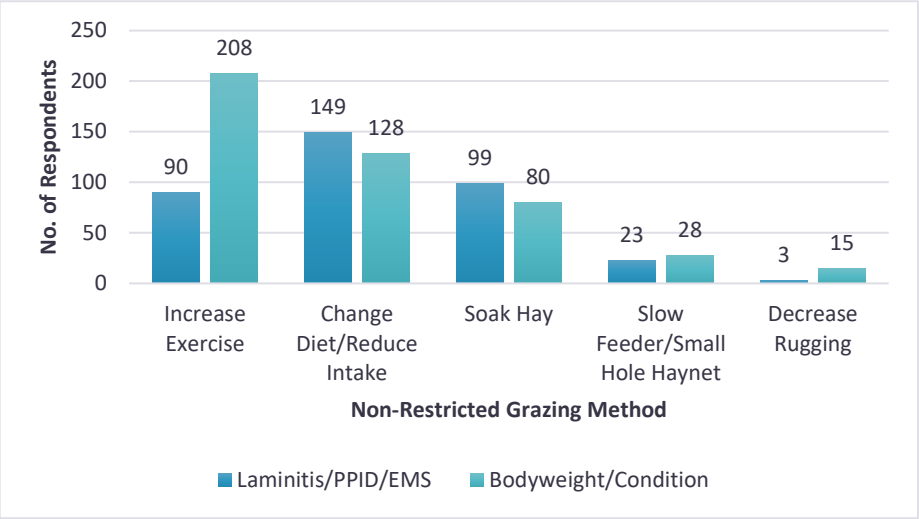


Figure 2.10. The number of respondents who used each non-restricted grazing method to manage either their horses' weight or laminitis/metabolic disorder.

Management restrictions affecting how RGs kept their horses were reported by 24% (112/466); these limitations are detailed in Table 2.7.

Table 2.7. Categorised responses to the open question: Are there any restrictions on how you can manage your horse due to rules or the situation at the place you keep/kept your horse? (N=464)

Yard Restriction	Number of Respondents	Descriptions
Yard Rules	44	Alteration of paddock not allowed e.g. no electric fencing, unable to strip graze, make starvation paddock or track system etc. **(33)** Not able to make a grass free area e.g. by adding sand to field **(4)** No control over forage provided e.g. set amount and type of hay provided no matter individual horse's condition **(3)** Not allowed to build or alter permanent structures **(3)** Hay not allowed in field **(2)** No say in fertiliser used in field **(1)** No loose schooling allowed **(1)**
Turnout Restrictions	33	Limited or no turn out during winter/bad weather **(18)** Set turnout hours **(15)** No horses turned out alone **(2)**
Limited due to Routine, Facilities or Setup at Yard	31	Set fields for horses – no choice in size, groupings or when moved e.g. mare and gelding fields, individual turnout paddocks **(17)** Unable to use certain types of restricted grazing e.g. no availability of school/crew yard, share field with cows so no strip grazing etc. **(7)** Insufficient grazing space for number of horses at yard or to use certain methods of restricted grazing **(6)** Grass mown at set times **(1)**
Condition of Grass or Land	10	Terrain and bad drainage make some methods unsuitable either all or part of the time e.g. steep hill prevents use of track when wet **(6)**

		Unsuitable grazing available e.g. very poor or very lush **(4)**
Limited due to other owners or horses	4	Compromise so horses can share the same field when they have different needs **(2)** Difficult to get owners to collaborate e.g. so all that need restricted grazing are together **(1)** Other owners prefer different restricted grazing techniques so must go with majority **(1)**
No Restriction	354	

Strip grazing was the method that had been tried by most respondents (68%), followed by grazing muzzles (61%) (Figure 2.11.), and though it was not listed 71 (15%) respondents reported using track systems in the 'other' box.

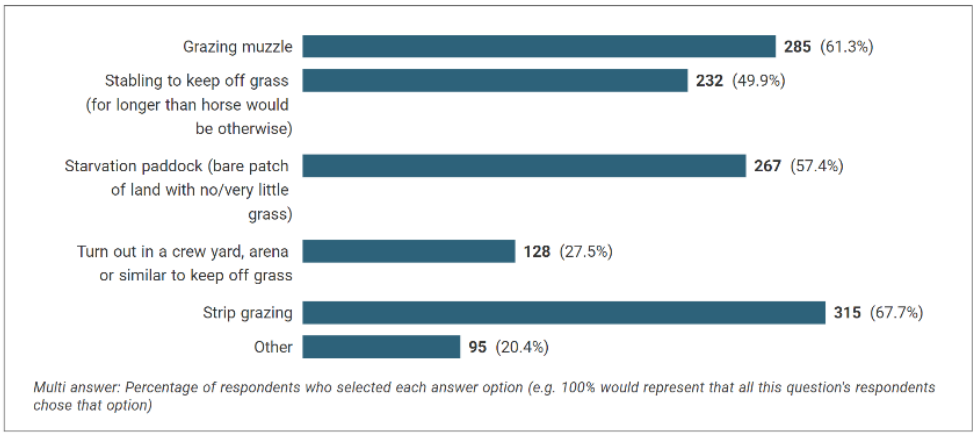


Figure 2.11. Response to question: What methods of restricted grazing have you ever used or tried on your horse?

Personal experience or judgement was the main factor influencing why respondents initially chose a method of restricted grazing (63%), followed by ease of implementation (52%) and then advice from online research (34%) (Figure 2.12.).

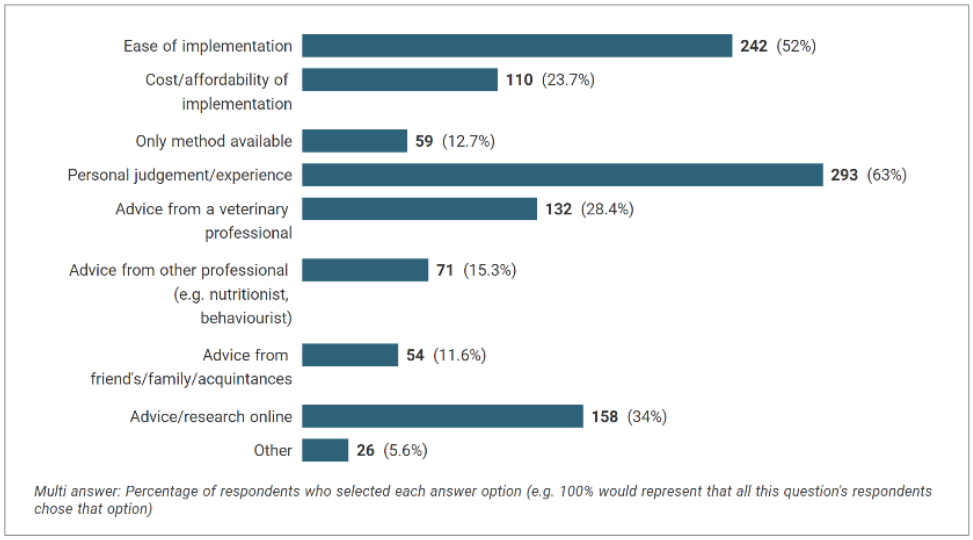


Figure 2.12. Response to question: What influenced the initial decision of which method of restricted grazing to use?

When online research was carried out, the main sources used were websites offering a professional's opinion e.g. from a reputable magazine or equine charity, general websites offering advice on restricted grazing and Facebook groups (Figure 2.13.).

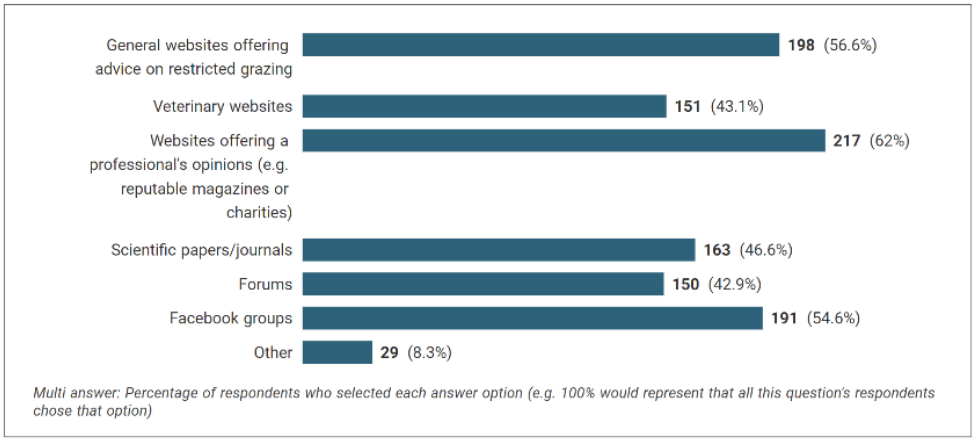


Figure 2.13. Response to question: If you have done research or found advice online on restricted grazing, what sources did you use?

Over 70% of respondents agreed that it was easy to find information about restricted grazing (Figure 2.14.), with over 50% also agreeing that the available information was easy to implement in a practical situation (Figure 2.15.).

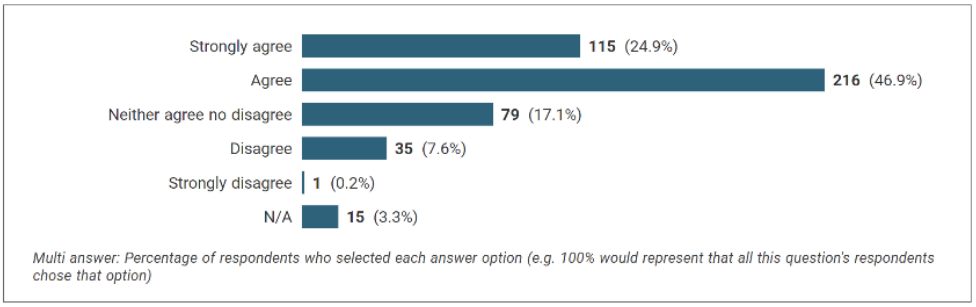


Figure 2.14. Response to question: How much do you agree with this statement: It is easy to find information about restricted grazing?

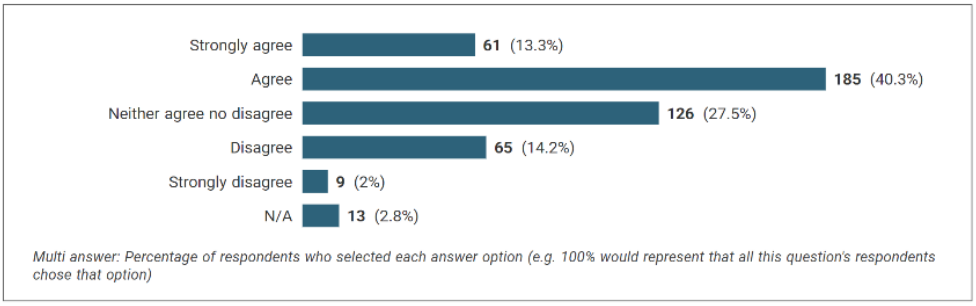


Figure 2.15. Response to question: How much do you agree with this statement: The information available is easy to implement in a practical situation?

Less than 50% of RGs believed the information available about restricted grazing made it easy for them to decide which method was most appropriate to use for their situation (Figure 2.16.).

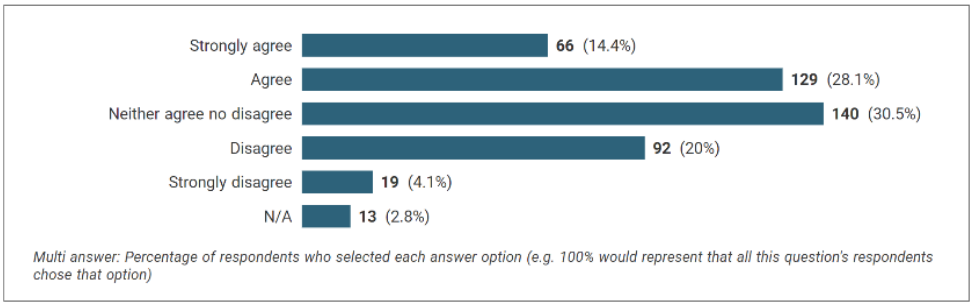


Figure 2.16. Response to question: How much do you agree with this statement: The information available makes it easy to decide which method of restricted grazing is most appropriate for my situation?

All respondents reported keeping track of their horse's condition in some way, the most common techniques being by eye (69%), using a weight tape (65%) and then using body condition scoring (64%) (Figure 2.17.).

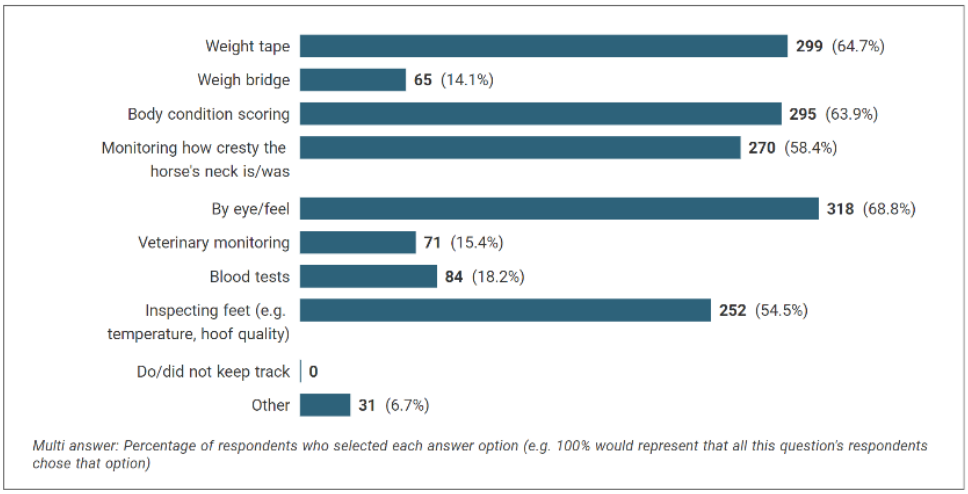


Figure 2.17. Response to question: How do/did you keep track of your horse's weight/condition and/or laminitis/metabolic disorder (if necessary)?

2.2.3.2. Experience and Opinions on Restricted Grazing

Respondents were asked to rate how good they thought grazing muzzles, stabling, starvation paddocks, crew yards and strip grazing were in terms of welfare, as previously described for NRGs. They were told to assume that in each case the horse would have at least some access to forage e.g. some provision of hay in starvation paddocks and stable. Only participants who gave a rating to every method were included in analyses. For analysis, the Likert scale descriptors were given numerical values from 1 to 5, with very bad being given a value of 1 and very good being given a value of 5. Figure 2.18. shows the approximate overall welfare rating of each method on the Likert scale and the average welfare score (/5) calculated during analysis. Respondent perception of welfare impact differed significantly between methods, Friedman test: χ^2 (4, N=446)=397.78, P<0.001, with strip grazing considered to have the least negative impact on welfare and stabling the most. Wilcoxon tests (with a Bonferroni adjusted alpha value of 0.005) making pairwise comparisons between each

method, all showed a significant difference. For each test N=446. Strip grazing was rated higher than all other methods, crew yards: Z=-4.815, P<0.001; starvation paddocks: Z=-7.695, P<0.001; grazing muzzles: Z=-11.288, P<0.001; stabling: Z=-14.388, P<0.001. Crew yards were rated higher than starvation paddocks: Z=-4.228, P<0.001; grazing muzzles: Z=-8.656, P<0.001, and stabling: Z=-12.187, P<0.001. Starvation paddocks were rated higher than grazing muzzles: Z=-5.436, P<0.001, and stabling: Z=-10.045, P<0.001, while muzzles were only rated higher than stabling: Z=-5.293, P<0.001. Respondents were asked to explain why they rated the methods as they did; this has been broken down into positive, neutral, and negative responses for each method (Table 2.8.).

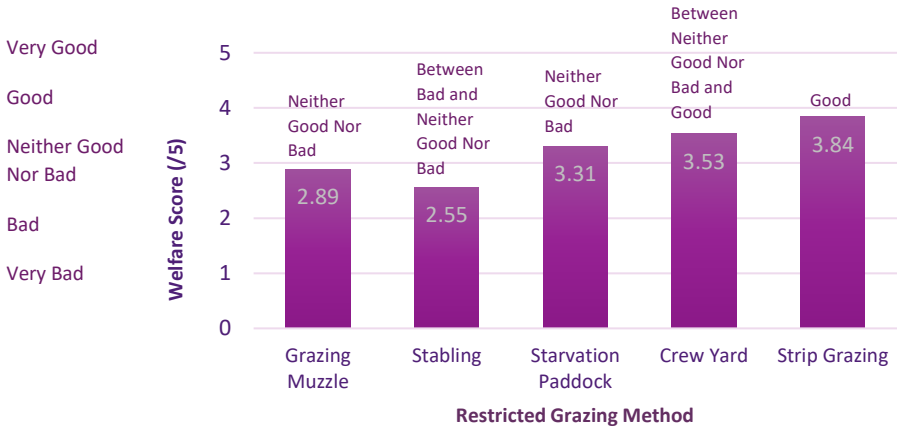


Figure 2.18. Graph to show approximate welfare rating (based on Likert scale values) and average welfare score /5 (calculated during analysis) given to each restricted grazing method by respondents who had restricted grazing (N=446).

Mann Whitney U tests were used to compare the welfare scores given by RGs and NRGs for each method, and no significant differences were found.

Table 2.8. Categorised responses to the open question: Please explain the reasons you gave each method the welfare rating you did (N=23)
(In each cell N represents the number of respondents who gave either a positive, negative or neutral rating to each method.)

Method	Positive Responses	Neutral Responses	Negative Responses
Grazing Muzzle	N=72 Horse can be turned out/exercise **(35)** Horse can be with companions **(27)** Effective **(14)** Allows trickle feeding **(9)** More natural/least disrupts normal routine **(6)** Graze longer/less stressed grass **(2)** Other **(12)**	N=13 Depends on the individual horse **(5)** Necessary evil/less cruel than alternatives or letting become ill **(5)** Other **(3)**	N=141 Negative psychological welfare e.g. stress/frustration **(50)** Rubs/sores/uncomfortable/often poor fit **(27)** Limits social interactions/effects herd dynamic **(21)** Abnormal dental wear **(20)** Horses can remove them easily **(18)** Ineffective e.g. compensatory eating/adapting to eat as much as when unmuzzled/access to unsuitable grass **(18)** Getting caught/injury **(9)** Restricted forage intake too much **(8)** Unnatural/limits natural behaviour **(7)** Decreases movement **(3)** Hard to monitor how much horse eating **(3)** Impacts drinking **(1)** Other **(25)**
Stabling	N=41 Effective **(9)** Can monitor exactly what horse eating **(7)** Good as long as not stabled full time **(6)** Good for short term/flare ups (not long term) **(6)** Horse sheltered from flies/heat/cold **(4)** Removes any risk associated with grass consumption **(3)** Company can be provided in some cases **(2)** Manageable **(1)** Other **(9)**	N=11 Depends on the individual horse **(6)** Necessary evil/less cruel than letting become ill **(4)** Other **(5)**	N=177 Not enough space/reduces exercise **(102)** Negative psychological welfare e.g. stress, boredom **(52)** Social isolation **(49)** Unnatural/limits natural behaviour **(28)** Leads to other physical health issues **(18)** Leads to development of stereotypies **(6)** Compensatory eating when turned out **(6)** May be left for long periods without forage **(5)** Other **(25)**

Table 2.8. Categorised responses to the open question: Please explain the reasons you gave each method the welfare rating you did (N=23) (In each cell N represents the number of respondents who gave either a positive, negative or neutral rating to each method.)

Method	Positive Responses	Neutral Responses	Negative Responses
Crew Yard	N=101 Horse can exercise/move freely **(62)** Can be with companions **(36)** Allows performance of natural behaviour **(12)** Removes any risk associated with grass consumption **(9)** Allows control of diet/forage intake **(7)** Positive psychological welfare **(6)** Effective **(3)** Other **(17)**	N=20 Dependent on exact setup/situation **(8)** Depends on the individual horse **(2)** Had not heard of this method **(2)** Other **(8)**	N=43 Reduces exercise/activity **(14)** Negative psychological welfare e.g. stress, boredom **(11)** Depending on surface, bad for airways/sand colic/too hard **(7)** May be left for long periods without forage **(5)** Causes other physical health issues **(3)** Horse may be in isolation **(2)** Compensatory eating when turned out **(2)** Lack of shelter **(1)** May cause stereotypies **(1)** Unnatural/limits natural behaviour **(1)**
Starvation Paddock	N=100 Horse can be turned out/exercise **(51)** Can be with companions **(27)** Allows performance of natural behaviour **(15)** Effective **(10)** Allows control of diet/forage intake **(7)** Positive psychological welfare **(7)** Other **(24)**	N=19 Dependent on exact setup/situation **(8)** Only okay in extreme/emergency situation **(3)** Depends on the individual horse **(3)** Other **(5)**	N=78 Negative psychological welfare e.g. stress, boredom **(26)** Reduces exercise/activity **(19)** Horses grazing short/stressed grass - more sugar **(14)** Ingestion of soil/sand resulting in colic **(12)** Causes other physical health issues **(12)** May be left for long periods without forage **(11)** Horse may be in isolation **(9)** Compensatory eating when turned out **(3)** May cause stereotypies **(2)** Unnatural/limits natural behaviour **(1)** Other **(7)**
Strip Grazing	N=105 Horse can be turned out/exercise **(45)**	N=15 Dependent on exact setup/situation **(4)** Depends on the individual horse **(2)**	N=57 Compensatory eating/gorging when fence moved **(17)**

Table 2.8. Categorised responses to the open question: Please explain the reasons you gave each method the welfare rating you did (N=23)
(In each cell N represents the number of respondents who gave either a positive, negative or neutral rating to each method.)

Method	Positive Responses	Neutral Responses	Negative Responses
Strip Grazing (Continued)	Allows performance of natural behaviour **(26)** Effective **(18)** Can be with companions **(17)** Easy to control grass intake/flexible **(15)** Positive psychological welfare **(12)** Still allows some access to grass **(6)** Constant access to forage/trickle feeding **(6)** Other **(15)**	Other **(9)**	Reduces exercise/activity **(15)** Sudden changes between not much grass to lots (sugar spikes, horses without forage for extended periods) **(10)** Horses grazing short/stressed grass - more sugar **(9)** Allows too much access to grass **(6)** Negative psychological welfare e.g. stress, boredom **(6)** Ineffective **(3)** Increased aggression between horses on strip **(2)** Horses may get caught in fence – injury **(2)** Horses may escape **(2)** Other **(6)**

The next questions asked which of the methods respondents had used they would use again or not and why (Table 2.9., 2.10.).

Table 2.9. Categorised responses to the open question: Which of the methods of restricted grazing that you have tried would you use again and why? (N=454)

Method	Number of Respondents	Descriptions
Strip Grazing	159	Effective **(26)** Easy to implement **(20)** Control over the amount the horse is eating **(18)** Pasture can be rested **(13)** Horse seemed happy with this method **(12)** Allows horse to have most normal life e.g. company, constant forage access **(11)** Increases exercise compared to other methods **(10)** Cheap/cost effective **(3)** Do not like other methods **(3)** No reason given **(86)**
Grazing Muzzle	110	Effective **(23)** Allows horse to have most normal life e.g. company, constant forage access **(20)** Easy to implement **(13)** Increases exercise compared to other methods **(13)** Only option available **(5)** Horse seemed happy with this method **(2)** Does not affect other yard users or horses **(2)** Makes use of whole field **(1)** Cheap/cost effective **(1)** No reason given **(49)**
Track System	106	Increases exercise compared to other methods **(41)** Effective **(16)** Allows horse to have most normal life e.g. company, constant forage access **(16)** Horse seemed happy **(6)** Easy to manage once implemented **(3)** Mentally enriching **(3)** Pasture can be rested **(3)** Cheap/cost effective **(2)** Do not like other methods **(2)** Can control grass availability (widening and narrowing track) **(2)** No reason given **(44)**
Starvation Paddock or Similar	104	Effective **(20)** Easy to implement **(11)** Control over the amount the horse is eating **(7)** Increases exercise compared to other methods **(6)** Horse seems happy **(6)** Allows horse to have most normal life e.g. company, constant forage access **(3)** Cheap/cost effective **(2)** No reason given **(57)**

Stabling	69	Effective **(12)** Easy to implement **(5)** Use to treat acute condition e.g. if has an attack of laminitis **(4)** Horse seemed happy **(2)** Allows pasture to recover **(2)** Fits around other needs e.g. horse in away from flies **(2)** Only option available **(2)** Control over the amount the horse is eating **(1)** No reason given **(43)**
Crew Yard or Similar	40	Allows movement/exercise **(6)** Allows horse to have most normal life e.g. company, constant forage access **(6)** Ease of implementation **(2)** No need to worry about horse accessing grass **(2)** Horse seemed happy **(1)** Effective **(1)** No reason given **(27)**
Smaller Paddock	12	Effective **(2)** Flexible (using electric fencing to change size if needed) **(2)** Horse seemed happy **(1)** Can control how much is eaten **(1)** No reason given **(7)**
Rotational grazing	5	Effective **(1)** Pasture can be rested **(1)** Allows horse to have most normal life e.g. company, constant forage access **(1)** No reason given **(3)**
None	5	Ineffective - compensatory eating if allowed onto grass for a short time, cause distress for horse **(1)** Use exercise instead **(1)** No reason given **(3)**
Other	51	

Table 2.10. Categorised responses to the open question: Which of the methods of restricted grazing that you have tried would you NOT use again and why? (N=369)

Method	**Number of Respondents**	**Descriptions**
Grazing Muzzle	150	Horse did not like it/seemed frustrated/distressed/depressed **(52)** Horse removed muzzle **(35)** Rubbed/caused sores/poor fit **(26)** Abnormal dental wear **(19)** Feelings of guilt/dislike/owners think cruel/inhumane **(19)** Ineffective **(11)** Horse unable/refused to eat **(8)** Compensatory eating on removal **(7)** Prevent/limit natural behaviour e.g. mutual grooming **(6)** Not suitable with owner's situation e.g. grass too short **(6)** Horse caught on self or something else **(5)** Could not find one that would fit horse correctly **(4)** Stomach ulcers (exacerbated or possibly caused) **(3)** Horse damaging/breaking/losing muzzle – becomes expensive **(3)**

		Horse became hard to catch **(3)** Too restrictive (not enough forage) **(3)** Horse would not drink while muzzled **(2)** Restricted forage intake too much **(2)** Do not know how much horse is eating **(2)** Judgement/interference from other people e.g. removing muzzle **(2)** Reduces movement **(2)** Would only use if people around to supervise **(2)** Other **(9)**
Stabling	64	Limits movement/exercise/being outside **(28)** Horse seemed bored/frustrated/distressed **(19)** Other physical health problem **(6)** Isolates and prevents social interaction **(5)** Compensatory/binge eating when horse is turned out **(3)** Horse may be left without forage for prolonged period **(3)** Unnatural/prevents natural behaviour **(3)** Cost – bedding etc. **(2)** Feelings of guilt/dislike/owners think cruel/inhumane **(2)** Ineffective **(1)** Development of stereotypies **(1)** Other **(18)**
Starvation Paddock or Similar	55	Horse seemed bored/depressed/distressed/frustrated **(12)** Limits movement/exercise **(11)** Horse was receiving too little forage **(10)** Damage to pasture **(8)** Other physical health problem **(7)** Horse had to be isolated when using this method **(6)** Ineffective **(6)** Feelings of guilt/dislike/owners think cruel/inhumane **(5)** Short stressed grass – higher in sugar **(5)** Horse escaping/breaking fences **(3)** Risk of sand colic **(2)** Abnormal dental wear **(2)** Increased aggression/difficulty handling **(2)** Unsightly **(2)** Unnatural/prevents natural behaviour **(1)** Labour intensive **(1)** Coprophagy **(1)** Other **(7)**
Strip Grazing	47	Compensatory eating/gorging when fence moved/sudden change in grass type **(13)** Damage to pasture **(10)** Ineffective **(9)** Horse seemed bored/depressed/distressed/frustrated **(7)** Horse escaping/breaking fences **(6)** Labour intensive **(5)** Not suitable with owner's situation **(4)** Limits movement/exercise **(4)** Once eaten grass down it is short and stressed – higher in sugar **(3)** Horse may be left without sufficient forage for prolonged periods **(3)** Allows access to grass that is too lush **(3)** Abnormal dental wear **(1)**

		Development of stereotypic behaviour **(1)** Increased aggression/difficulty handling **(1)** Does not allow established dung area **(1)** Meant horse had to be isolated **(1)** Hard to control how much grass horse has access to **(1)** Other **(5)**
Track System	17	Results in short stressed grass – higher in sugar **(4)** Damage to pasture **(3)** Horse escaping/breaking fencing **(3)** Allowed access to too much grass **(2)** Other physical health issues **(2)** Ineffective **(2)** Not suitable with owner's situation **(1)** Expensive **(1)** Labour intensive/not practical **(1)** Horse seemed bored/depressed/distressed/frustrated **(1)** Increased aggression between horses (and injuries) **(1)** Other **(3)**
Smaller Paddock	8	Limits movement/exercise **(4)** Damage to pasture **(2)** Unnatural/prevents natural behaviour **(1)** Meant horse was isolated **(1)** Not effective **(1)** Other **(2)**
Crew Yard or Similar	5	Horse seemed bored/depressed/distressed/frustrated **(1)** Limits movement/exercise **(1)** Labour intensive **(1)** Other **(2)**
None/N/A	29	
Other	27	

Respondents were then asked whether there were any other methods they had not used they would consider trying in the future, or not consider trying (Table 2.11., 2.12.).

Table 2.11. Categorised responses to the open question: Are there any other RGMs you would consider trying in the future? (N=316)

Method	**Number of Respondents**
Track System	104
Strip Grazing	26
Crew Yard or Similar	18
Grazing Muzzle	16
Starvation Paddock or Similar	14
Equicentral	14
Stabling	3
Smaller Paddock	1
None/N/A	79
Other	41

Table 2.12. Categorised responses to the open question: Are there any other RGMs you would NOT consider trying in the future? (N=310)	
Method	**Number of Respondents**
Stabling	79
Grazing Muzzle	71
Starvation Paddock or Similar	44
Strip Grazing	20
Track System	15
Crew Yard or Similar	11
Equicentral	1
Smaller Paddock	1
None/N/A	33
Other	35

The percentage of respondents who had used each method that would and would not use the method again is shown in Figure 2.19. More people said they would use track systems again than had originally said they used them and so this method was excluded from the graph.

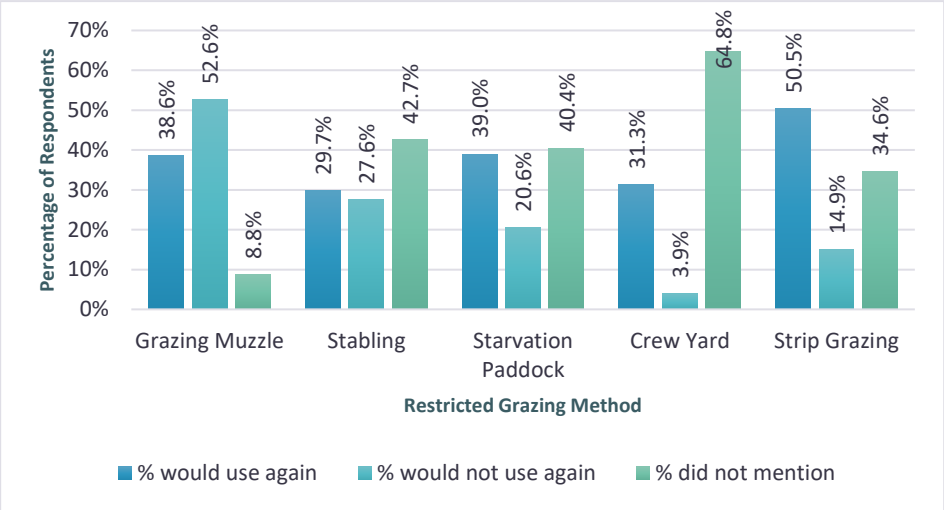


Figure 2.19. A graph to show the percentage of respondents who had used a method and would or would not use it again, and the percentage who had used a method but did not mention whether they would or would not use it again.

2.2.4. Further Questions on Strip Grazing

When asked, 293 participants indicated they had strip grazed and would be happy to answer further questions specifically on this method. Strip grazing was most likely to take place in the spring, although for many it varied depending on how much grass was available that year (Figure 2.20.), and 44% strip grazed for different reasons depending on the season (Figure 2.21.).

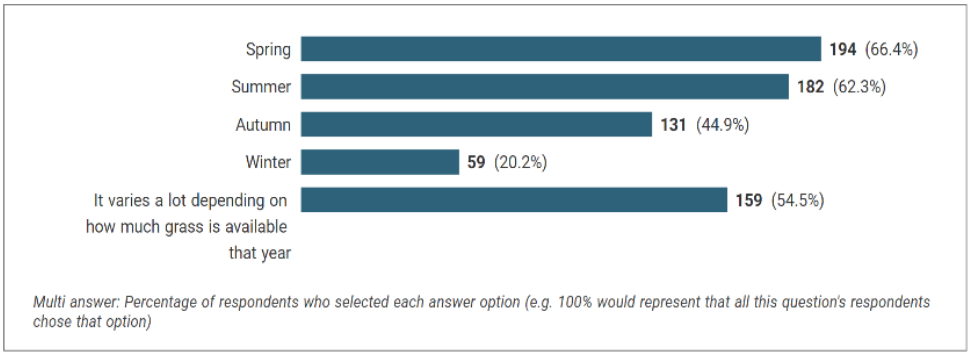


Figure 2.20. Response to question: What times of year do you usually strip graze?

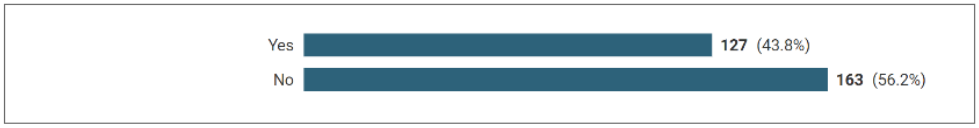


Figure 2.21. Response to question: Do you strip graze for different reasons in different seasons e.g. pasture management vs weight control?

Figure 2.22. demonstrates the different forms of strip grazing and were included in the questionnaire. The most common method of strip grazing was to have a single mobile fence which travels up the field (B) while all others remain in place (48%), but only slightly fewer used two mobile fences travelling up the field (A) (41%). Only 4% moved the fence so the paddock was made up entirely of new grass each time the fences were moved (C) – this is a form of rotational grazing rather than strip grazing, but was included as it was thought that some people practised this method and considered it to be true strip grazing. Other variations were used by 6%, and these mainly involved using a combination of two of the different methods (Figure 2.23.).

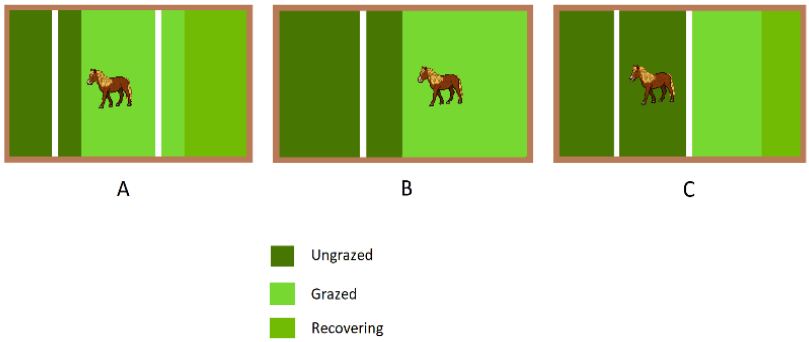


Figure 2.22. Diagram provided in the questionnaire demonstrating three different forms of strip grazing.

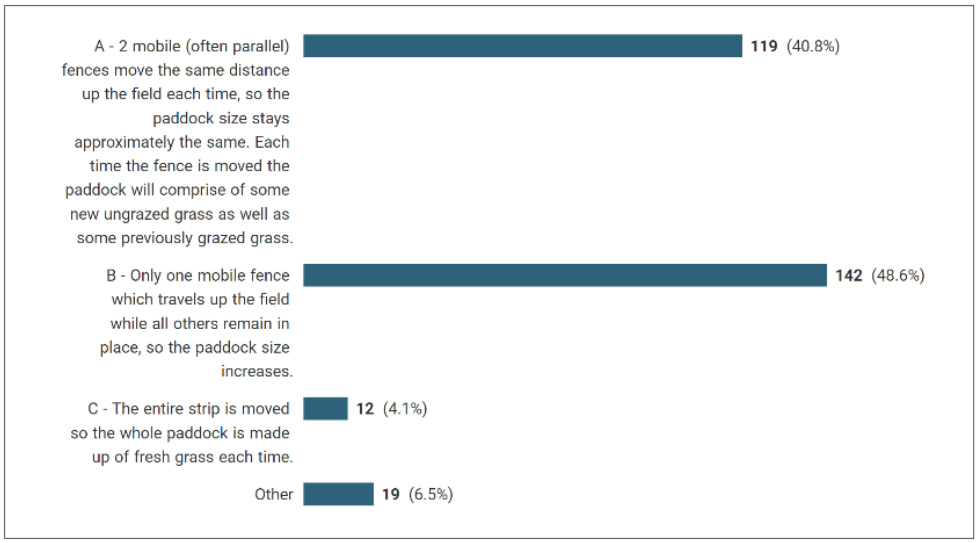


Figure 2.23. Response to question: Which of these descriptions/diagrams best represents the type of strip grazing you normally practise? Each diagram shows the pasture just after the strip has been moved.

The main factor influencing how often and how much respondents moved the strip fencing was how quickly the grass grew/got eaten down (Figure 2.24., 2.25.).

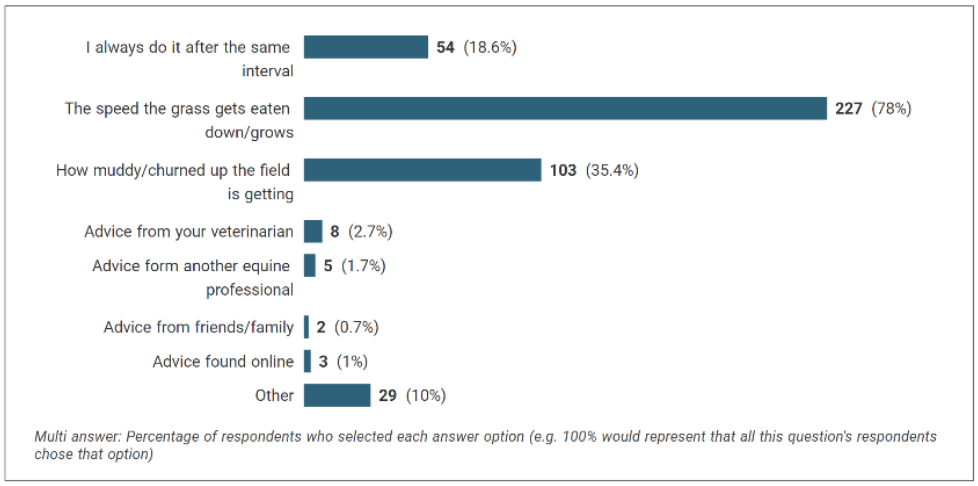


Figure 2.24. Response to question: How do you decide how often to move the strip?

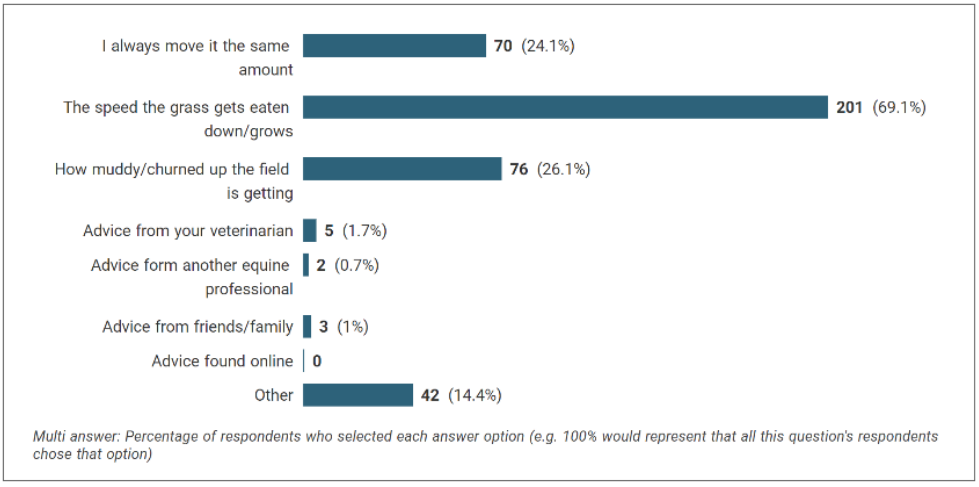


Figure 2.25. Response to question: How do you decide how much you move the strip by each time?

Similar numbers of horses were strip grazed individually, or with one or two others (Figure 2.26.), and for the majority of horses this was the same situation as when they are not being strip grazed (Figure 2.27.).

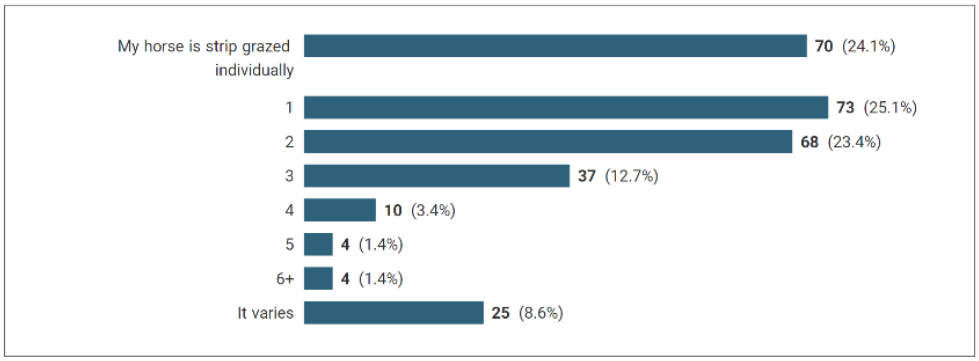


Figure 2.26. Response to question: When strip grazed, how many other horses are in the same strip as your horse?

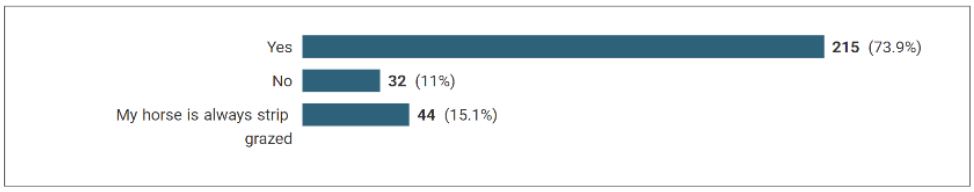


Figure 2.27. Response to question: Is this the usual number of horses turned out with your horse when you are not strip grazing?

Thirty percent of respondents indicated they used a muzzle on their horses while strip grazing for at least part of the time (Figure 2.28.).

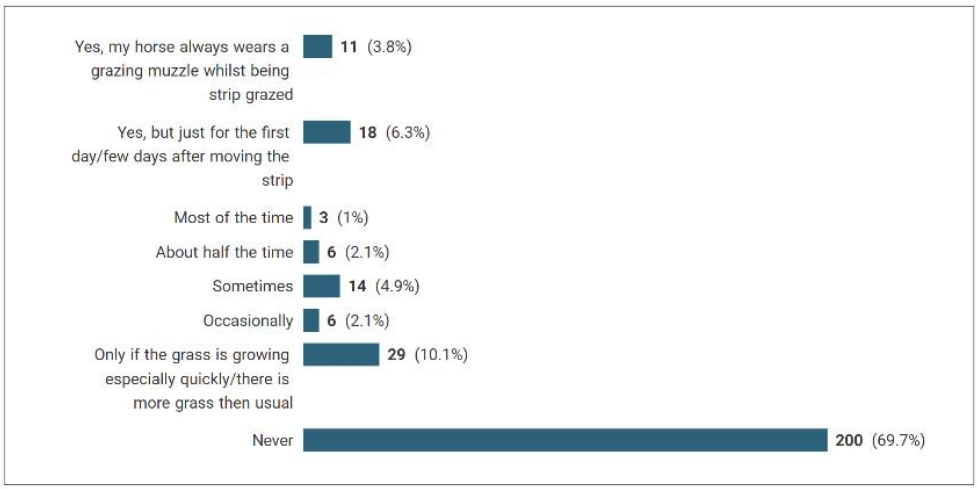


Figure 2.28. Response to question: Do you ever use a grazing muzzle on your horse while also strip grazing?

Respondents were then asked whether they had experienced any issues when strip grazing, and if there were any issues they had not experienced but thought were a potential risk (Table 2.13., 2.14.).

Table 2.13. Categorised responses to the open question: Have you ever had any problems with strip grazing? (N=274)

Issue Experienced	Number of Respondents	Specific Issues Mentioned
No issues	112	
Escaping	103	Breaking or getting through or under fences **(65)** Only occasionally/in specific circumstances e.g. battery flat **(20)** Jumping over fences **(18)** Fences falling down e.g. in bad weather **(10)**
Pasture issues	21	Overgrazing and associated issues e.g. weeds, bare patches/no grass growth when dry, short stressed grass **(12)** Churned up and muddy when wet **(9)**
Impact on behaviour or psychological welfare	15	Anticipatory behaviour when waiting for fence to be moved **(5)** Horse stressed or frustrated **(4)** Aggression between horses **(3)** Horses becoming dangerous or difficult to handle **(3)** Pacing/fence walking **(2)** Other behavioural changes **(2)**
Ineffective	14	
Gorging on fresh grass	11	
Other physical health issues	7	Injuries due to breaking through fence **(3)** Increased worm burden **(2)** Limits movement/exercise **(1)** Rug caught in fence **(1)**
Labour intensive	7	
Any other issue	13	

Table 2.14. Categorised responses to the open question: Do you think there are any other potential issues that could occur with strip grazing? (N=240)

Potential Issue	Number of Respondents	Specific Issues Mentioned
Other physical health issues	56	Limits movement/exercise **(15)** Injury due to getting caught on temporary fencing **(14)** Colic **(9)** Increased worm burden **(7)** Digestive health e.g. gastric ulcers **(7)** Increased dental wear due to short grass **(2)** Other **(9)**
No potential issues	52	
Pasture issues	50	Overgrazing and associated issues e.g. weeds, bare patches/no grass growth when dry, short stressed grass **(30)** Churned up and muddy when wet **(18)** General/other issues mentioned **(3)**
Escaping	42	Breaking or getting through or under fences **(33)** Fences falling down e.g. in bad weather **(6)** Jumping over fences **(3)**
Impact on behaviour or psychological welfare	27	Anticipatory behaviour when waiting for fence to be moved **(5)** Horse stressed or frustrated **(4)** Aggression between horses **(3)** Horses becoming dangerous or difficult to handle **(3)** Pacing/fence walking **(2)** Other behavioural changes **(2)**
Gorging on fresh grass	22	
Ineffective	14	
Labour intensive	10	
Any other issue	12	

2.2.5. Further Questions on Grazing Muzzles

When asked, 251 participants indicated they had used grazing muzzles and would be happy to answer further questions specifically on this method. Most horses wore a grazing muzzle every day when their grazing was being restricted (Figure 2.29.) and were most likely to have it on for between 4 and 12 hours/day, although 11% were muzzled for 19-24 hours/day (Figure 2.30.).

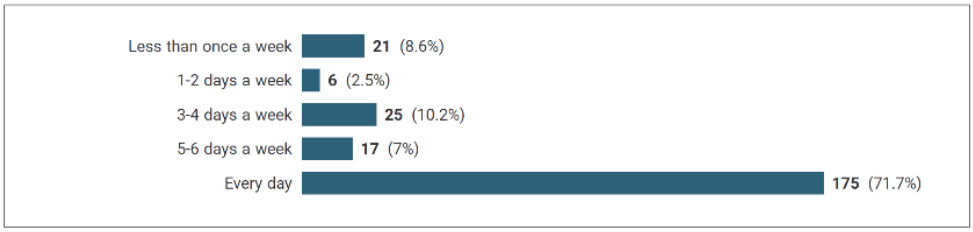


Figure 2.29. Response to question: When restricting grazing how many days a week does your horse usually wear a muzzle?

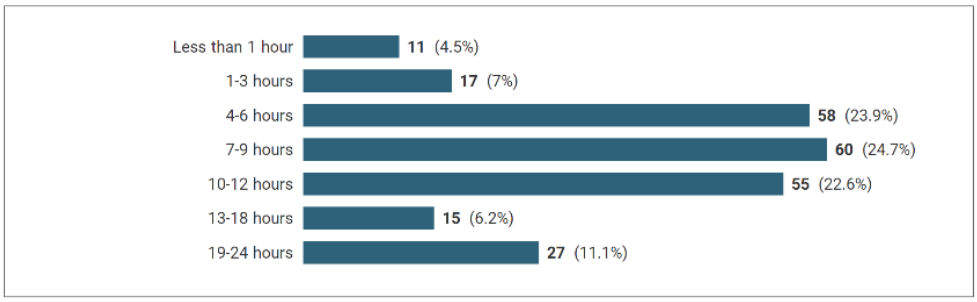


Figure 2.30. Response to question: On a day your horse is wearing a muzzle, how long does it normally have it on for?

The most common muzzle style muzzle used was a woven bucket with a solid base and single hole in the bottom (Figure 2.31.).

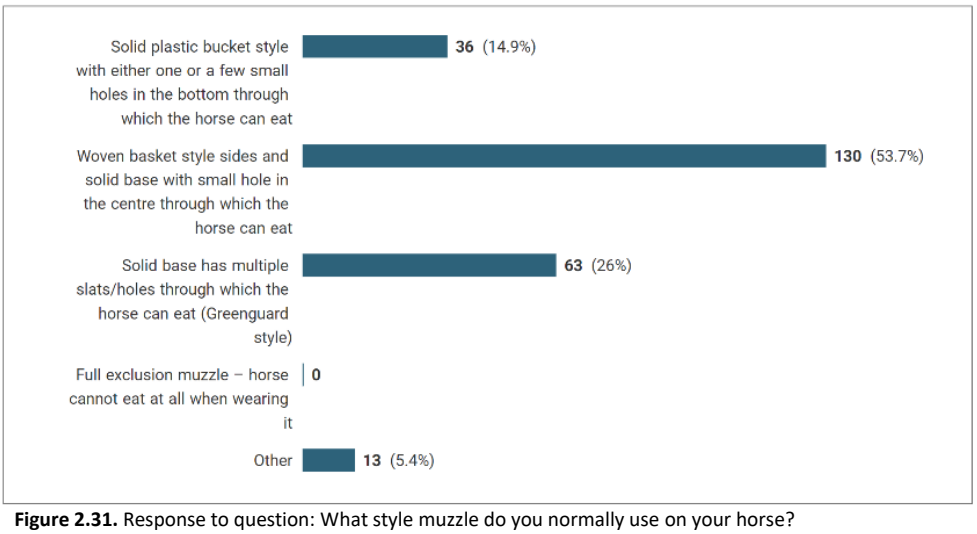


Figure 2.31. Response to question: What style muzzle do you normally use on your horse?

Respondents were most likely to use a muzzle on their horse in spring, although 43% also said it varied depending on grass availability that year (Figure 2.32.).

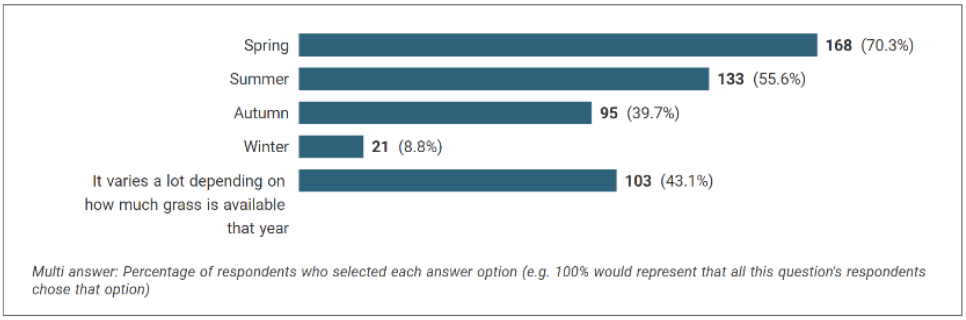


Figure 2.32. What times of year do you usually use a grazing muzzle on your horse?

The vast majority of horses were turned out with others when muzzled (Figure 2.33.); this was not the normal turnout situation for only 5% of horses (Figure 2.34.).

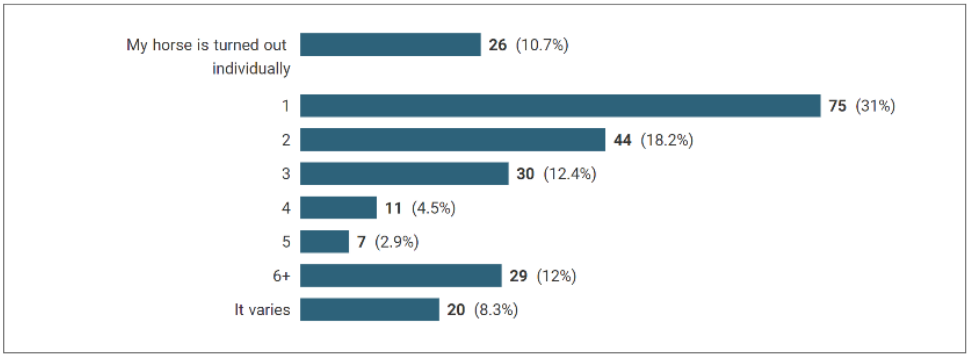


Figure 2.33. Response to question: When muzzled, how many other horses is your horse usually turned out with?

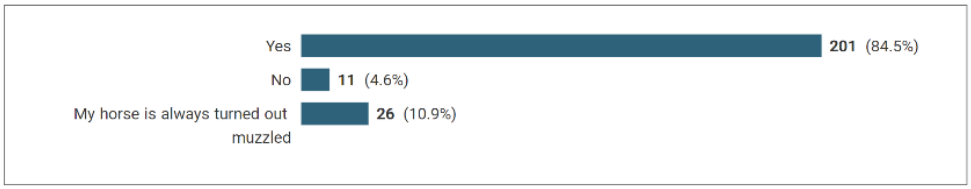


Figure 2.34. Response to question: Is this also the usual number of horses turned out with your horse when it is not muzzled?

For most horses, they were the only one muzzled in their turnout group (Figure 2.35.).

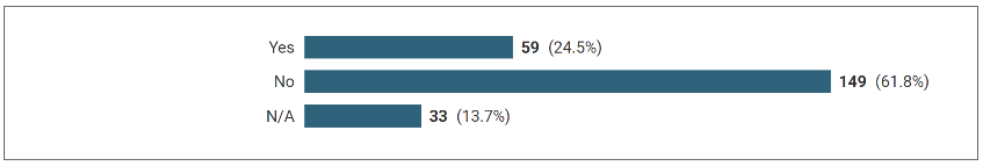


Figure 2.35. Response to question: If your horse is turned out with others, are any of them usually muzzled too?

Of owners that kept their horses in the same social group when they were muzzled, 61/211 (29%) reported seeing differences in how horses interacted when one or more were muzzled (Figure 2.36.); these changes are reported below in Table 2.15.

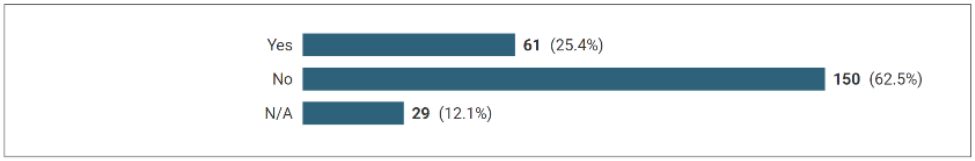


Figure 2.36. Response to question: If your horse is kept in the same social group, did you notice any differences in how the horses interacted when one or more were muzzled?

Table 2.15. Categorised responses to the open question: If your horse is kept in the same social group, did you notice any differences in how the horses interacted when one or more were muzzled? (N=61)

Differences	Number of Respondents	Specific Changes Mentioned
Impeding mutual grooming	27	Mutual grooming stopped **(25)** Mutual grooming made more difficult **(2)**
Impact on relationships with other horses	21	General change/decrease in social interactions **(5)** Muzzled horse 'bullied' or harassed more by others **(4)** Decreased interaction with others e.g. avoidance of muzzled horse or muzzled horse going to stand away from others **(3)** Relationship changes e.g. companions no longer initiate grooming with muzzled horse or now prefer to spend time with others **(3)** Decreased harassment from muzzled horse **(3)** Decrease in play **(2)** Muzzled horse spending more time displacing others **(1)**
Behaviour change in muzzled horse	14	Horse appeared withdrawn/subdued/depressed **(5)** Horse appeared aggressive/defensive/grumpy **(4)** Decreased in activity/increase in standing **(3)** Horse appeared distressed/less settled **(3)**
Companions interacting with muzzle	15	Other horses remove or try to remove muzzle **(12)** Others pull at/chew/play with muzzle **(3)** Others show general interest in muzzle **(2)**
Muzzled horse using muzzle to interact with companions	3	Hitting/nudging other horses with muzzle **(2)** Using muzzle to dribble water on other horses **(1)**
Other	2	Companions appeared distressed due to muzzled horse being distressed **(1)** Muzzled horse unable to groom self **(1)**

The majority of respondents also reported that their horses learnt to eat (Figure 2.37.) and drink (Figure 2.38.) straight away or at least by the end of their first session wearing the muzzle.

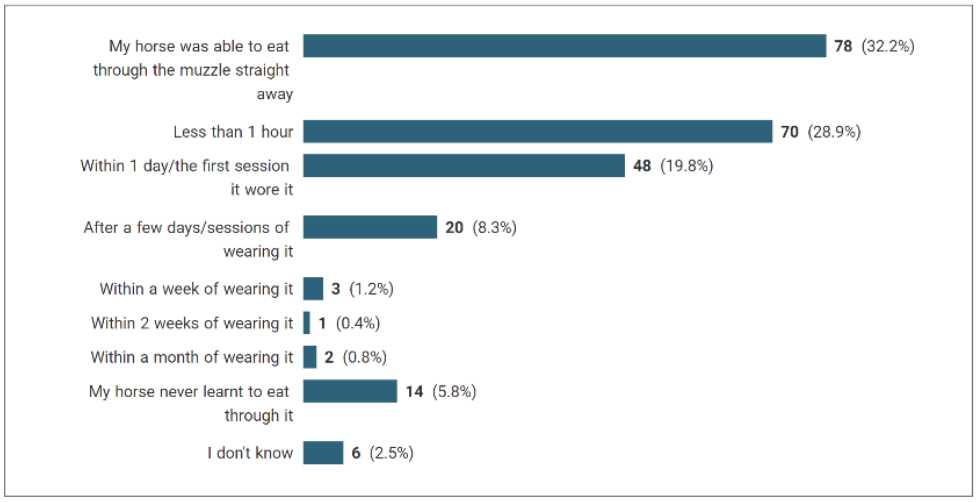


Figure 2.37. Response to question: How long did it take for your horse to learn to eat through the muzzle?

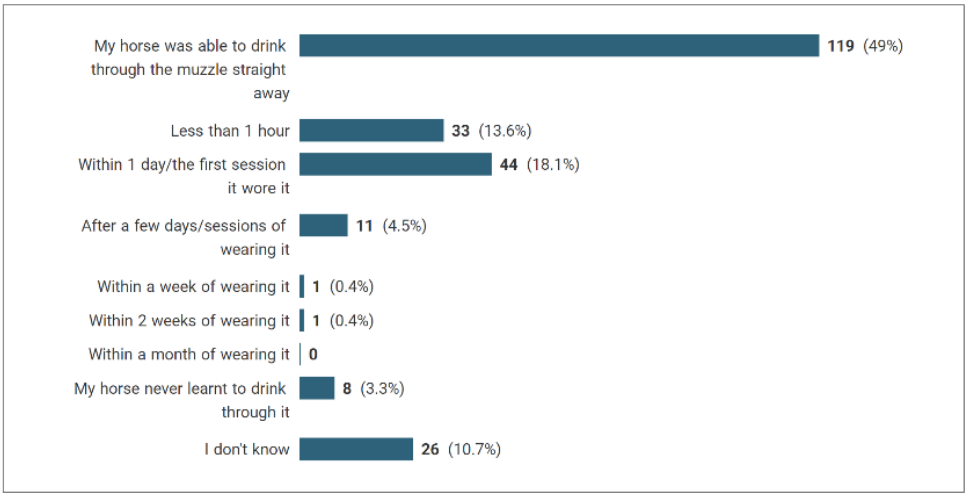


Figure 2.38. Response to question: How long did it take for your horse to learn to drink through the muzzle?

Respondents were asked how they introduced their horse to the muzzle, the majority said they did so 'gradually', use of positive reinforcement was described by 6 respondents (Table 2.16.).

Table 2.16. Categorised responses to the open question: How did you introduce your horse to wearing the muzzle? (N=235)

Type of Introduction	Number of Respondents	Specific Techniques Mentioned
Gradual	120	Began muzzling for a short time and slowly increased **(102)** Gradual and fed through muzzle **(34)** Gradual but no specific method mentioned **(11)** Gradual and checked horse could eat and drink **(8)** Positive reinforcement specifically mentioned **(6)** Gradually increased size of muzzle aperture **(3)**
Abrupt – put muzzle straight on and turned horse out	50	Muzzle put on horse without any kind of introduction or training **(50)** Abrupt but checked horse could eat and drink **(7)** Abrupt but also mentioned monitoring/watching horse **(6)**
Feeding through muzzle (but no mention of gradual introduction)	42	Fed treats/grass/hay etc through hole(s) or in bottom of muzzle **(42)** Checked horse could eat and drink **(9)** Increasing size of hole in muzzle **(1)**
Tried on horse while stabled to get used to	4	
Respondent wasn't the one to introduce muzzle/did not remember	8	
Other	11	

Most owners reported some form of adverse reaction to the muzzle being introduced (Table 2.17.).

Table 2.17. Categorised responses to the open question: How did your horse react initially when turned out wearing the muzzle? (N=239)

Reaction	Number of Respondents	Specific Behaviours Mentioned
Largely unaffected	79	Either no reaction/grazing straight away or very mild reaction e.g. rubbing muzzle on leg for first few minutes **(79)** Initial reaction fine but after using for a bit horse became distressed/avoided being caught/kept removing muzzle **(4)**
Behaviour change	71	Horse appeared annoyed/grumpy/didn't like or hated muzzle **(21)** Horse appeared frustrated **(17)** Horse appeared depressed/sulking/resigned/unhappy **(17)** Horse appeared stressed **(13)** Horse appeared confused **(4)** **Extreme reaction** – horse reacted by bucking, rearing, bolting and throwing his whole body on the ground **(1)**
Rubbing muzzle on legs/objects/other horses or pawing at it	60	Horse managed to quickly destroy muzzle by learning to stand on base **(1)**
Mild aversion – only initial or only occasional frustration etc.	47	
Did not attempt to graze	28	
Attempted to eat but was unable	6	Increased size of hole, then successful **(1)** Grass being flattened, not going through muzzle **(1)**
Lots of head shaking/tossing	6	
Other	5	

Owners also reported experiencing issues with using muzzles, mainly due to them causing rubs or sores on their horse's face, but also due to the horse frequently removing the muzzle (Table 2.18.).

Table 2.18. Categorised responses to the open question: Have you ever found any problems with using a grazing muzzle? (N=240)

Issue	Number of Respondents	Specific Issues Mentioned
Sores/Rubbing on horse's face	104	
Removal of muzzle by horse or herd mates	83	
Impact on behaviour or psychological welfare	30	Horse appeared unhappy/depressed **(10)** Decreased/prevented social interactions **(10)** Horse appeared stressed/anxious **(9)** Horse frustrated **(3)** Horse difficult to catch **(2)** Decreased activity/increased time standing **(1)** Other **(2)**
No issues	28	
Abnormal dental wear	22	
Damage to muzzle	10	Wears out/enlarges aperture(s) quickly when grazing **(5)** Breaks muzzle attempting to remove it **(5)**
Muzzle getting caught/stuck	9	Caught on something in field **(4)** Stuck on horse's teeth/mouth/face **(3)** Stuck on horse's foot **(2)**
Over heating/breathing issues	8	Hot/sweaty **(5)** Impacts breathing when hot **(3)**
Never learnt/refused to eat/drink	8	
Ineffective	6	
Labour intensive	4	
Interference/Muzzle removal by people	4	
Compensatory/Binge eating	3	
Other	18	

The main concern owners had was that the muzzle would get caught on objects in the field or on the horse itself (Table 2.19.), though this was only reported as happening by 9 owners in the previous question.

Table 2.19. Categorised responses to the open question: Do you think there are any other potential issues with grazing muzzles? (N=217)

Potential Issue	Number of Respondents	Specific Potential Issues Mentioned
Muzzle getting caught on objects in field	63	
Impact on behaviour or psychological welfare	57	Decrease/alter/prevent social interactions **(30)** Stress/anxiety **(12)** Frustration **(9)** Could make horse unhappy/depressed **(5)** Possible development of stereotypies **(1)** Unwanted behaviour when handling/riding **(1)** Other **(3)**
Abnormal dental wear	54	
Sores/Rubbing	35	
Removal of muzzle	15	
No issues	12	
Ineffective	9	
Over heating/breathing issues	8	Impacts breathing/ventilation **(5)** Hot/sweaty **(4)**
Compensatory/Binge eating	6	
Interference/Judgement by people	3	
Unexpected positive effects	1	Prevent muzzled horse from bullying/harassing others **(1)**
Other	41	

2.3. Discussion

2.3.1. Overview

The purpose of this exploratory questionnaire was to gather data on restricted grazing practices being carried out on horses in the UK. The vast majority of respondents were horse owners or carers and were very experienced in the horse world with only 7% having less than 10 years' experience with horses and none having less than 2 years. Other surveys have reported similar demographics, suggesting comparisons may be drawn between them (Jaqueth *et al.* 2019; Boden *et al.* 2013). It is likely that in general this group of participants were responsible for making decisions for the horses' care, as opposed to loaners/sharers who may have less control.

2.3.2. Non-Restricted Grazers

Of the 35 respondents who indicated they had not used any form of restricted grazing in the past, 12 went on to describe RGMs when asked how they managed their horses' pasture and a range of grass/feed related health issues. On the information and consent page prior to beginning the questionnaire a definition of restricted grazing for the purposes of the questionnaire was provided, in case some respondents had different ideas on what practices counted as restricted grazing. However, these 12 respondents may not have understood the definition, may not have read it, or may have selected 'no' when asked if they restricted grazing erroneously. Alternatively, despite reading the definition they may not have wanted to think of themselves as 'restricting' their horses due to negative connotations. As a result, the ability to generalise results from analyses of this group of respondents to the wider population of horse carers who do not restrict grazing is limited, and is further limited because of the small sample size.

Respondents listed the RGMs they had heard of, with grazing muzzles and strip grazing being mentioned by the majority of people. These methods were also most frequently used by those who had restricted grazing. Stabling was also used by over 50% of restricted grazers but was only mentioned by 10 non-restricted grazers as a method they were familiar with. This may be because stabling is viewed as a standard management practice because of its widespread use (Hotchkiss *et al.* 2007) and not a restriction method by some people, even if it is being used to limit pasture access.

Over half of NRGs had cared for horses that had had laminitis, PPID or required weight management; these health issues generally include restricted grazing as part of treatment though other methods are also available. The most common alternatives to restricted grazing described for managing these issues were altering forage provision e.g. by soaking hay (shown to decrease dry matter and aid in

weight loss (Argo *et al.* 2015; McGowan *et al.* 2013)), using a slow feeder (shown to increase feeding time without increasing intake and reduce frustration (Rochais *et al.* 2018; Hallam *et al*. 2012)) or using a different type/quality of forage, reducing or using a lower calorie feed, and increasing exercise. These were also the most common non-RGMs used by RGs alongside restricted grazing; it is likely they may find these methods more effective when used in conjunction.

When NRGs were asked which method they thought they would try if they needed to restrict grazing in the future there was not one clear choice but a spread with no method being suggested by more than 22% of respondents. This indicates owners are split on what method is best, though these choices are also likely to reflect what is possible to do at their current yard, experience of observing others use these methods and what they think would best suit their horse.

2.3.3. Factors Influencing Horse Carers' Choice of Restricted Grazing Method

Interestingly, in most cases welfare rating was not associated with the methods people used. Strip grazing was reportedly tried by the most respondents and also perceived as best for welfare by both groups. However, grazing muzzles had been tried second most frequently while rated as second lowest in terms of welfare, and turnout in crew yards or similar had been used by least people of the options given but were viewed as second best for welfare. It is possible that some respondents viewed physical health and welfare as two separate things, as has been seen in other studies (Horseman *et al.* 2016), and may have been prioritising health at the expense of other aspects of welfare when choosing a method to use. Alternatively, it may indicate that horse carers are unable to use their preferred method, for example muzzles are cheap and non-labour intensive whereas many yards may not have a crew yard or similar available. This is supported by owners answers to the question asking what influenced their initial decision of which method to use; though most respondents said it was their personal judgement or experience that led them to choose which methods to try, over 50% said ease of implementation was a factor. The vast majority reported being the main person responsible for the day to day care of their horse, therefore respondents are likely to be the ones implementing the restricted grazing measures, rather than having yard staff do this for example. This is likely why ease of use is key, with horse carers preferring to avoid labour intensive and time-consuming practices. This is corroborated by Furtado *et al.* (2017) who found time management to be a major influence over how owners managed their horses' weight and general management (also Myers & Myers 2015). Additionally, nearly 25% said cost impacted their decision, also reported as an issue by Myers and Myers (2015) and for 13% the method used was the only method available to them.

For around 1/3 of respondents their initial decision was influenced by research or advice from online, demonstrating the importance of this medium for disseminating information to horse carers. Approximately 75% of respondents also indicated that they had used online sources to find advice or do research into restricted grazing. A variety of different sources were widely used, with the most common source being a website offering a professional's opinion; this may be a reputable magazine or charity, but this may also include resources created by people claiming to be experts, but who do not have any relevant qualifications. This is also the case for other websites providing advice on restricted grazing and Facebook groups, where people may speak confidently and be persuasive without having the evidence to back up claims which may just be based on opinion (Myers & Myers 2015). However, Facebook groups and forums may play an important role in providing a support network to horse carers. Studies have found human weight loss support groups on Facebook provide perceived emotional, informational and instrumental support to users, the latter two forms of support were also facilitated by online forums but to a much lesser extent (Taiminen & Taiminen 2016). Although, respondents of the current study utilised a wide range of sources, with nearly half gaining restricted grazing information from scientific papers. The majority of respondents agreed it was easy to find information on restricted grazing, though fewer also agreed this information was easy to implement in a practical situation, and even fewer believed the available information made it easy to decide which RGM was most suitable for their situation. This demonstrates that although horse carers may be able to access information, they may struggle to put this into practice to effectively limit grass intake and could potentially be a reason some turn to online support groups. This indicates there is a gap in the market for user friendly guidance on restricted grazing, presented in a way that is accessible to horse carers of all educational backgrounds and levels of experience. The NEWC (2015a) has provided guidelines for horse carers on muzzling, but many may be unaware of the availability of these guidelines or struggle using them.

Facilities at the yard undoubtedly affect the methods available, if there are no stables/arena/yard area then these methods will not be an option, but rules made by the yard manager/landowner may also prevent the use of certain methods. Nearly a quarter of respondents from both groups had restrictions imposed on how they could manage their horse due to rules or the situation where their horse was kept. One of the common rules mentioned was that horse carers were unable to alter the paddocks e.g. by using electric fencing to strip graze, sectioning off some of the field to make a starvation paddock or creating a track system. Set turnout hours, or limited/no turnout in winter or bad weather were also common restrictions. This may lead to horses spending longer in either the field or stabled than owners would prefer. Several mentioned horses being assigned set fields, with owners having no say in the groupings, size of the field or when the horse moves fields. Rules such as these bring challenges when trying to limit grazing as owners may have to compromise on which method they use. A third of RGs kept their horses at livery yards, these respondents are most likely

to be subjected to such rules. There is little research on the rules in place at livery yards and the extent to which the equine owning population may be affected, but similar restrictions as reported in this questionnaire have been described by Birke *et al.* (2010), for example relating to turnout availability and which fields horses could access. Equine stakeholders also identified limited grazing as a potential welfare issue at livery yards (Horseman *et al*. 2016).

Peer pressure, both real life and online (Myers & Myers 2015) and the 'culture' at an individual's yard (Furtado *et al.* 2017; Birke *et al.* 2010) are also likely to influence how owners manage their horses, with some practices being viewed as acceptable while others are not. Birke *et al*. (2010) received reports from owners that there was pressure to conform with the way the majority at the yard managed their horses, and that in some cases horses' welfare may have been compromised due to disagreements between owners. Yard culture and peer pressure were not directly asked about in this questionnaire though issues of this nature were brought up by a few participants, but almost exclusively in relation to muzzles. It may not be safe for horse carers to use muzzles if there is a risk they will be removed when the carer is not there, and the horse is allowed to graze freely. This could potentially occur without owners knowing, for example if they only came to the yard twice a day to turnout and bring in, others could remove the muzzle after the owner has left and put it back on again before they return. Muzzles are a comparatively recent invention and it is much less common to see them than a stabled horse; stabling may have become normalised and therefore not seen as a welfare problem (Horseman *et al.* 2017; Burn 2014). Respondents also reported feelings of guilt or considering the method inhumane as a reason they would not use muzzles again. This reason was also given regarding stabling and starvation paddocks though by far fewer people. Again, this could be due to other RGMs resembling common management styles, which have been normalised, in appearance, while muzzles are more likely to contrast these.

In other instances, muzzles were removed by passers-by who may not have had equine knowledge, or owners stopped using muzzles due to pressure from members of the public who thought they were cruel. Fields of horses may back onto roads or people's property, and it is not uncommon for footpaths to pass through them. This means people who do not understand the needs of horses are often exposed to them, and may intervene with a horse's management believing they are helping the horse, or because they wanted to feed it and did not consider the potential impact of doing so. This kind if interference from members of the public has been reported in Horse and Hound articles. For example, Murray (2019) reported how one owner had experienced their horse having her muzzle removed and then being fed bread on private land with no footpaths going through it, and her owner receiving reports from others of muzzles being cut off with knives. Muzzles are likely targeted due to people not understanding what they are for, but other pieces of equipment are interfered with possibly for the same reason, such as fly masks which owners reported have also been removed by passers-by (Murray 2019). Members of the public feeding horses is also a common problem, one

owner reported her horse suffered from choke after being fed crab apples despite signs being displayed asking people not to feed the horses (Jones 2019), while another's horse died of colic after grass cuttings were emptied into its field (Turner 2016). Therefore, members of the public can influence the methods of restricted grazing owners can use and their lack of understanding can result in horses suffering poor welfare.

Nearly half of respondents used restricted grazing as a form of pasture management. Treading by animals can cause damage due to poaching when the ground is very wet or by compaction, leading to decreased pasture yield and soil degradation (Drewry *et al.* 2008). This means horses may need to be removed from pasture or restricted to a smaller area to allow it to rest and recover and prevent long term damage, especially during wet weather or when stocking densities are high (Nie *et al.* 2001). However, laminitis and weight management were the main reasons for restricting grazing and metabolic disorders were also common reasons; these health issues are all linked, though suffering from one does not necessarily mean a horse will develop one of the others. Weight gain is a risk factor for laminitis (Pollard *et al.* 2019b) and the main known risk factor for EMS (Morgan *et al.* 2015), PPID and EMS are also risk factors for laminitis (Wylie *et al.* 2013) and some now support the view laminitis should be considered a symptom of these endocrine disorders rather than a disease in its own right (Morgan *et al.* 2015).

Owners monitored their horses' health in a variety of ways. Monitoring techniques are likely to differ in their accuracy, but any regular monitoring may be beneficial by helping owners become more aware of changes in their horses' health (Furtado *et al.* 2018a).

2.3.4. Respondent Experience and Perception of Welfare

RGs and NRGs gave very similar welfare ratings to each of the five listed methods, scoring them in the same order from best to worst, suggesting that welfare score was influenced not only by respondents' experience of the methods but also by their perception of how they thought these methods might affect welfare. Though this may have been influenced by some respondents who restricted grazing answering the questions intended for non-restricted grazers. However, perceptions of different methods are still likely to have a large impact, as most RGs reportedly had not used all five methods listed, but still gave a score to every method. Knowledge of equine behaviour and biology are likely to have had an influence, as well as attitudes held by other stakeholders. RGs gave significantly different scores to all methods, indicating they believed there was a true difference in how good each method was for welfare. In comparison, despite similar scores there were only significant differences between the two highest scoring and two lowest scoring methods from the NRG section as these had the largest difference between them. This is likely due to the fact the sample size for NRGs was much smaller.

The main concerns seemed to relate to physical welfare, namely the issue of reduced exercise which was mentioned as a problem most frequently by respondents when responding to free text questions, rather than psychological welfare which was discussed less often. This may in part be because physical welfare issues are more obvious, and the health problems these methods aim to prevent are also physical. It is possible that physical welfare may be prioritised over psychological welfare by some as it may have a greater influence over whether the horse can be used for its intended purpose e.g. ridden. Exercise may be frequently considered due to its important role in weight loss and management (de Laat *et al.* 2016), a key part of prevention and treatment of these diseases. Horse carers' concerns are likely correct; Hampson *et al.* (2010) found horses in a 6x6m yard walked 1.1km/day on average, compared to 4.7km/day for horses in a 0.8ha paddock, and Maisonpierre *et al.* 2019) also found decreasing paddock size decreased exercise. This will undoubtedly be an issue when stabling, and though it will depend on individual circumstances, starvation paddocks, crew yards and strip grazing are also likely to reduce available space compared to regular paddocks and so decrease exercise. Furthermore, exercise and the ability to move freely are likely to have psychological benefits for horses, as physical activity in nature has been found to improve human psychological wellbeing (Brymer *et al.* 2014). Therefore, preventing horses' innate desire to move will impact psychological welfare (Henderson 2007), and so this aspect may be implied by some respondents when discussing exercise.

Compensatory eating (when horses consume a disproportionate amount if allowed unrestricted access to grass following a period of restriction) was mentioned as a concern with all five main methods (this excludes track systems). Ince *et al.* (2011) found horses stabled to restrict grazing were

able to consume up to 49% of their daily DMI in the 3 hours they were turned out, while Longland *et al.* (2016b) found evidence of compensatory eating in ponies following a part time muzzling regime. Furthermore, Glunk and Siciliano (2011) found DMI rate increased as time allowed to graze decreased. Therefore, respondents' concerns are founded, compensatory eating risks reducing the efficacy of restricted grazing and needs to be taken into consideration whatever method is being employed. For some horses it may be unsuitable for them to be allowed any free access to pasture whilst on a restricted grazing regime.

When considering negative impacts on psychological welfare respondents typically talked about their horses feeling frustrated, stressed, bored, depressed or unhappy, whereas when talking about positive effects they said their horse seemed happy or that it could behave naturally. The most likely causes of negative psychological welfare when restricting grazing are social isolation, insufficient forage provision (also a physical welfare issue) and boredom from being left in a barren environment, all of which have been implicated in the development of stereotypic behaviour (Watson 2018), which was a concern raised by some respondents. This suggests that these factors could lead to horses experiencing the negative feelings described by respondents, and so respondents' worries may be justified. To minimise this, horses should be kept in groups where possible, and if this is not an option allowing some time where horses have the option to socialise and make physical contact each day could be beneficial (de Graaf-Roelfsema 2007). Thinking of novel ways to provide forage or splitting rations into several feeding sessions can slow consumption and promote trickle feeding (Furtado *et al.* 2018b; Watson 2018). Both are likely to reduce boredom as the horse will spend less time with nothing to occupy it (Watson 2018; Jarvis 2009). The likelihood of a method either meeting these needs or preventing them being met will often depend on how it is used in an individual situation, but different methods offer different opportunities and present different potential issues.

Respondents were asked which methods they would and would not use again, and where reasoning was provided effectiveness was either the most or second most frequent explanation. Effectiveness is clearly essential, otherwise there is no point in using a method whether it is easy, cost effective and perceived as 'natural' or not. An ineffective method will not only be a waste of time and resources and cause unnecessary distress to the horse but will leave the horse at risk of laminitis and weight gain. Although, as effectiveness was self-reported it is not possible to determine whether respondents' reports reflect the true efficacy of these methods. Ease of implementation/ management and the horse seeming 'happy' with the method were reasons mentioned regarding the six most frequently mentioned methods, even if only by a few people. Ease of implementation was also selected as a large influencer when making the initial decision of what method to use, showing this remains important. The ability for horses to live the most 'normal' life possible (with an emphasis on having company and constant forage access) and allowing increased exercise in comparison to other methods were also given as reasons to these same methods other than stabling.

That the chosen method was either cheap or cost effective was also mentioned regarding the four most frequently chosen methods. Though some of these reasons were only brought up by small numbers of respondents, the fact they are common across methods demonstrates that these are likely the main priorities of horse carers when choosing which methods to employ. While horse carers appeared to have the same priorities, they disagreed which methods met with these priorities. Below respondents' opinions of each of the main methods are considered, taking into account the key benefits and issues of each method described by the highest number of participants from responses to questions throughout the questionnaire.

2.3.4.1. Strip Grazing

Strip grazing was the method the highest percentage of respondents said they would use again in the future; this in combination with the fact respondents gave strip grazing the highest welfare score suggests it is the preferred method of restricted grazing. The ability to exercise was seen as the main advantage, followed by the ability to perform natural behaviour, while compensatory eating was the main welfare concern, followed by reduction in exercise. Respondents had conflicting opinions on the impact of strip grazing on exercise, though this may relate to what other methods they are comparing it to, i.e. strip grazing may reduce space and exercise compared to using a muzzle in a large turnout field, but will likely increase these compared to stabling. The form of strip grazing used will also impact on this; slightly fewer people used 'true' strip grazing, where two fences move simultaneously up the field, than a version where only one fence was moved so the paddock gets progressively larger. The latter version has the benefit of increasing space available, though also means pasture does not have the chance to rest, potentially increasing the likelihood of exposure to short, stressed grass which has higher concentrations of fructan (Virkajarvi *et al.* 2012).

Horse carers using this method should take care to minimise this risk for example overgrazing can be reduced by ensuring the strip is large enough for the number of horses on it. Respondents were also concerned with the sudden change in grass availability when the fence was moved. This has indeed been found as a risk factor for laminitis by Wylie *et al.* (2013) and Luthersson *et al.* (2017), although not by Pollard *et al.* (2019b). How much of an issue this poses is likely to be related to how frequently the strip is moved, grass type and growth rate, though there is currently no research on this. It is possible this risk may be reduced by using a grazing muzzle in conjunction with strip grazing, to slow the rate at which horses graze down the new strip of grass, though only 30% of respondents ever used these two methods together and evidence on whether this might be effective is also lacking.

The main reason respondents would continue to use strip grazing was because they found it effective and easy to implement, while the main reasons they would not were compensatory eating and

pasture damage. About 1/3 of respondents who indicated they had used strip grazing did not say they either would or would not use this method again, this suggests that this group did not feel especially strongly about strip grazing, i.e. it may not be their first choice method to use and they instead prefer others, but do not necessarily feel strongly about not using it ag ain.

The majority of strip grazing reportedly takes place in spring and summer, although over half of respondents said it depended on the grass availability that year, and it was common to use strip grazing for different reasons depending on season. Spring and summer are typically thought of as the time horses are most at risk of weight gain and laminitis and Giles *et al.* (2014) found obesity was most prevalent during summer. However, there is conflicting evidence regarding seasonality and laminitis with Luthersson *et al.* (2017) finding no association but Wylie *et al.* (2013) finding laminitis was four times as likely to occur in summer and winter compared to spring. Less respondents may also have strip grazed during winter due to increased risk of pasture damage as horses would be confined to a smaller area, though alternatively some may have strip grazed in winter to try and minimise pasture damage by allowing parts of the field to rest. Most respondents did not follow a set routine when strip grazing, and instead the main factor in deciding how much and often to move the strip was grass growth rate. Although, it is not known how successfully horse carers are able to estimate grass growth and available forage.

One of the benefits of strip grazing is that horses can be kept in groups (Hartmann *et al.* 2012), though about 25% were strip grazed individually. Only 11% of horses were grazed with a different number of field mates when being strip grazed; this is positive as it suggests strip grazing is not causing many horses to be isolated where they normally would not be. Furthermore, it suggests horses are being kept in the same social group which would be beneficial as social instability can increase aggression (Fureix *et al.* 2012). However, this cannot be confirmed as respondents were only asked whether the number of companions their horse was turned out with changed, not whether these companions were the same.

Of respondents who strip grazed, 38% did not identify any issues with the practice. This figure may be larger as the 6% of respondents who did not answer the question may have intended their lack of answer to be taken as meaning ‘no issue’. By far the main complaint was horses escaping, through a variety of methods, and this was also a common concern among those who had not previously had a horse escape. This could be dangerous for several reasons, the most obvious being horses gaining abrupt access to lush grass which could trigger laminitis (Luthersson *et al.* 2017; Wylie *et al.* 2013), but horses may also get stuck when attempting to escape, get out into areas that contain hazards or with horses they are at risk of fighting with, resulting in injury and distress. Temporary fencing should be regularly checked for damage/alteration to minimise likelihood of escape.

2.3.4.2. Grazing Muzzles

In contrast to strip grazing, muzzles were the method respondents seemed most dissatisfied with; they were rated second lowest for welfare but were also the only method a greater percentage of respondents said they would not use again than said they would. Nevertheless, nearly 40% of respondents said they would use muzzles again which is greater for some other methods, which instead had high percentages of respondents who did not mention them at all. This suggests muzzles polarise opinion; they had the highest response rate for any method, over 90% of respondents that had used them indicating whether or not they would use them again and only a small percentage not mentioning muzzles in regard to either question. This demonstrates horse carers tend to have strong feelings about muzzles, with users either loving or hating them and few feeling indifferent towards them. Comparatively, the other four methods all received less than 70% of users indicating whether they would use them in the future. As there was only one text box provided for each of these questions rather than a box per method, it is likely respondents chose to only discuss the methods they felt most strongly about.

The main arguments in support of grazing muzzles were that they are effective, which is supported by research (Davis *et al.* 2019a; b; Longland *et al.* 2011). Participants also perceived that they allow horses to be out with companions, exercising and trickle feeding, a perception supported by Longland *et al.* 2016a. The main argument against muzzles was that they adversely impacted mental welfare, with respondents reporting horses seeming distressed, frustrated or depressed whilst wearing them. There is contrasting evidence available on this, with some studies observing behaviours indicative of frustration and distress (Cameron & Hockenhull 2018; Longland *et al.* 2016b) while Davis *et al.* (2019a; b) found no increase in physiological indicators of stress, though subjects had at least 6 months prior experience of using grazing muzzles. It may be the case that even if horses experience distress initially, successful habituation can reduce or eliminate distress caused. Furthermore, individual responses to muzzling tend to vary (Davis *et al.* 2019a; Cameron 2018; Longland *et al.* 2016b), meaning muzzling is more likely to cause distress to some horses than others. Avoidance behaviours to being muzzled have been observed in some cases; mild avoidance was recorded in horses previously habituated to muzzling, in one case this remained consistent throughout the study (Davis *et al*. 2019b) whereas in another study it increased slightly throughout (Davis *et al.* 2019a), indicating that horses became less accepting of muzzles as time went on. However, subjects in neither study appeared to find the practice overly aversive, with horses standing still for muzzling and showing minor avoidance such as looking or leaning away from the handler (Davis *et al.* 2019a; b). In comparison, Cameron (2018) observed more extreme avoidance to having the muzzle fitted, which increased as the study progressed, in one horse who had not been muzzled prior to the study. However, these three studies were short term, so it is unclear whether avoidance behaviour would persist or even worsen long-term.

In this study, muzzled horses were more likely to be turned out in groups than horses being strip grazed, with only 10% on individual turnout. This was not the usual turnout situation for only 5%, meaning very few horses were potentially being isolated for muzzling when they would not usually be. Although an advantage of muzzling is being able to allow horses to socialise by during group turnout, there may be an impact of muzzles on social interactions and herd dynamics. This was identified as an issue by respondents and is recognised by the NEWC (2015a) as an area requiring further research to understand muzzles' potential effect. Most horses were also kept in the same social group as when not muzzled, reducing the chance of agonistic interactions (Henderson 2007), and 70% of respondents did not notice differences in how a social group interacted when one or more horse was muzzled. Although if horse carers do not spend much time observing their horse with its herd mates differences may be missed. For the owners who did notice changes impediment of mutual grooming was the primary difference mentioned. Mutual grooming is believed to promote social bonding (Schneider & Krueger 2012), but long-term implications of prevention of mutual grooming have not been studied. Some respondents in this study reported muzzled horses being harassed more by others, while others also reported that their horse did not harass companions as much when it was muzzled, which could potentially be beneficial for herd relations. Cameron (2018) found no change in the incidence of agonistic behaviour of muzzled horses kept in the same social group, while Davis *et al.* (2019b) observed increased chasing and biting from one of their six horses when it was unmuzzled, towards a muzzled horse. Some reported horses standing and refraining from eating or interacting whilst muzzled, which was also observed by Longland *et al.* (2016b). Horses are likely to be affected on an individual basis, so it is important owners spend time observing their horses, especially when first introducing the muzzle.

Another potential issue is that although horses can be muzzled in a large field, voluntary exercise may be reduced. This was reported by some respondents, and Cameron (2018) found horses spent more time standing when muzzled and less time eating. Unmuzzled horses travel constantly whilst grazing (Olson-Rutz *et al.* 1996), so if muzzled horses spend less time grazing, they will likely also move less. Horses are selective grazers (Marinier & Alexander 1991); Davis *et al.* (2019a) found individually housed muzzled horses did not travel as far as when unmuzzled, suggesting the restriction may have caused horses to become less selective and so travel less. However, this was not the case for group housed horses who travelled similar distances and it was suggested this was because horses were moving together as a herd, although exercise intensity was decreased when muzzled (Davis *et al.* 2019b).

Additionally, a common issue reported by respondents was horses being able to remove the muzzle, rendering it dangerous and useless, which was clearly a concern for Longland *et al.* (2016a; b) as they fitted ponies with headcollars over the muzzles to prevent this from occurring. However, some horse carers may be reluctant to do this, as it could increase the likelihood of horses becoming caught on

something in the field which was also a concern. However, the number of respondents who were worried about muzzles getting caught was much greater than the number who reported this having occurred. This may mean that the risk of getting caught is lower than perceived, although care should always be taken to ensure the field is clear of potential hazards as the risk of injury is potentially high if a horse does get caught. Horses causing damage to the muzzle was also reported by several respondents, sometimes this appeared to occur in attempts to remove the muzzle, while on other occasions the muzzle aperture was worn out or enlarged through grazing so more grass could be consumed. Longland *et al.* (2016b) reported one pony in their study requiring frequent muzzle changes due to modifying the muzzle aperture, despite only being muzzled 10hrs/day for 3 weeks. This would greatly increase the cost associated with muzzling if horse carers were required to regularly replace muzzles for this reason.

Rubs and sores on the face were also commonly mentioned, which indicates muzzles may not be designed very well; Longland *et al.* (2016b) added fleece sleeves to prevent rubbing and checked daily for signs of this, and the NEWC (2015a) warns of common places rubbing can occur. Some brands of muzzle include fleece lining around the nose and are advertised as being designed to prevent chafing (Shires n.d.), while Greenguard claim that as long as their muzzles are fitted correctly they should not rub and provide a list of the most common reasons for rubbing and how to combat these (Chester 2017). However, there is no research to demonstrate whether these designs successfully prevent rubbing. Greenguard Equine (n.d.) also provide instructions on sizing (though it is made clear these may only be applicable for North American clients) and how to fit the muzzle, which is not the case with most other brands. The NEWC (2015a) provide instructions of how to fit the muzzle to your horse correctly, but it may be difficult to purchase the correct size when buying online as sizing is usually described in terms of 'pony', 'cob', 'full' etc. Different breeds of pony can be similar heights and have head lengths but have very different nose circumferences, leading them to require different sizes of muzzle. Muzzles also may come with no instructions of how to fit them to your horse, so if owners do not know of the existence of the NEWC (2015a)guide they may simply guess when fitting, which would increase the risk of discomfort and rubbing.

Abnormal dental wear was also a concern and provided as a reason why respondents would not use muzzles again; Greenguard Equine (n.d.) states all muzzles risk causing dental wear, though this can be reduced by regularly cleaning the muzzle to remove sand or dirt that will rub against the teeth. Harman (n.d.) suggests that along with muzzle material horses' grazing technique will have an impact, and that ensuring the horse can access sufficient grass will decrease the likelihood of it pressing down hard on the muzzle when grazing, which increases the chances of dental wear.

The most common type of muzzle used was one with woven sides and a solid base with a single hole, which has been the design used in research carried out so far, though approximately 1/4 of

respondents used a Greenguard style muzzle with multiple slats in the basket. As multiple styles are common studies should also be done using these designs, otherwise results on efficacy and welfare impact may not be applicable to a large proportion of muzzle users. Most people who muzzled their horses did so every day for between 4 and 12hrs, though a few people did muzzle for 19-24hrs/day. The NEWC (2015a) does not recommend muzzling for longer than 10-12hrs/day, although Davis *et al*. (2019a; b) found no adverse effects on welfare muzzling for 24hrs/day compared to 10hrs/day. However, it is not known whether another RGM was being used whilst horses were not muzzled, it is important horses are not just allowed free access to pasture after a period of muzzling to prevent compensatory eating, which Davis *et al.* (2019a; b) found prevented weight loss. Pollard *et al.* (2019b) also found muzzling part time rather than full time or not at all was associated with an increased risk of laminitis. Like strip grazing, muzzling was most common in spring followed by summer, although grass availability that year was a factor for many. It is positive that over 80% of respondents reported their horses learnt to eat and drink through the muzzle within the first session of wearing it, although small numbers of horses took much longer than this or were never able to learn. Method of introduction, environmental conditions and individual horses' personality are all likely to influence how quickly horses are able to use muzzles.

Approximately half of muzzle users reported some form of gradual introduction of them to their horse, such as slowly increasing the amount of time the muzzle is worn, which is recommended by NEWC (2015a). Only a very small number mentioned using some form of positive reinforcement or treats, which is used by the NEWC (2015b) in their demonstration video Owners may have done this but not thought to mention it, especially if they feed treats often. However, about 1/5 of muzzle users introduced the muzzle abruptly, putting it straight on and turning their horse out. The NEWC (2015b) recommends a slow approach to ensure the horse is comfortable and does not create any negative associations with the muzzle, as well as recommending the horse is not left unsupervised for longer than 30 minutes during its first turnout session. People who introduce muzzles abruptly in this way may increase the chances of horses feeling frustrated or fearful. It is not clear what influenced owners' method of introduction, and whether those who used this abrupt technique did not know of alternative methods, were under time pressure or had other reasons. Approximately 1/3 of horses reportedly had no initial adverse reaction to being muzzled, while about 1/5 only showed a mild aversion. However, negative behaviour changes were commonly reported, as was horses rubbing muzzles on themselves or other objects, which was also seen by Cameron (2018). One respondent described an extreme reaction from their horse which included throwing its whole body on the ground; this is likely a rare reaction, but demonstrates the importance of horses being monitored initially, and suggests muzzles may not be suitable for all horses. Further research is required to investigate the potential impact of introduction method on both initial and subsequent reaction to being muzzled.

2.3.4.3. Stabling

Stables were rated as worst for welfare, though similar numbers of respondents said they would and would not use stabling again, with the main reason in support being they were effective, while the main reasons against were that they limit exercise, are unnatural and have an adverse impact on horses' psychological welfare. Whilst stabled, assuming this is done individually, owners can have complete control of their horse's feed intake which is likely why users have found this method effective. Box rest is usually prescribed for treating laminitis (Menzies-Gow *et al.* 2010) not only for control of intake but to reduce stresses on the weakened laminae associated with moving, and to relieve pain (Parks *et al.* 1999). Therefore, stabling can be an important and necessary part of treating acute laminitis, but published data is not available on the efficacy of using stables for weight loss, and this may be impeded due to reduced opportunity for movement reducing calories burnt.

It is likely stabled horses will get even less exercise than the 1.1km/day recorded by Hampson *et al.* (2010) for horses in the 6x6m yard as standard UK stables are likely smaller than this; the Department for Environment, Food and Rural Affairs (DEFRA 2017) recommends a minimum of 3.65x4.25m stables for large horses. Respondents concerns over stabling, and isolation due to stabling, negatively impacting psychological welfare are supported by evidence; for example Placci *et al.* (2019) recorded higher physiological signs of stress in horses individually stabled for at least 18hrs/day than horses that spent most of their time turned out in a group. Furthermore, Søndergaard *et al.* (2011) found horses work to achieve even minimal social contact, demonstrating they do not like to be physically isolated from conspecifics. Owners may be able to decrease stress experienced by stabled horses if they can allow visual contact and social interaction with neighbouring stabled horses (Cooper *et al.* 2000). However, Hockenhull and Creighton (2014a) found being able to see but not touch, or see and touch other horses were both associated with increased frustration compared to horses able to do neither; they suggested it may be more frustrating for horses to be able to see and touch conspecifics but not fully interact with them. Some respondents reported their horse seemed happy being stabled, and as all horses are individuals this method will likely suit some better than others. However, care must be taken in assuming a horse is happy if it is not reacting; generally horses can be categorised as active or passive copers based on their response to stressful situations (Budzynska 2014). Therefore, passive copers may appear calm but may not necessarily be experiencing less distress than horses behaving reactively (Ellis *et al.* 2014), this applies to all methods of restricting grazing. Horse carers may attribute human emotions to their horses (Hötzel *et al*. 2019); anthropomorphisation such as this could influence carers' view of horses being 'happy' when stabled. Humans may perceive stables as providing safety, privacy and comfort, though horses' perception may be very different (Goodwin 1999).

2.3.4.4. Starvation Paddocks

Starvation paddocks were rated third in terms of welfare, the main perceived benefits were horses being able to exercise and socialise, though some respondents were concerned horses may still be isolated and exercise may be reduced, and the main concern was that the method would negatively impact psychological welfare. As discussed earlier, paddock size will influence voluntary exercise (Maisonpierre *et al.* 2019), but owners can encourage movement by adding enrichment such as poles or spreading out any supplementary forage, or provisioning forage in creative ways (Furtado *et al.* 2018b). This may also help to alleviate boredom and slow forage consumption, further concerns raised by some, and forage consumption may be further slowed by using hay balls or trickle nets (Furtado *et al.* 2018b). Some respondents indicated they did not agree with starvation and so did not agree with this method. The name 'starvation paddock' may put some owners off; despite the name the intention with this method is not to leave horses starving with long periods without forage, which can cause EGUS (Luthersson *et al.* 2009). Respondents were told when providing welfare scores, they should assume in each case the horse had access to some forage, but some may not have read this. Though the term 'starvation paddock' is commonly used, another term should perhaps be used to avoid negative connotations. Horse carers should ensure there is sufficient grass in the paddock for the time the horse will be out, and if there is not extra forage such as soaked hay should be provisioned, which can also be done if owners are worried horses will only be consuming short stressed grass.

Sand colic was also a concern and is likely the most common cause of colic in sandy areas (Frape 2004), therefore it may be useful for owners to know the soil type of their paddocks so extra precautions can be taken if necessary. Niinistö *et al.* (2019) did not find an association between method of forage provision (e.g. net, trough or ground) and sand accumulation, though if this is a concern supplementary forage should be provided off the ground in some form (Frape 2004). Furthermore, providing supplementary forage may decrease the likelihood of horses ingesting sand when grazing short grass.

2.3.4.5. Crew Yards or Similar

Respondents gave very similar reasons for and against crew yards as starvation paddocks, though rated crew yards better for welfare. This may be because there is no risk of horses consuming short stressed grass, or any grass at all, and horse carers have complete control over forage provision which respondents cited as an advantage. Furthermore, there may not be any negative connotations associated with the name, which could have influenced ratings. Again, the ability to exercise and be with companions will depend on size of the yard/arena and the availability of horses with shared

dietary needs, though enrichment can be added as with starvation paddocks. Some respondents indicated a disadvantage was horses may be left for long periods without forage, and as no other forage is available this must be provisioned by carers if horses are left in crew yards longer than a couple of hours (Ellis *et al.* 2015). Consumption may be slowed as with starvation paddocks. Some also raised concerns over yard surface, for example that concrete might be too hard or the risk of sand colic if a sand school is used. Mats or some form of bedding can be laid onto concrete to provide comfort (Baumgartner *et al.* 2015). While if the surface is sand, feeding directly from the floor should be avoided, and sufficient forage for the number of horses should be provided to reduce competition and prevent less dominant horses consuming hay that has fallen onto the floor (Niinistö *et al.* 2019).

2.3.4.6. Track Systems

Although track systems were not provided as an option in any of the MCQs or mentioned in the questionnaire, more respondents than expected reported using them. Furthermore, even more respondents indicated they had used this method when talking about the methods they would and would not use again than when initially listing track systems in the 'other' box when asked what methods they had tried. This may be because respondents did not think to list track systems in 'other' if they were using methods already listed, but when given the chance to explain in detail their opinions on a method they used this opportunity to discuss track systems. Therefore, it is not possible to calculate the percentage of track system users that would or would not use them again as it is possible some people may have used them and not mentioned them. However, high numbers of respondents indicated they would use this method again, with only low numbers saying they would not. The main benefit described by respondents was that track systems increase exercise compared to other methods, and Kari and Räty (2014) demonstrated horses on a track indeed walked further than those in a standard paddock. In comparison, the most frequently listed issues were that they result in short stressed grass, damage pasture, and issues with horses escaping. The original idea of Jackson (2016) who developed this method was that the track should be grass free, so short stressed grass would not be an issue. However, if the land is not owned by the respondent it is unlikely the land owner would allow grass to be removed as it may be difficult for the pasture to recover if they wish to use it for another purpose in the future. Track systems were also clearly the method most people wanted to try who had not previously used them, being chosen by four times as many people as the second most chosen method, strip grazing. Although track systems had been tried less frequently than other methods, increasing the likelihood people would say they wanted to try them, other methods such as crew yards that had been tried by comparatively few people did not receive nearly so many mentions in this context. It is possible that the way track systems/Paddock Paradise

have been marketed has influenced horse carers' desire to try them. Articles have been written about them on several popular equine magazines and websites (e.g. Horse and Hound 2019, Spillers: Fricker 2019), increasing awareness of their existence, and social media (e.g. Facebook group: Horse Track System 2014) provides opportunities to follow others' successful experiences setting them up and inspire followers to attempt the same. Only a small number also said they would not consider trying track systems in the future. Track systems appear popular with those that have used them, and many more would like to try them. However, logistics of setting up a track especially if the horse is not kept on the owner's own land may be difficult and there are only a few yards set up as track systems in the UK. When searching 'track system' or 'paddock paradise' in the BHS livery yard directory only returns one result (BHS n.d.), while Livery List (n.d.) lists seven track system yards in the UK. More track system yards do exist, but it is unclear how many, and they are still uncommon. Independent research into track systems is required to evaluate their impact on weight and laminitis management and other factors.

2.3.4.7. Equicentral

Equicentral is a system of grazing management that was not known to the authors before undertaking the study but was mentioned by some respondents either as a method they had used or would like to try. According to its creators, Myers and Myers (2015), it integrates natural horse behaviour and sustainable land management, and can reduce cost and workload for carers. In this system horses have continuous access to a communal yard area with water, shelter and a soft area to lie down, which adjoins to multiple fields. Horses are given access to one field at a time, allowing the others to rest and recover in a system of rotational grazing, while having constant access to the yard area to encourage them to rest there during the middle of the day. If needed access to the fields can be shut off at any time (Myers & Myers n.d.) There were 6 respondents who said they would use this method again, while 14 wanted to try it, and only 1 person said they would not consider trying it. The questionnaire link was shared by a user from another equine page onto the Equiculture Facebook page, which is likely the main source of participants who had used this method. Again, this method would be difficult to set up without owning land, and would depend on the layout of fields, and maybe even building a yard area which could be costly and time consuming. There have not been any studies into this method, but it demonstrates that equine stakeholders are recognising the need for innovative and sustainable grazing strategies to combat the many welfare issues associated with traditional grazing management.

2.3.5. Benefits and Limitations of Using Questionnaires

The main source of participants was through equine Facebook groups and pages, including charity, regional, health and product/equipment pages. This may have introduced bias into the sample, for example people who are members of certain pages may have preferences for certain restricted grazing practices, or may be more likely to be experienced owners.

Though the questionnaire was aimed at both horse carers who had and had not restricted grazing, over 90% of respondents had restricted grazing. This is likely due to the fact it had greater saliency for this group; the questions and possible benefits of collecting such data would be much more relevant and so they were more invested in the topic. This has been identified as an important factor in increasing responses (Porter 2004), and may be part of the reason the questionnaire achieved a relatively large number of responses considering, if a participant chose to answer all possible sections, it is likely to have taken them longer than previously reported ideal response time of 10 minutes, and possibly longer than the maximum suggested time of 20 minutes (Revilla & Ochoa 2017). Some participants did leave out some questions, possibly as that particular question was not relevant to them, but also likely due to survey fatigue (Porter 2004). However, the aim of the free text questions was to gather detailed insights into owners' experiences which could not have been captured by MCQs. This is the probable explanation for the decreasing responses to the free text questions towards the end of the main section of the questionnaire. Another possibility is that if people who had not restricted grazing saw the questionnaire was about this, they may have decided it was irrelevant to them before reading information explaining it was aimed at all UK horse carers.

Although respondents were often asked to explain why they gave an answer it was fairly common for no justification to be provided. This may in part be due to respondents feeling they had provided previous justification in answers to earlier questions. However, respondents were also more likely to provide no justification when asked about positive experiences with restricted grazing compared to negative experiences. A possible explanation for this is due to negative recall bias (Baumeister *et al.* 2001), with respondents feeling more strongly about methods they did not wish to use again due to their negative experiences with them than they did about the methods they were happy to use again. This could have impacted the questionnaire results as potentially useful information on ways that RGMs can be used to benefit equine welfare an owners' needs may have been omitted.

Another limitation was loss of participants due non-completion of the questionnaire. Results were only recorded if respondents clicked the 'Finish' button at the end of the questionnaire, data from partially completed questionnaires were not submitted. A progress report showed that a large number of respondents (282) dropped out without completing the questionnaire on page 4, which was the main section of the questionnaire. At the end of this page participants were told they had

come to the end of the section, and instructions were given so participants could choose to answer more questions on either strip grazing or grazing muzzles, or to commence to the end of the questionnaire. It is likely that a large proportion of these participants who dropped out at this point had completed the questions on this page, but did not believe it was necessary to commence to the end of the questionnaire in order for their responses to be recorded and so closed the page. It will be ensured on any future questionnaires that participants are made aware very clearly that they must press the 'Finish' button on the final page of the questionnaire in order for their responses to be recorded, to avoid loss of participants such as this again.

Results of this current study are based on opinions and so are subject to bias, meaning limited conclusions can be drawn about the success of the methods discussed at managing or preventing common health problems. Respondents may also not have interpreted questions as intended in some cases which would affect how they answered. However, gaining an understanding of current usage practices and horse carers' experiences with these methods can help to inform and target future research into this area so that equine welfare can be optimised.

2.3.6. Conclusion

This study found that horse carers restrict grazing for a number of different reasons, mainly with the aim of improving welfare by preventing health issues, and they have several options of methods to use. Individual horse carers who restrict grazing, and who do not, have differing opinions of the welfare impact of each method, but these are similar between both groups. However, perceived welfare impact is not the only influencer over which method horse carers use, factors such as ease of implementation, cost and yard rules or facilities can limit the options available for restricting grazing, though less obvious restrictions may also have an impact such as yard culture and even attitudes of members of the public. This means horse carers may be dissatisfied with the methods they are using due to them not being their preferred choice. Strip grazing appears to be the method favoured by the greatest number of respondents, though overall widely differing opinions were held over which method was best for welfare. In general respondents tended to have similar priorities when deciding on a RGM, and a good understanding of horses' basic welfare needs. However, respondents did not agree on whether different methods met these welfare needs and had had very different experiences using the same methods. Questionnaires rely on self-reporting and so are likely to be biased, but this study has provided insight into the challenges faced by horse carers when aiming to restrict grazing in order to combat equine health issues. Future research should investigate the efficacy of all common RGMs as the majority are not well explored, as well as considering how these may be best implemented so they are accessible to horse carers and equine welfare can be optimised.

3. The Impact of Individual Strip Grazing on Equine Behaviour

3.1. Materials and Methods

3.1.1. Study Design

Behavioural observations were carried out on ponies already participating in an intervention trial conducted by Longland (2019, not yet published) and funded by WALTHAM, investigating the effect of strip grazing on horses' bodyweight. Ethical approval was granted by the Royal Veterinary College Ethical Review Panel. This study was deemed important as according to findings from the questionnaire study strip grazing is the most commonly used method of restricted grazing in the UK. However, no empirical data previously existed on the impact of strip grazing on ponies' behaviour or welfare.

Twelve ponies were randomly allocated to either the control group or one of two test conditions. All ponies had an individual paddock, the total size of which had been calculated so that subjects were allocated the equivalent of 1.5% of their bodyweight in grass per day for the 4-week study period. This is the amount typically advised to reduce the bodyweight of overweight horses and is close to the minimum recommended daily allowance of forage for horses (Dixon 2014; Frank *et al.* 2010). Therefore, total paddock area varied with pony bodyweight; all paddocks were 10m across, but small ponies' paddocks were approximately 7m in length, medium ponies' 10m and large ponies' 15m. The grass in the study pasture contained 3.5 tonnes of dry matter/ha. As ponies were part of an existing study the basic experimental design could not be altered.

Ponies in the control condition were given access to their entire study allocation of grass immediately so their paddock remained the same size throughout. The control was therefore also a form of restricted grazing as a limited ration of grass was provided. This was because it was not deemed ethical to give control ponies unlimited access to grass and risk them gaining too much weight and becoming obese. In condition 1 the back electric fencing was moved daily so ponies were allocated another 1.5% of their bodyweight in grass per day, while still having access to the area they had previously. This meant that each day the area of their paddock they could access increased. In condition 2, ponies were still allocated 1.5% of their bodyweight in grass daily, although they had 2 electric fences (a back and a front) which moved simultaneously. This meant the total area of their paddock they could access remained the same, but its location moved gradually up the paddock. Fences began being moved at approximately 09:30/10:00 each day. The twelve study paddocks were arranged in one row across the field; a diagram of the paddock layout can be found in Figure 3.1. The electric fences were set between 3000v and 4000v.

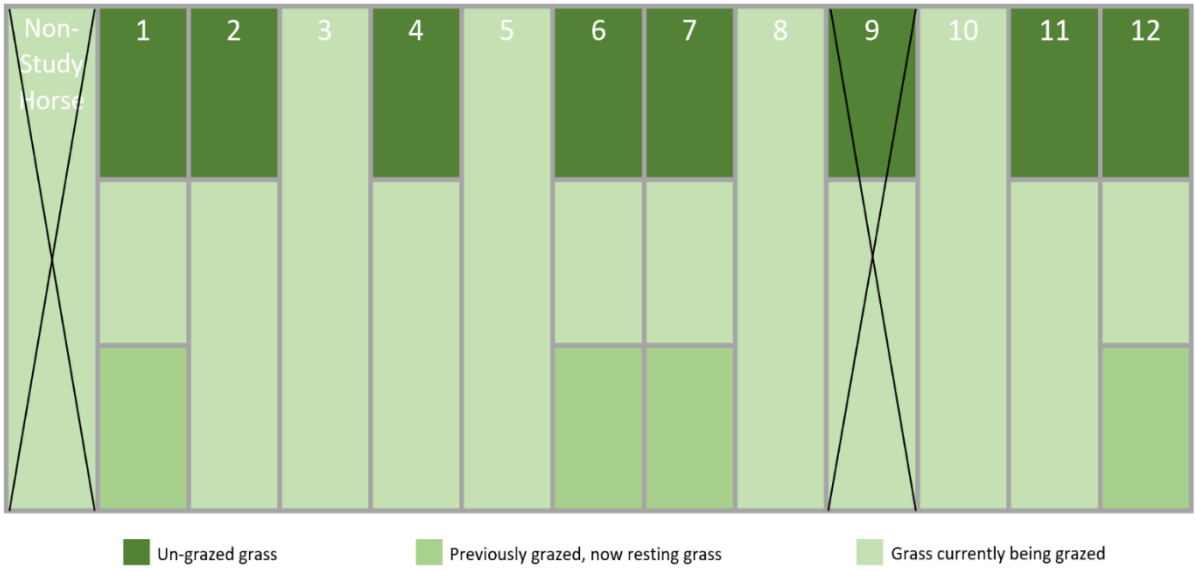


Figure 3.1. Diagram to show the layout of the study paddocks, plus a paddock containing a horse not involved in the study. The non-study paddock and paddock 9 are crossed through as observational data were not collected on these horses. (Not to scale.)

Ponies all had a clear view of the other ponies in the study. They were able to have partial physical contact with their direct neighbour on each side if they chose, although this may have been avoided due to the increased risk of touching the electric fence, which would result in a shock. They were not provided with artificial shelters but a row of trees and bushes running along the back of the study paddocks may have provided some shelter. Ponies had constant access to water, and this was checked daily. Faeces were also removed daily from the paddocks.

Subjects were turned out for approximately thirty minutes in the sand school in either pairs or a group of three with horses they had shown affiliative behaviour towards at least 6 days a week. Pony 8 was the exception to this, as she behaved aggressively towards other ponies, seemingly out of fear. The first group of ponies (ponies 10-12) was turned out into the sand school when fences began to be moved. This meant 11's and 12's fences had already been moved when they were returned to their paddocks. Whereas, for all other ponies their fences were moved whilst they were still in their paddocks, and they were turned out in the sand school shortly after their fences had been moved, once the previous group of ponies had been removed from the sand school and put back in their paddocks.

Ponies were all fed 100g/100kg bodyweight of Spillers lite and lean balancer per day, split between a morning and evening feed. The morning feed was given before the strip grazing fences were moved.

3.1.2. Subjects

There were twelve ponies originally used in the study, but pony 9 was removed due to a cough before the observation period and so is not included in the data set. Details of the 11 ponies included

in this study can be found in Table 3.1. The ponies had been participating in the study for 12 days before behavioural observations began, so they were used to their routine. A horse not used in the study was in a paddock to the left of pony 1, as they were close friends who became distressed when separated. This horse's location was also noted down when 1 was being observed, as 1 was recorded as standing near another horse when it was near this non-study horse.

Table 3.1. Subject details.

Number		Sex	Age (years)	Breed	Height (hh)	Condition	Familiar With
1		Gelding	17	Welsh D x Arabian	14.2	2	7 & non-study horse
2		Mare	19	Arabian	14.2	1	3 & 4
3		Mare	4	Connemara	14.3	Control	2 & 4
4		Gelding	10	Arabian	14.05	1	2 & 3
5		Gelding	8	Welsh D	14.0	Control	6
6		Mare	20	Welsh B x Welsh D	13.2	2	5
7		Mare	17	British Spotted Pony	13.0	2	1 & 2
8		Mare	15	Arabian	14.3	Control	N/A
10		Gelding	11	Welsh A	11.1	Control	11 & 12
11		Gelding	4	Welsh A x Welsh B	11.0	1	10 & 12
12		Mare	6	Welsh A	11.2	2	10 & 11

Ponies were sourced from a variety of locations, and some were known to each other before the study began while others were not. However, all ponies had been at the study location for at least 2 months and had all been acclimatised to the ponies who would be in the neighbouring paddocks during the study in advance. During this process ponies were put in neighbouring paddocks which resembled those used in the study although they were larger (20x40m) and ponies were not strip grazed. Each pony was put in these mock-up paddocks for three days for three hours at a time, so each pony had been exposed to both its neighbours for nine hours.

On arrival all ponies underwent general health checks, were wormed, had their teeth checked by an equine dentist or vet, were seen by a farrier and had their flu and tetanus vaccinations brought up to date. To partake in the study ponies were required to have a body condition score of <7, although ideally a score of 4-6 (on a scale of 1-9, with 1 being the thinnest and 9 being the fattest, Henneke *et al.* (1983)).

3.1.3. Behavioural Observations

Observations were carried out between approximately 08:00 and 18:30 over two and a half days in July 2019, beginning on day 12 of the 4-week study. Several paddocks could be observed clearly at a time from a set point, so ponies were observed in groups of two to six per session. Pony groups were observed at different times of day, so that data could be collected on subjects at all periods throughout the day. Observations were also carried out when ponies were turned out in the sand school in pairs or groups, each pair or group was observed on one occasion on the same day. A timeline showing the schedule of behavioural observations is shown in Figure 3.2. Frequency of behaviour was also recorded whilst horses were waiting to be fed and have their strip grazing fences moved. Sessions can be categorised into one of the following:

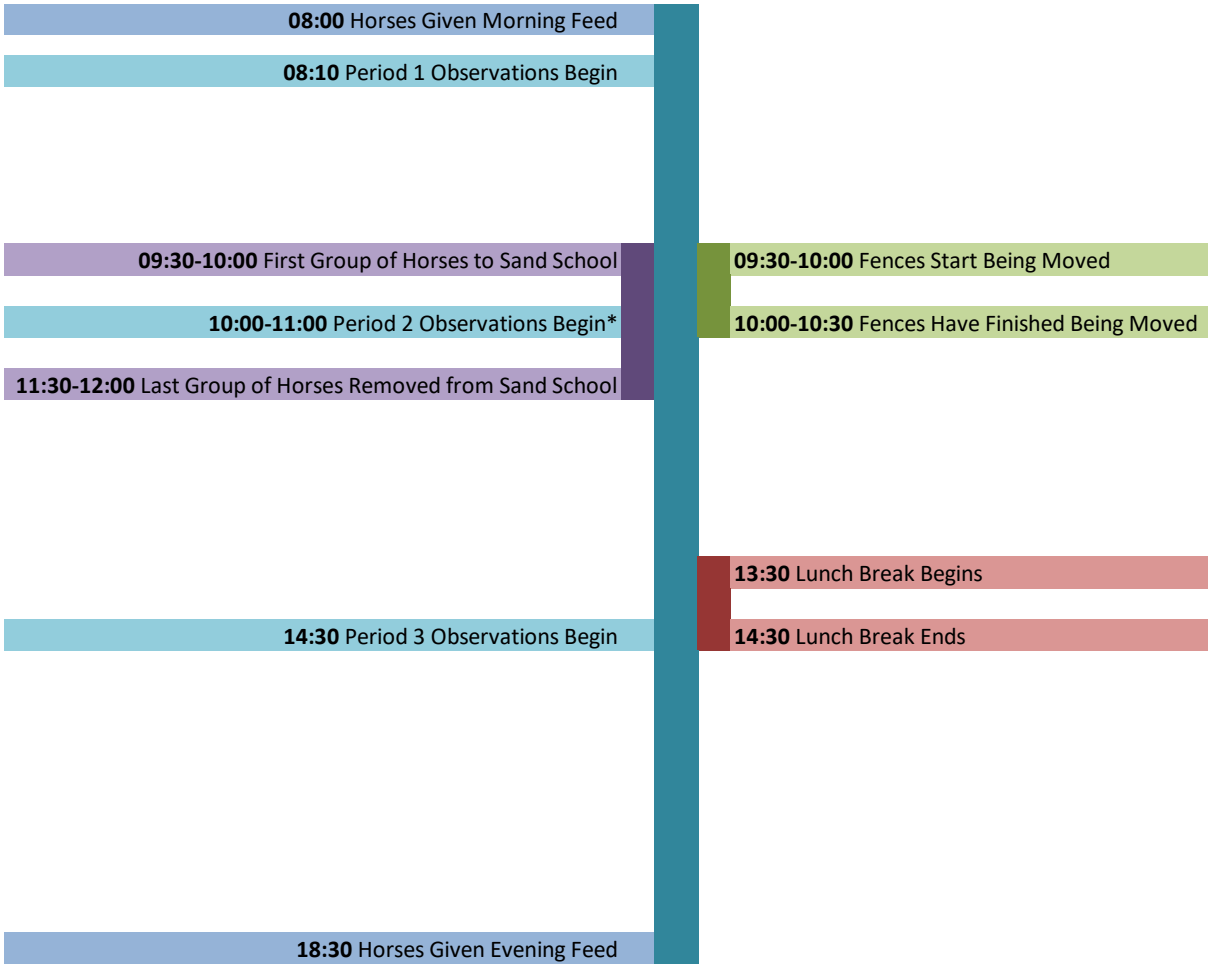
1. Period 1 - Before fences had been moved in the morning
2. Period 2 - When fences had been moved ≤4 hours previously
3. Period 3 - When fences had been moved >4 hours previously that day
4. Group/pair turnout in sand school
5. Just before ponies were given their morning feed
6. Just before ponies were given their evening feed

Instantaneous scan sampling (Martin & Bateson 2007) was carried out during sessions 1-4, with behaviour recorded every 3 minutes using the ethogram shown in Table 3.2. This interval was chosen based on pilot data from previous research, so that several ponies' behaviour could accurately be recorded while still retaining a sufficient level of detail. The ethograms used in this study are based on 'The Equid Ethogram' (McDonnell 2003), and were influenced by previous experience from a pilot study.

During sessions 4-6, and part of session 1, the frequency that certain (mainly stress related or social) behaviours occurred was recorded continuously, the ethogram used is shown in Table 3.3. This was because these behaviours were thought likely to be particularly relevant to the ponies' welfare, and tended to occur for a very short duration, meaning they could easily be missed in between the 3-minute intervals. This method was used exclusively during sessions 5 and 6 because these took place over a short period of a few minutes and many distinct behaviours occurred in quick succession. Ponies were observed before one morning and one evening feed. It took approximately 5 minutes for all ponies to be fed, but each pony was observed only for slightly over 1 minute. Ponies were fed in succession, starting with 1 and ending with 12, and approximately three ponies were observed at a time. Once a pony had been fed it would no longer be observed, the observer would walk down the row of ponies and include the next pony along into the group being observed; this continued until all ponies had been fed.

During session 1, frequency was recorded after ponies had been fed, up until their fences had been moved (making up the last 25-35 minutes of period 1). This occurred alongside scan sampling for period 1 which continued. All subjects had frequency of behaviour in this session recorded only once. This was to capture behaviours that may have been related to anticipation of the fences being moved, and could have easily been missed between the 3-minute scan sampling intervals. For comparison, control ponies were observed as well as ponies in conditions 1 and 2. Ponies 1-6 were in their paddocks while the fences were being moved, whereas ponies 10-12 were taken to the school and returned to their paddocks once their fences had been moved.

Frequency was recorded alongside scan sampling during session 4 when ponies were in the sand school, as again many behaviours occurred in quick succession for only a brief amount of time.



*On the day that observations were carried out on horses while they were in the sand school period 2 observations began later, after all horses had been removed from the sand school.

Figure 3.2. Timeline to show daily experimental and observation schedule. All timings are approximate and varied slightly each day. (Timeline not to scale.)

Table 3.2. Ethogram of Observed Behaviours: Instantaneous Scan Sampling.

Behavioural Classification	Behaviour	Description
Agonistic	Ears back (at another pony)	Ears facing backwards, pinned flat down against head
	Lunge (at another pony)	Swift thrust of body from close range towards another pony, usually with ears back
	Retreat	Moving away from another pony in response to the other pony's behaviour
Frustration Related	Pace	Walks either a circle following the perimeter of the paddock or back and forth along one fence line
	Paw	A foreleg is lifted off the ground slightly, extended quickly forward and the toe is then dragged backwards across the ground towards the body, this is often done repetitively
	Tail swish	Tail is swiftly moved in a flicking motion
Grazing	Grazing	Ingesting grassy vegetation
	Grazing new grass (condition 1 & 2 ponies only, periods 2 & 3 only)	Grazing only the fresh grass the pony had been provided access to that day, once the strip grazing fence had been moved
	Grazing under fence	Reaching under the paddock fence with the muzzle to graze grass on the other side of the fence
Greeting	Greet (without contact)	Ponies approach nose to nose with deliberate sniffing of one another's exhaled breath, ponies are separated by an electric fence and do not make physical contact with one another
Repetitive Head Movements	Head nod	Repeated, rhythmic up and down movement of the head in a 'yes' motion
	Head shake	Repeated, rhythmic side to side movement of the head
Repetitive Oral Movements	Lick and chew	Side to side grinding of the upper and lower jaw whilst sticking the tongue in and out
Rest	Lying down	Lying recumbently on the ground either sternally or laterally
	Standing at rest	Standing inactive or asleep in a relaxed position with eyes partly or nearly closed, or closed, head lowered, relaxed lips, ears rotated laterally and often bearing weight on three legs
Self-Maintenance	Auto-grooming	Nibbling and biting, or using the hoof to scratch own body
Spooking/Startling	Spook	Startle response where the pony either suddenly jumps or runs away from the stimulus that caused it
	Startle	Pony flinches or jumps slightly but without travelling, usually turns to look at the stimulus that caused it
Standing Alert	Standing alert	Standing still, either relaxed, whilst seemingly paying attention to surroundings, likely to be turning head to look at different stimuli
Trotting/Cantering	Canter	Running in a three-beat gait
	Trot	Movement forward in a two-beat gait
Vocalisation	Squeal	High pitched, short vocalisation, mouth is typically closed
	Whicker	Low pitched, gutturally pulsated vocalisation
	Whinny	Loud, prolonged call, typically beginning high pitched and ending lower pitched
Walking	Walk	Movement forward in a four-beat gait
Other	Blow nose	Forceful, extended exhalation clearing the nostrils
	Drinking	Ingesting water
	Investigating pony droppings	Looking at and smelling faeces
	Urinating	Expelling of urine through the urethra

Table 3.3. Ethogram of Observed Behaviours: Frequency Sampling.

Behaviour	Description
Approach	Pony moves forward towards another pony
Bite	Pony opens and rapidly closes its jaws on the flesh of another pony
Blow Nose	*See Table 3.2*
Browse	Ingesting woody vegetation
Buck	Head and neck are lowered and both hind legs lifted off the ground with simultaneous backwards extension
Canter	*See Table 3.2*
Charge	Rapid approach towards another pony, usually with ears back
Chase	Rapid pursuit of another pony at trot, canter or gallop, with apparent effort to catch up/overtake it
Chew Object	Side to side grinding motion of the upper and lower jaw on an object in the mouth
Displace Another Pony	One pony approaches another pony, typically with ears back, moving it away and then taking its place
Displaced by Another Pony	One pony is moved off and has its place taken by another other pony
Ears Back (at Another Pony)	*See Table 3.2*
Flehmen	Head elevated, neck extended, upper lip everted exposing upper incisors and adjacent gums while drawing air and fluids through the teeth
Graze Through Fence	Reaching head through the sand school fence to graze grass on the other side of the fence
Greet (with Contact)	Ponies approach nose to nose with deliberate sniffing of one another's exhaled breath, physical contact (usually muzzle to muzzle) is made
Head Nod	*See Table 3.2*
Head Shake	*See Table 3.2*
Jump Object	Pony uses mainly hind leg propulsion to move suddenly forward over an object, with forelegs leaving the ground first, followed by hind legs
Kick	One or both hind legs are lifted off the ground and rapidly extended backwards towards another pony
Kick Threat	Similar to kick, but without sufficient extension or force to contact target
Leap	Propulsion off the ground using both fore and hind legs
Lick and Chew	*See Table 3.2*
Lunge	*See Table 3.2*
Mutual Grooming	Standing, usually head to shoulder or head to tail, with another horse, gently nipping, nuzzling or rubbing each other's bodies
Nip	Similar to bite, but teeth are only closed round a small piece of flesh
Non-reciprocated Grooming	One pony gently nipping, nuzzling or rubbing another pony's body, but this is not being reciprocated by the other pony
Pace	*See Table 3.2*
Paw	*See Table 3.2*
Play Fight	Two ponies rear and interlock forelegs, often whilst nipping each other
Rear	Pony stands up on back legs with front feet raised off the ground
Retreat	*See Table 3.2*
Scratch on Object	Pony rubs body back and forth on an object
Snort	Sound produced by quick, forceful exhalation through the nose
Spook	*See Table 3.2*
Squeal	*See Table 3.2*
Strike	One or both forelegs rapidly extended forward towards another pony
Tail Swish	*See Table 3.2*
Trot	*See Table 3.2*
Whicker	*See Table 3.2*
Whinny	*See Table 3.2*
Yawn	Deep, long inhalation with mouth widely opened

3.1.4. Location Observations

During sessions 1-4, every 15 minutes ponies' location within the paddock or sand school was also recorded; arrows were drawn on diagrams of the paddocks/sand school to show the direction each pony was facing and where within the paddock/sand school it was positioned.

For analysis, ponies were classified as either standing near another pony, being orientated towards another pony or not standing near another pony, definitions are provided in Table 3.4. When in the sand school ponies could only be classified as standing near or not near each other, as there was no physical barrier between them as was the case in the paddocks.

Table 3.4. Location Definitions.

Category	Definition
Standing near another pony	Two ponies in neighbouring fields positioned within 3m of each other (distance estimated visually)
Orientated towards another pony	Pony facing towards one of its neighbours whilst standing within 1.5m of their shared fence (distance estimated visually), but the neighbour not being positioned within 3m of this pony
Not standing near another pony	All cases not described above

3.1.5. Analysis

Statistical analysis was carried out using IBM SPSS Statistics 24. Kruskal-Wallis tests were used to identify whether condition influenced the proportion of scans ponies were observed performing different behaviours both overall and for each of the three time periods. The behavioural categories in Table 3.2 indicate how behaviours were grouped for analysis. Post hoc Mann-Whitney U tests were then used to make pairwise comparisons between conditions where a significant result was found. Analyses have now been re-run on significant results using bootstrapped one-way between-groups analysis of variance (ANOVA) (based on 3000 bootstrap samples) and post hoc Tukey honest significant difference (HSD) tests to compare paired treatments. The bootstrap approach does not require the distributional assumptions for parametric tests to be met (Kelley 2005) and provides confidence intervals (CIs) for the mean values and their differences between groups, which may be more appropriate than retrospective power calculations (Gerard *et al.* 1998). Results from these re-run analyses are presented.

Friedman tests were also used to investigate the impact of time period, irrespective of condition, on the proportion of scans ponies were observed performing different behaviours. Post hoc Wilcoxon's tests were used to make pairwise comparisons between time periods where a significant result was

found. Due to a lack of time and schedule changes ponies 7 and 8 were not observed in time period 1, meaning they had to be excluded from these Friedman tests, resulting in data from a total of nine ponies being analysed. Friedman and post hoc Wilcoxon tests were carried out in another context, comparing the percentage of scans ponies in conditions 1 and 2 were recorded performing three different types of grazing – grazing, grazing new grass and grazing under their fence. Control ponies were not tested as they could not be classified as 'grazing new grass', because 'new grass' refers to the fresh grass ponies in the test conditions could access once their electric fence had been moved each day. Only time periods 2 and 3 were included as in time period 1 this recently uncovered grass was no longer considered to be 'new' grass. Additionally, a Wilcoxon test was used to compare the proportion of scans ponies were observed grazing new grass in time periods 2 and 3. Control ponies were not included and only periods 2 and 3 were compared for the same reasons stated above. For comparison, the proportion of scans control ponies were observed grazing in time periods 2 and 3 was also compared using a Wilcoxon test. Analyses have now been re-run on significant results using one-way repeated measures ANOVAs and post hoc pairwise comparisons tests with a Bonferroni adjustment. This method provides CIs for the mean values and their differences between groups, which again may be more appropriate than retrospective power calculations (Gerard *et al.* 1998). Results from these re-run analyses are presented.

Descriptive statistics were used to describe the proportion of scans ponies were observed performing different behaviours when turned out into the sand school, as there was not another condition to compare this data to. This is due to the fact ponies were kept individually in the study paddocks and were unable to display many of the behaviours that they performed in the school. The frequency that behaviours were performed was reported, and in some cases the percentage of scans ponies were observed performing these behaviours was also reported, where it was deemed that this added value and context. Descriptive statistics were also used to report the proportion of scans ponies were recorded standing near to each other, or orientated towards another pony, as well as the frequency of stress related behaviours performed just before feed time and before the fences being moved. The frequency represents bouts of behaviour, not one single action. Statistical tests were not carried out on this data due to the small number of data points.

3.2. Results

3.2.1. Sessions 1-3: Grazing Behaviour

There was no significant difference found in the overall percentage of scans ponies were observed grazing between the conditions (control, condition 1, condition 2). Although, when each of the three time periods were tested separately, the condition ponies were in had a significant impact on the percentage of scans they were recorded grazing during period 3 (fences had been moved >4 hours previously) (Figure 3.3.), one-way between-groups ANOVA: F (2, 8)=9.809, P=0.007. Post hoc Tukey HSD tests found control ponies were observed in a significantly greater proportion of scans grazing in period 3 than condition 2 ponies, mean difference (MD)=24.47, bootstrapped CI [14.37, 35.49], P=0.006, while there was a difference trending towards significance between control and condition 1, with control ponies being recorded grazing in the greatest percentage of scans, MD=15.33, bootstrapped CI [6.99, 24.96], P=0.079. There was no significant difference between conditions 1 and 2.

Time period also had a significant impact on the percentage of scans ponies were observed performing any type of grazing (Figure 3.4.), one-way repeated measures ANOVA: Wilks' Lambda=0.216, F (2, 7)=12.709, P=0.005, multivariate partial eta squared=0.784. Post hoc pairwise comparisons with a Bonferroni adjustment revealed that ponies were recorded grazing in significantly more scans in period 2 compared to periods 1, MD=43.22, CI [15.70, 70.75], P=0.004, and 3, MD=28.04, CI [5.68, 50.41], P=0.016. There was no significant difference between the percentage of scans ponies were recorded grazing in time periods 1 and 3.

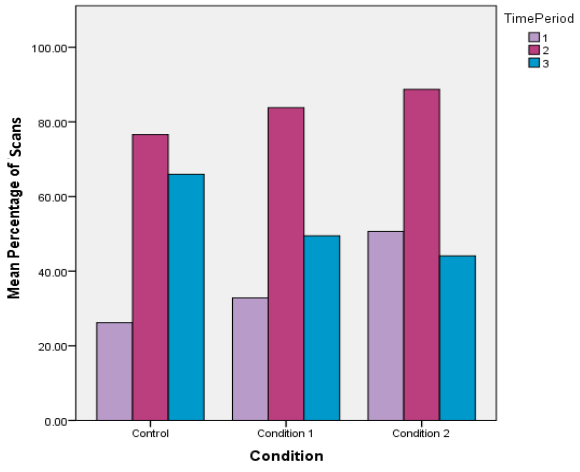


Figure 3.3. A graph to show the mean percentage of scans ponies from each condition spent grazing across the three time periods. Condition only had a significant impact on percentage of scans ponies were recorded grazing in period 3.

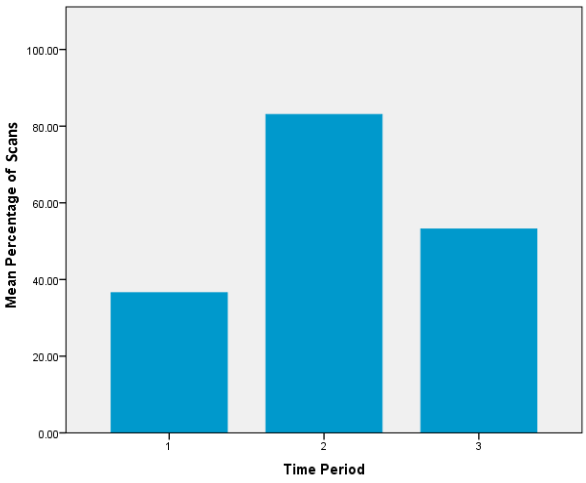


Figure 3.4. A graph to show the mean percentage of scans ponies were recorded performing any type of grazing in each time period.

There was a significant difference in the total percentage of scans ponies in conditions 1 and 2 were recorded performing different types of grazing (Figure 3.5.), being observed during the greatest proportion of scans grazing new grass, followed by grazing, then grazing under their fences, one-way

repeated measures ANOVA: Wilks' Lambda=0.032, F (2, 5)=75.614, P<0.001, multivariate partial eta squared=0.968. Post hoc pairwise comparisons with a Bonferroni adjustment revealed the ponies spent a significantly greater percentage of scans grazing new grass than grazing, MD=42.65, CI [15.79, 69.51], P=0.006 and grazing new grass than grazing under their fence, MD=46.96, CI [28.66, 65.26], P<0.001. There was no significant difference between the percentage of scans the ponies were observed grazing and grazing under their fence.

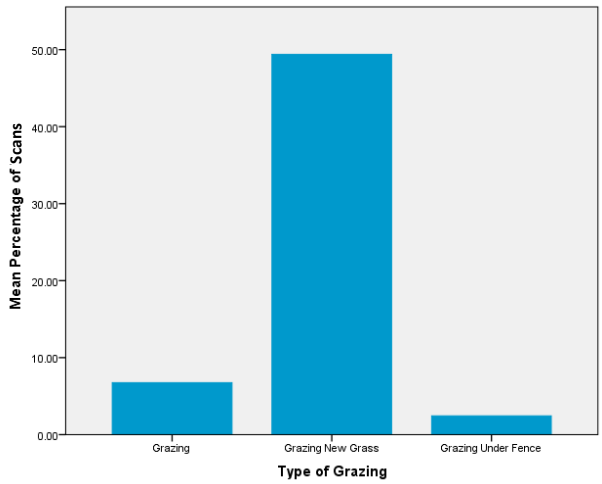


Figure 3.5. A graph to show the mean percentage of scans ponies in conditions 1 and 2 were recorded performing different types of grazing.

3.2.2. Sessions 1-3: Other Behaviours Observed During Scan Sampling

Time period had a significant impact on the percentage of scans ponies were observed standing alert (Figure 3.6.), one-way repeated measures ANOVA: Wilks' Lambda=0.252, F (2, 7)=10.416, P=0.008, multivariate partial eta squared=0.748, with ponies spending the greatest proportion of scans standing alert in time period 1 and least in time period 2. Post hoc pairwise comparisons with a Bonferroni adjustment revealed ponies were recorded standing alert in a significantly larger percentage of scans in time period 1 than 2, MD=27.09, CI [5.83, 48.34], P=0.015, and in time period

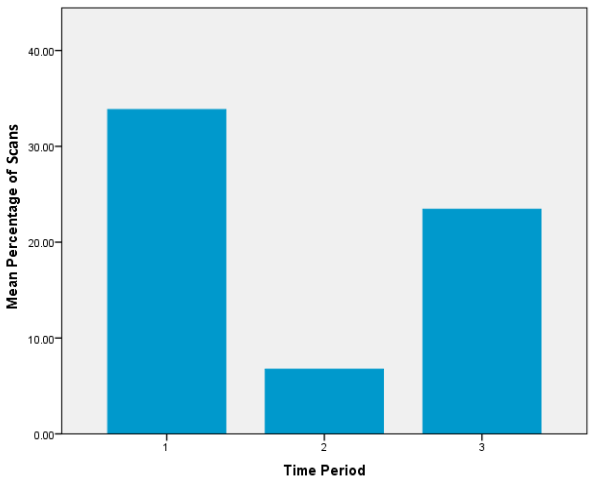


Figure 3.6. A graph to show the mean percentage of scans ponies were recorded standing alert across the three time periods.

3 than 2, MD=16.64, CI [2.03, 31.34], P=0.027. There was no significant difference in the percentage of scans ponies were observed standing alert between periods 1 and 3.

Time period had no significant effect on the performance of any of the other behaviours tested. Condition also had no significant effect on the performance any of the other behaviours tested, either in total or when split between the three time periods; these were the same behaviours as those tested against time period but also included standing alert.

3.2.3. Session 1: Before Fences Moved

Figure 3.7. shows the behaviours performed by ponies in conditions 1 and 2 in the 25-35 minutes before fences were moved. The most commonly displayed behaviour was head shaking, followed by pacing and ears back. All the ponies who had their fence moved while they were still in the field (1, 2, 4 and 6) walked to the back of the paddock and waited while the experimenter was moving the fence. Pony 11's and pony 12's fences had already been moved when they were returned to their paddocks from the sand school.

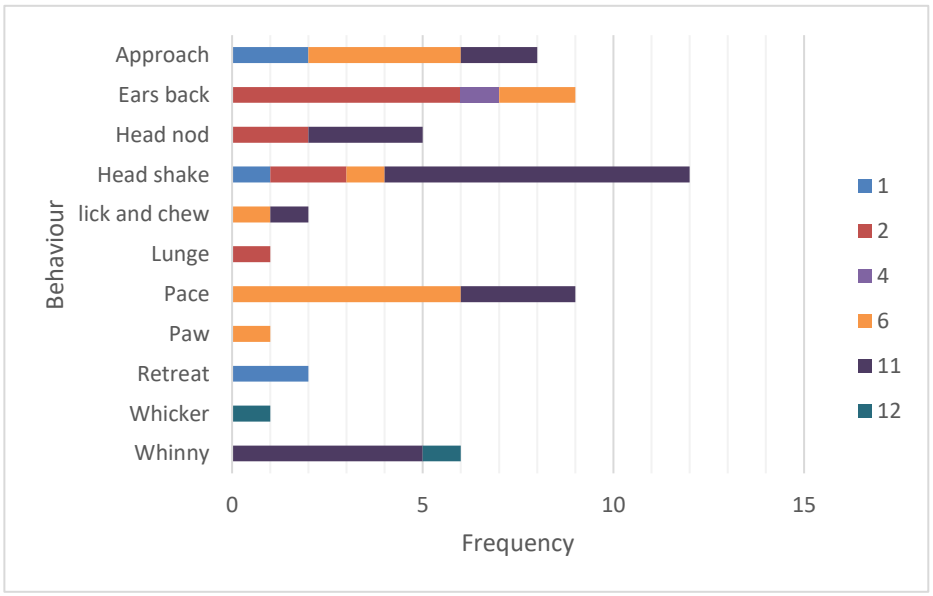


Figure 3.7. A graph to show the number of times ponies in conditions 1 and 2 were observed performing each behaviour in the 25-35 minutes before the fences were moved. Each pony is represented by a different colour.

Ponies in the control group were observed at the same time as their neighbours in the test conditions, and the behaviours they were observed performing are shown in Figure 3.8. Pawing was the most frequently recorded behaviour, though this was only shown by one pony (10).

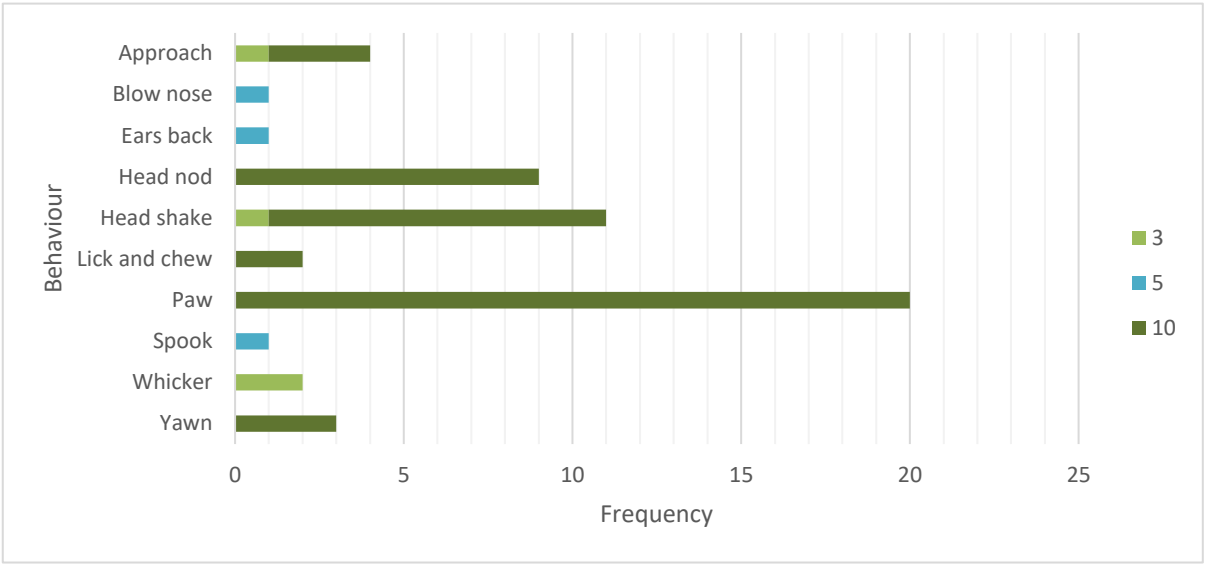


Figure 3.8. A graph to show the number of times control ponies were observed performing each behaviour in the 25-35 minutes before condition 1 and 2 ponies' fences were moved. Each pony is represented by a different colour.

3.2.4. Sessions 1-4: Location Observations

When in their study paddocks ponies spent 27.1% of their time near to a neighbouring pony, 38.4% of their time orientated towards a neighbouring pony and 34.6% of their time neither near nor orientated towards another pony.

When ponies were turned out into the sand school, they spent 60.7% of the time standing near each other and 39.3% of the time not standing near each other.

3.2.5. Session 4: Behaviours Observed in the Sand School

Whilst turned out in groups into the sand school ponies were observed performing several behaviours not seen whilst in the study paddocks. Figure 3.9. shows the behaviours exhibited by ponies whilst in the sand school and the frequency that each behaviour was performed. Ponies were most frequently recorded approaching and then standing near each other and this was shown by all ponies, but trotting, nose blowing, squealing and scratching on objects were also common. It was also noticed by the observer that many of the ponies were very keen to try and rub their bodies on handlers during handling, for example when being led from the paddocks to the school.

In some cases, ponies spent large amounts of time performing a single behaviour. Pony 7 spent 50.0% of her time in the school scratching on objects, whilst pony 3 spent 20.0% of her time chewing objects. The majority of mutual grooming events were between ponies 11 and 12, who spent 15.4% of their time in the school engaged in this behaviour. In total ponies spent an average of 48.7% of

their time turned out in the school standing alert. Pony 2 was also the only subject to show a flehmen response, each time after sniffing other ponies' droppings.

Play fighting was engaged in exclusively by ponies 10 and 11, though pony 12 who was turned out in the sand school with them also joined in with other behaviours which appeared to forms of play such as chasing, jumping over objects in the school such as jump wings and poles, leaping in the air, rearing, bucking, trotting, threatening to kick, kicking, nipping, biting and squealing. In this situation the behaviours displayed were interpreted as play rather than serious fighting as ponies appeared to sometimes alternate offensive and defensive roles and stopped short of causing injury (McDonnell 2003), and these behaviours have been recorded in play situations by other sources (Crowell-Davis *et al.* 1987; McDonnell 2003). Agonistic behaviours were observed infrequently outside a play context.

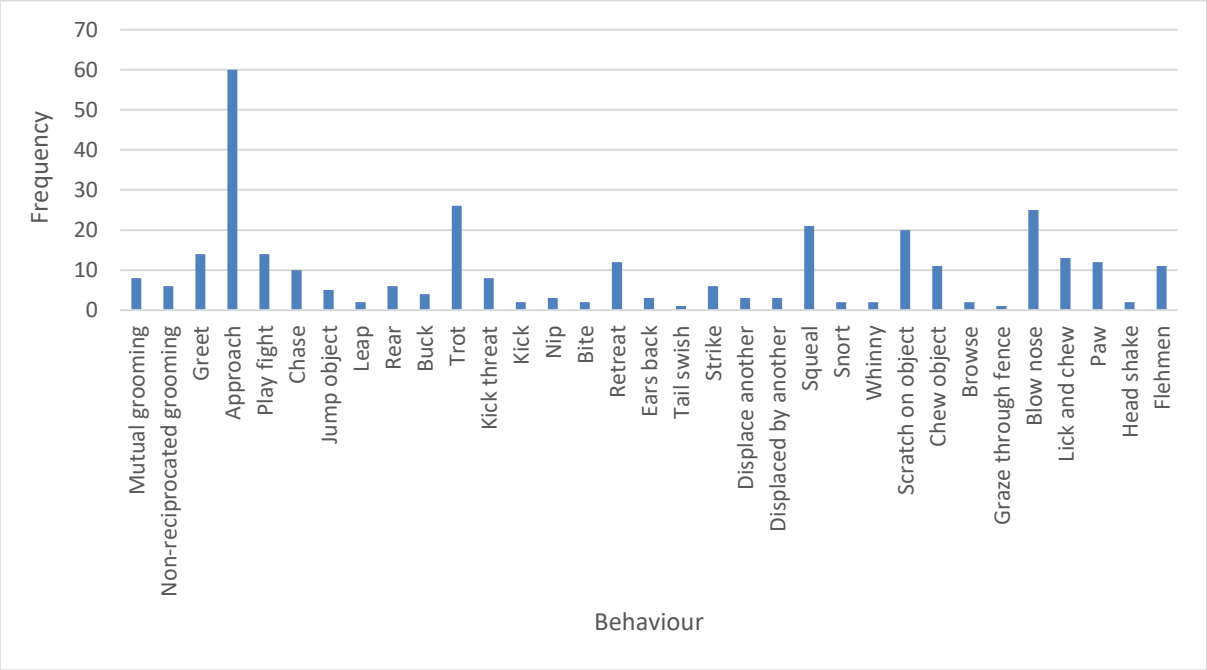


Figure 3.9. A graph to show the number of bouts of each behaviour ponies were observed performing whilst turned out in the sand school.

3.2.6. Sessions 5 and 6: Behaviours Observed Just Before Feeding Time

Figure 3.10. shows the behaviours observed whilst ponies were waiting to be fed their morning feed, and Figure 3.11. shows the behaviours observed while ponies were waiting to be fed their evening feed. In both cases whickering was performed most frequently and by the most ponies, while pacing was performed second most frequently.

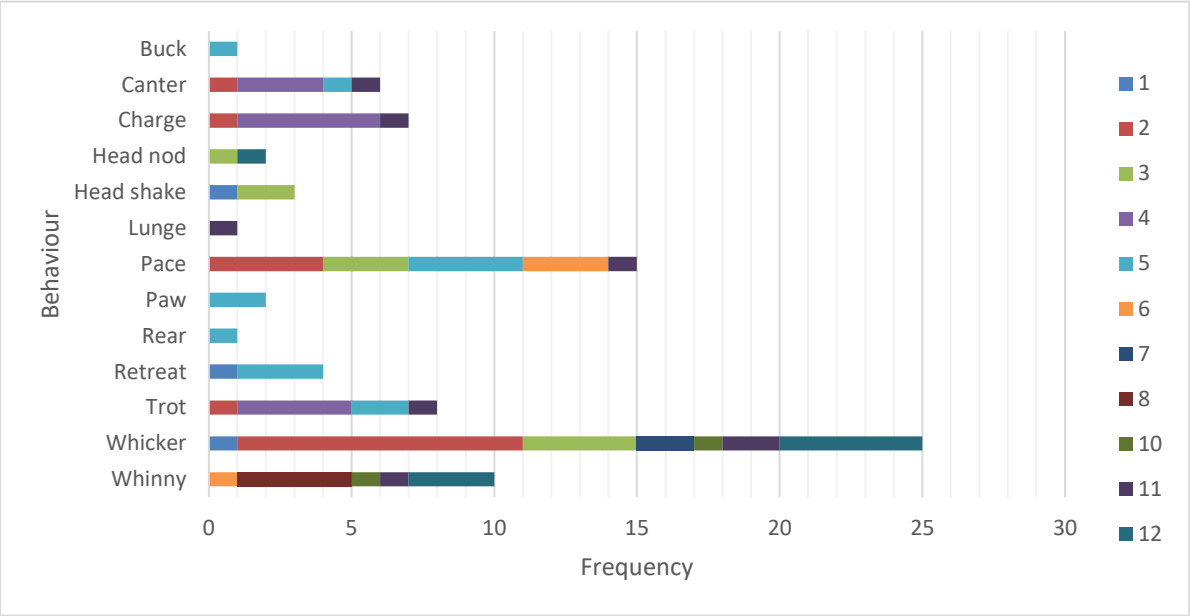


Figure 3.10. A graph to show the number of times ponies were observed performing each behaviour whilst waiting to be fed their morning feed. Each pony is represented by a different colour.

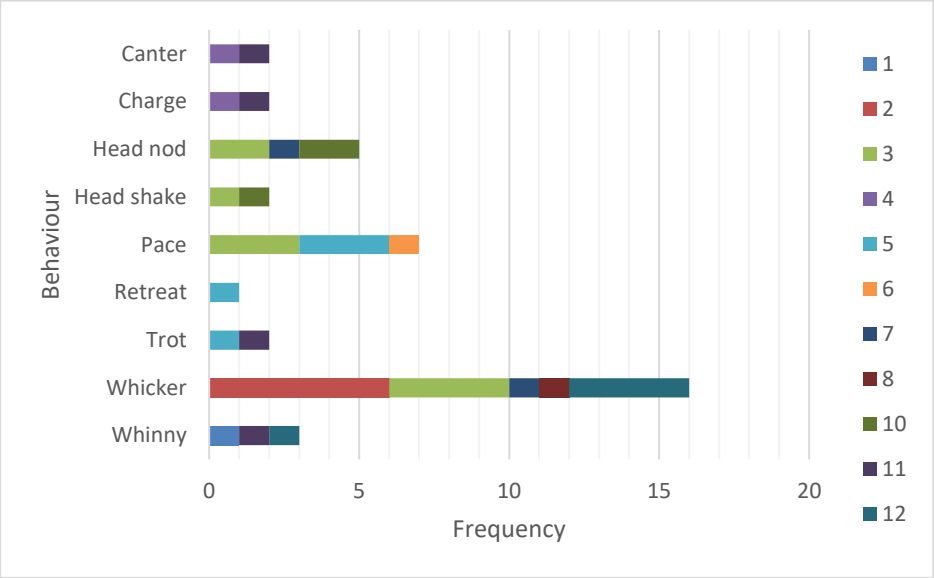


Figure 3.11. A graph to show the number of times ponies were observed performing each behaviour whilst waiting to be fed their evening feed. Each pony is represented by a different colour.

3.3. Discussion

3.3.1. Sessions 1-3: Grazing Behaviour

Results indicate that ponies in all conditions were observed grazing in approximately the same percentage of scans throughout the whole day. If strip grazing does not decrease time spent grazing it may be less likely to decrease weight gain and prevent laminitis. Nevertheless, strip grazing may have an impact on factors such as bite size or grazing intensity which it was not possible to measure in this study but would affect the actual amount of grass consumed by grazing ponies. Further, ponies were not observed overnight so it is not known what percentage of time they spent grazing during this time and what impact strip grazing may have had. It will also be important to consider the weight loss data collected by Longland (2019) from the entire study, which are currently unpublished, in conjunction with the findings from the behavioural data collected from these observations, as the former is necessary to ascertain strip grazing's effectiveness as a weight management tool. However, the current study focused on the welfare implications of these restrictive grazing practices and these can be evaluated using the findings presented here.

All ponies were observed grazing in significantly more scans in period 2 than periods 1 and 3, grazing most in the time period just after fences had been moved for the day. However, there was no significant effect of condition found on the percentage of scans ponies were observed grazing in period 2, with the control horses also grazing most in this period, suggesting it was not just the effect of the fences being moved resulting in increased grazing. It may be the case that during this time of day is when ponies tend to graze the most anyway. Other research has found that during summer horses spend the greatest percentage of time grazing overnight when it was coolest (Arnold 1984; Boyd *et al.* 1988), although both these studies took place in hotter climates (Western Australia and Virginia, USA respectively) so it these findings may not be reflective of diurnal changes in the time budgets of horses during summer in the UK, giving one explanation for contrasting findings. Arnold (1984) found that during winter (which is mild in Western Australia) horses grazed with a similar intensity throughout the day other than a trough between 03:00 and 06:00. The temperature was fairly mild during the observation period of this study, and so temperatures may have been more similar to the winter period in Arnold's study (1984). Boyd *et al.* (1988) found horses spent 36.7% of their time foraging 08:00-20:00, compared to 56.2% 20:00-08:00; in comparison Maisonpierre *et al.* (2019) found horses spent 60.8% of their time grazing during the day (05:00-21:00) which is similar to this study's finding of 60.9%. From looking at these studies' findings it is not conclusive whether horses in similar weather conditions to this study may be more likely to graze in the late morning and early afternoon (period 2), but it remains a possible influence.

Ponies in the control group were observed grazing in the smallest proportion of scans in period 2, and it is possible that with a larger sample size this difference may in fact have been significant. Conversely, control ponies may have been influenced to graze more if ponies in the test conditions spent a greater percentage of time grazing due to fences being moved, as a result of their close proximity to and view of ponies in the test conditions. The group of 11 ponies may have developed behavioural synchronicity despite the individual turn-out paddocks, as is observed in free-ranging horses (Souris *et al.* 2007). Additionally, according to Deneubourg and Goss (1989) mimicking the behaviour of neighbouring conspecifics is beneficial for many animals, improving cooperation. This suggests it is possible that ponies in test conditions grazed more in period 2 due to the strip being moved, and that control horses may have been showing synchrony with the larger group of ponies being strip grazed. As there was no significant difference between the proportion of scans ponies were observed grazing in periods 1 and 3, this indicates ponies returned to their pre-fence-move level of grazing.

It is interesting that condition only impacted percentage of scans ponies were observed grazing in period 3, with control ponies observed grazing in a significantly greater proportion of scans than ponies in condition 2, while the difference between control and condition 1 shows a trend towards significance. The difference in the percentage of scans ponies were observed grazing between periods 2 and 3 is the smallest in the control group, suggesting control ponies were more consistent with the percentage of time they spent grazing through the majority of the day, compared to condition 1 and 2 ponies. Test condition ponies may have been 'bingeing', concentrating grazing efforts in period 2 and as a result grazing less intensely in period 3. These ponies may have been hungrier than the control group at the time fences were moved due to having access to less grass overnight. It is unclear what impact an altered grazing pattern such as this might have on equine digestion and health, though it is essential that horses are able to have a near constant supply of forage to the digestive system in order to prevent EGUS (Luthersson *et al.* 2009). Therefore, if test condition ponies grazed so intensely throughout the day that there was no longer sufficient grass to allow trickle feeding all through the night this may put them at increased risk of EGUS. This is unlikely to be the case as ponies in all conditions spent time grazing in period 1, though future studies should aim to record the time budgets of strip grazed ponies overnight as well as during the day. Moreover, if ponies are only strip grazed for a few hours of the day and then stabled with a set amount of forage for example, these results suggest that strip grazing may result in ponies consuming more forage during turnout compared to if they had been turned out into a regular paddock without being strip grazed. Ince *et al.* (2011) found ponies on a restricted grazing regime of 3 hours pasture turnout/day and spending the rest of their time stabled consumed 49% of their daily DMI during the 3 hours at pasture by week 6, while during week 1 they consumed only 22%. This suggest ponies may already compensate for reduced turnout time by grazing more in the time they turned out. If ponies

already compensate when given limited turnout, there may be no further impact seen due to increased grazing time just after given access to new grass when being strip grazed, although it if these factors have a cumulative effect this could lead to ponies overeating even more in compensation. Rapid consumption of daily forage ration may also alter time budgets, for example decreased time spent foraging could lead to increased time spent inactive and may increase the likelihood of abnormal behaviours or stereotypies developing (Hothersall & Casey 2012).

All study paddocks (including control) were fairly small, especially condition 2, and so would not have allowed much exercise; although they were still considerably larger than the BHS recommended minimum stable sizes of 3.05m x 3.05m for small ponies to 3.65m x 4.25m for large horses (DEFRA 2017). Maisonpierre *et al.* (2019) found paddock size influenced the amount of time horses spent standing and ambulating, with subjects in what was considered a 'standard' sized paddock (40x60m) spending a significantly greater proportion of time walking and a significantly lower proportion of time standing compared to subjects in 'small' paddocks (10x60m). Therefore, a possible benefit of the method implemented in condition 1 is that as the paddock gets larger each day ponies may gradually spend more time ambulating and less time standing. Furthermore, Maisonpierre *et al.* (2019) found no difference in the amount of time horses spent grazing between the two field sizes, why may imply horses should not consume more in larger fields than smaller ones, which may be counterintuitive. However, this would be irrelevant if horses do not utilise this extra space, and results suggests that when in a strip grazing system this may be the case due to the fact ponies in the two test conditions were recorded grazing new grass in significantly more scans than simply grazing in any area of the paddock. This means these ponies would have been spending a large proportion of their day only walking back and forth across a strip approximately 1x10m, therefore getting minimal exercise. Strip grazing is commonly used as a method of weight management, but if ponies decrease their exercise by grazing only a small area for the majority of the day this may hinder weight loss. In comparison, both 'standard' and 'small' fields in the Maisonpierre *et al.* (2019) study were much larger than any of those in this study. Horses in 'standard' fields spent a median of 4.6% of their time ambulating during the day (05:00-21:00), while ponies in this study were recorded as walking a median of 2.7% (mean 2.5%) of the time. This further supports their hypothesis that decreasing paddock sizes decreases the percentage of time horses spend walking. In comparison, wild horses were observed walking for an average of 9.3% of the time between 08:00 and 20:00 (Boyd *et al.* 1988). However, Maisonpierre *et al.* (2019) used accelerometer data to classify behaviour compared to the in-person observations used in this study, which may have led to differences in what was categorised as walking/ambulating between the two studies. Additionally, no significant difference was found in the percentage of scans ponies were observed walking between the control and two test conditions in this study, which may suggest that either the trend does not continue once

paddocks are reduced to a certain size, or that the difference in size between the paddocks used was not enough to impact the percentage of time ponies spent walking.

As well as potentially impacting weight management, decreased exercise due to decreased paddock size may negatively impact animals suffering from osteoarthritis. Management of this condition involves regular gentle exercise, therefore being confined to a small paddock may be unsuitable (van Weeren & Back 2016). Furthermore, strip grazing may be an unsuitable method even if this is carried out in a large field if horses are likely to spend the majority of the day in a small area to graze the newly uncovered grass as those in the study did. Concentration of movement to one area of the field may also lead to poached ground or damaged grass.

3.3.2. Sessions 1-3: Other Behaviours Observed During Scan Sampling

Ponies were observed standing alert in significantly more scans in time periods 1 and 3 than 2, this is the inverse of time spent grazing as when ponies were not grazing the majority of their time was occupied by standing alert. It is possible the high percentage of scans ponies were observed standing alert when not grazing was influenced by the fact subjects were in individual paddocks. Kiley-Worthington (1984) found individually housed horses spent significantly longer standing alert than group housed horses, and this behaviour may be a sign of poor welfare due to reduced social contact. Restricting horses' opportunity to express social behaviour is known to cause distress. Yarnell *et al.* (2015) found singly housed horses unable to make physical contact with conspecifics had increased physiological indicators of stress as well as being more difficult to handle than horses provided with physical contact of varying degrees. It was necessary for ponies to be kept individually for this study, so the amount of grass they consumed could be accurately calculated, though in practice horses should be strip grazed in groups to improve welfare. One problem that may arise is that this could lead to competition for access to fresh grass, resulting in some horses consuming more grass than others and possibly increased social tension, but research into horses strip grazed in groups or pairs is required to ascertain to what extent this may be an issue. Other options to increase social contact while individually strip grazing could be to use an alternative fencing between paddocks that allows neighbours to make contact without the risk of an electric shock, or to provide longer periods of turnout in a grass free area in groups, providing alternative forage such as hay.

The fact that neither time period nor condition had an effect on any of the other behaviours tested could be viewed as a positive; there was no increase in behaviours related to frustration or distress in condition 1 or 2 ponies compared with control ponies, suggesting they did not find being strip grazed stressful. There were low instances of these types of behaviours in all conditions, with ponies spending 90.3% of their time either grazing, standing alert or standing at rest. These three

behaviours also occupied the majority of time free ranging Przewalski horses (Boyd *et al.* 1988), at 80.3%, though they spent a greater percentage of time walking than the ponies in this study, and also in engaging in social interactions, which ponies in this study were unable to do due to being individually paddocked. Consequently, strip grazing may be an option for managing grazing whilst causing minimal distress. Although, the absence of behavioural signs of distress does not necessarily mean ponies were free from distress, as physiological parameters were not measured. Indeed, Squibb *et al*. (2018) found no correlation between behaviour and physiological signs of stress, suggesting horses that appeared calm were experiencing greater distress than would have been expected from observing behaviour alone. The current study was also fairly short term, so it is not known how these living conditions may impact ponies in the long term.

3.3.3. Session 1: Before Fences Moved

Similar behaviours were displayed whilst ponies were waiting for fences to be moved as to waiting for hard feed, and individual ponies tended to show comparable levels of reactivity, although a few ponies did show quite contrasting responses to the different situations. Interestingly, control ponies also showed some of these 'problematic' behaviours, with 3 and 5 only displaying a few at low levels, whereas 10 showed the most of these behaviours of any pony during this period of time. Control ponies may have shown some of these pre-feeding behaviours due to synchrony with neighbouring ponies in conditions 1 and 2. However, this is unlikely the sole case for pony 10, since he displayed the most reactive behaviours. Ponies 10, 11 and 12 were typically turned out in the sand school first, with 11's and 12's fences having been moved on their return, while other ponies more often had their fences moved while they were in their paddocks. While this likely made little difference to the larger weight management study ponies were taking part in, it is likely to have impacted the behaviour of ponies 10-12. It was beyond the ability of the researchers in this study to alter the routine used in the weight management study ponies were primarily taking part in. This is because during this period the other test condition ponies were supposed to be showing anticipatory behaviours in response to predicting that their fences would be moved to allow access more grass, but 10-12 may instead have been anticipating being turned out in the sand school. These discrepancies between the experiences of different ponies makes the behaviour of ponies 10-12 less comparable with the behaviour of the other subjects recorded during this session. Therefore, it is possible 10 performed these behaviours in anticipation for the social contact provided by group turnout, or the chance for increased movement, or interaction with other objects not present in the study paddocks. Pawing has previously been recognised as a result of barrier frustration (Houpt 1986), which may have been the case here with the pony wanting to be let out from his paddock into the school. Young *et al*. (2012) also acknowledged pawing as an indicator of stress, suggesting pony

10 may have been stressed at this point. Some ponies also displayed pawing behaviour when in the sand school, this occurred when interacting with objects in the school so is likely to be investigative behaviour (McDonnell 2003), although it may be possible it was also driven by frustration.

Only ponies in the test conditions paced round their paddocks, suggesting this behaviour was a result of frustration at being unable to get to the fresh grass after cues had predicted fences were about to be moved. Young *et al*. (2012) include pacing as an indicator of stress on their behavioural scale, which was correlated with cortisol levels, suggesting ponies performing this behaviour in both pre-feeding and pre-fence-moving situations were also experiencing some stress. Furthermore, owners planning to implement restricted grazing should take care, as they may reinforce undesirable pre-feeding behaviours by rewarding the horse (by allowing access to fresh grass) while it is performing them (Houpt 1986). This is also true when providing horses with hard feed. If horses are not to be housed in the strip grazed paddock full time, it may be beneficial to move the fence without them present to limit frustration and the opportunity for unwanted behaviours to be reinforced, although this could potentially just shift the performance of such behaviours to when horses are waiting to be turned out.

3.3.4. Sessions 1-4: Location

Jørgensen *et al.* (2009) found horses spent over 60% of their time within 2m of another horse, a similar result to the one seen in this study when ponies were turned out in the sand school. In comparison, ponies were only classified as standing near another horse 27.1% of the time when in their study paddocks, though they spent a further 38.4% orientated towards a neighbour. When subjects were orientated towards another pony, this may signify that they wanted to stand near their neighbour but were unable. Ponies spent 65.5% of their time in the study paddocks standing either near or orientated towards another pony, suggesting that orientation towards a conspecific indicated a desire to stand with that neighbour. Ponies' welfare may be impacted negatively if they are prevented from standing near to conspecifics when they want to, although apparent orientation towards another pony may be coincidental.

3.3.5. Session 4: Behaviours Observed in the Sand School

When the ponies were turned out in the school, they performed many behaviours they were unable to whilst in the paddocks including mutual grooming, greeting behaviour and play related behaviour. There may have been a rebound effect of ponies performing these behaviours at higher rates than would be expected if they had not been confined. This was seen by Christensen *et al.* (2002), who

found 2-year-old stallions stabled singly spent an increased proportion of time social grooming, showing greeting behaviour and playing once turned out in groups compared to stallions who had been stabled in groups. This suggests horses build up a motivation to perform certain social behaviours when prevented from expressing these for a certain time (Christensen *et al.* 2002). Singly housed stallions also demonstrated increased aggression while group housed stallions showed more subtle agonistic interactions (Christensen *et al.* 2002); this may have also been the case for ponies in this study. As there was no comparison group containing ponies that had been group housed it cannot be determined whether any of the behaviours displayed was a result of their housing, or whether they would have behaved in this way anyway. However, it is possible that some ponies showed a rebound effect in the behaviours they performed, suggesting they valued being able to interact and make physical contact with conspecifics even if they did not generally appear to be stressed in the study paddocks. Søndergaard *et al.*'s (2011) findings support this idea, discovering young female horses housed unable to make physical contact to conspecifics showed similar levels of motivation to achieve all types of contact (muzzle, head or full body). This implies subjects viewed these types of contact as equal in value when the alternative was no contact, and that horses should be given the minimum of muzzle contact when housed (Søndergaard *et al.* 2011). When ponies showed nose to nose greeting behaviour in the school they consistently made physical contact, whereas when they did this over the paddock fences they did not, likely due to the fear they may receive a shock from the electric fence if they came too close. This may have resulted in frustration from being unable to achieve physical contact whilst in the study paddocks, potentially compromising welfare.

As the perimeter of the study paddocks was electric fencing there were no trees or objects present, there was no opportunity for ponies to scratch or rub their bodies on anything when in the paddocks, other than by rolling. Four of the ponies, especially pony 7, spent time scratching on the fence or other objects in the school, and it was also noticed by the observer that many of the ponies were very keen to try and rub their bodies on handlers during handling. It is possible that ponies missed having the ability to scratch and rub themselves when in the paddock and so also showed a rebound effect with this behaviour in the school. Ralph (2017) recommends providing your horse with something to rub on such as a scratching post or moveable object like a tractor tyre in the field, as well as surfaces to rub on in the stable. DeVries *et al.* (2007) also concluded that providing dairy cows with mechanical brushes helped to satisfy cow's natural desire to perform grooming behaviours as well as keep them clean, and potentially alleviate frustration or stress when housed in barns. The cows in this study spent more than five times as much time engaged in grooming behaviour after brushes were provided, with 91% of grooming time accounting for brush use (DeVries *et al.* 2007). Furthermore, Schukken and Young (2010) observed increased milk production in cows in their second lactation and decreased incidence of mastitis for cows in their second or higher lactation,

suggesting that improved welfare and increased cleanliness in cows led to these results. It is possible that the provision of grooming aids may have a similar benefit to equine welfare and is something that should be considered when horse carers are creating a strip grazing system, or indeed in a regular turnout paddock.

3.3.6. Sessions 5 and 6: Behaviours Observed Just Before Feeding Time

Hockenhull and Creighton (2014b) found pre-feeding behaviour problems were reported for 70% of UK leisure horses, and that restricted access to forage was associated with pre-feeding frustration. Using the same classifications as Hockenhull and Creighton (2014b), 8/11 and 7/11 ponies would have been considered to show a pre-feeding behaviour problem before being fed their morning and evening feeds respectively, although these behaviours were shown at a greater rate before their morning feed (vocalising was not classed as problematic behaviour). The behaviour categories used by Hockenhull and Creighton (2014b) were aggression (seen in this study as charging or lunging at a neighbouring pony), frustration (in this study: pawing) and stereotypic (in this study: pacing, repetitive head movements). Similar behaviours have also been observed by others before feeding and interpreted as being indicative of agitation (Ellis *et al.* 2014). Due to the common nature of these behaviour problems it is entirely possible ponies in this study had already developed behavioural problems related to feed time, rather than them being a direct result of the conditions in this study. However, some of the management practices used during the study may have contributed to these behaviours, for example ponies fed last may have increased performance of such behaviours as a result of observing the ponies at the beginning of the row being fed, whilst having a delay before receiving their own feed (Cooper *et al.* 2005).

3.3.7. Limitations

Individual coping strategies and personalities varied greatly between ponies; this is to be expected as the ponies had different influences of genetics and past experience. Budzynska (2014) recognised different horses can react differently to the same situation and stimuli and have varying coping strategies to stressful situations. This has implications for welfare as passive copers may be less likely to be identified as experiencing distress than active copers, meaning intervention is less likely. The small sample size meant individual differences are likely to be more influential on results than if a larger sample had been used, as well as meaning findings are less generalisable to the wider equine population. Therefore, only so much can be inferred from these results, and further research in this area is required. Furthermore, small sample size can also lead to tests not having sufficient power,

therefore increasing the risk of committing a type 2 error (Pallant 2016). For this reason, behavioural differences trending towards significance are also considered to be potentially relevant as with a larger sample these may have been significant. Small sample sizes are common problem in equine research, with many published studies having fewer than 10 participants (e.g. Longland *et al.* 2016a, b). The often-high cost of studies (McGreevy *et al.* 2018) and limited funding available for equine research (Voss 2018) has been considered to contribute towards this phenomenon. Moreover, this study was only carried out over three days; in future it would be valuable to observe subjects at the beginning, middle and end of the study for comparison, or continually throughout if possible. Due to the short time period available for data collection in some cases not all ponies were observed in all time periods, meaning they had to be excluded in some analysis which decreased an already small dataset. Furthermore, observations were only carried out during the daytime and over one season, limiting the ability to generalise the results to times outside of these.

3.3.8. Conclusion

No difference was found in the proportion of scans ponies spent grazing overall between conditions. However, strip grazed ponies (conditions 1 and 2) spent the majority of scans grazing new grass, therefore spending most of their time in the new strip made available each day. Ponies in conditions 1 and 2 also spent less scans grazing in time period 3 compared to control ponies. Results from Longland (2019) are required to determine whether strip grazing is an effective strategy for managing bodyweight in ponies, so that findings from this study can be put into context and allow horse carers to make informed decisions regarding the use of this method. Although, some may wish to use strip grazing for land rather than weight management, so findings from the current study are likely to have relevance in this context even if strip grazing is not found to impact bodyweight. Other than during the short periods while waiting to be fed and for fences to be moved, ponies did not seem to be distressed by the strip grazing methods employed. Therefore, if found to be effective, this method would appear to be a suitable option for managing horses' weight while limiting any adverse impact on welfare. However, physiological variables were not measured, and varying coping strategies may result in distress not being identified in some animals. Due to the design and aims of this study it was necessary for ponies to be kept individually, but in practice this is not recommended as social isolation has been found to result in poor equine welfare, with ponies in this study showing rebound effects for social behaviour when turned out in groups. Although, research needs to be conducted on the impact of strip grazing when more than one pony is in a paddock as this has not yet been explored. This is the first known study into the effect strip grazing on equine behaviour, and further exploration in this area is needed to establish links between this method of restricted grazing and behaviour, so that welfare implications can be better understood.

4. Final Conclusions

For some time, it has been understood that restricted grazing may be necessary to treat and prevent certain equine health problems. For a few RGMs there is evidence supporting that they successfully achieve this, though other methods lack evidence completely. Research has also suggested restricting grazing may threaten to compromise welfare in other ways. Horse owners and carers are likely to be the ones implementing these practices but their views regarding such methods had not previously been investigated. This project has shed light on the various factors that influence horse carers' decisions regarding restricted grazing practices and the reasons these interventions are required. The questionnaire phase revealed the perceived impact of common RGMs on equine health and welfare, while the following intervention trial investigated the behavioural impact of strip grazing (the method found most popular with questionnaire respondents).

Questionnaire responses showed that all RGMs are believed to compromise welfare by some, but the majority of respondents agreed that using such methods was necessary to prevent poor welfare due to poor physical health. Responses also demonstrated that a number of factors, which may be beyond carers' control, limit the methods available for individuals to use. This leaves horse carers compromising between what they believe is best for their horse's welfare and what measures they are realistically able to take. Horse carers disagreed on which method was best in terms of welfare and effectiveness at managing health issues, experiencing vastly different outcomes using the same methods. However, strip grazing was favoured by the largest number of respondents. These varying outcomes are likely due to individual differences in the horses, how their owners are implementing the methods and environmental factors such as grass quality.

The intervention trial found strip grazing altered the percentage of scans ponies spent grazing in different time periods throughout the day, though not the length of time spent grazing overall. This raises questions on whether DMI would be reduced, especially as strip grazed ponies concentrated their grazing efforts on the period after the strip had been moved, when fresh grass was made available. One of the main benefits of strip grazing identified by questionnaire respondents was that it increases horses' ability to exercise compared to other methods. Strip grazed ponies were observed walking the same amount as control ponies, suggesting strip grazing may not reduce exercise compared to turnout in a paddock the same size as ones the control ponies were in. However, strip grazed ponies spent most of their time grazing the new strip of grass, therefore remaining mainly in one area of the field. It is possible they may not have travelled as far as control ponies when grazing, who utilised the whole area available, although this was not measured so it is not known if this would be the case. Therefore, it is not known whether strip grazed ponies might exercise more than ponies in other methods of restricted grazing, and it is likely to vary widely

between methods used. Future studies could use pedometers or GPS trackers to measure voluntary exercise and compare this between different restricted grazing techniques. Ponies were only rarely observed performing distress related behaviours outside of specific times of day (when waiting to be fed and waiting for fences to be moved), suggesting strip grazing may not have greatly adversely impacted psychological welfare. Although, for this to be confirmed physiological measures of welfare should also be collected and correlated against behavioural measures in future research. Any aversive impact subjects may have experienced due to social isolation could be reduced by strip grazing horses in groups.

Future research should focus on establishing the efficacy of controlling and preventing health issues for the RGMs where this data is currently lacking. Studies should also investigate the impact these methods have on other aspects of welfare so it can be confirmed whether questionnaire respondents' concerns are legitimate. Results yielded from future research should go towards creating guidelines to advise horse carers on how best to implement RGMs, as currently little evidence-based guidance is available. Guidelines would inform users how to use RGMs so they are most effective but minimise any potential adverse effects on other aspects of welfare. However, restricting grazing is a compromise that often may be necessary due to the suboptimal way that many leisure horses in the UK are fed and managed, for example on unsuitable grass species. Therefore, to prevent diseases such as obesity and laminitis without the need for restricted grazing, we need to look more widely at the way horses are kept in this country, and what changes can be made to create lasting improvements in equine welfare.

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Appendix A: Full Questionnaire

University of BRISTOL

Horse Owner Opinions On Restricted Grazing Methods

Participant Information and Consent

I am part of the Animal Welfare and Behaviour Group at Bristol Veterinary School, and am conducting research into the methods of restricted grazing used with horses in the UK and equine stakeholders' opinions on these.

Why is this research important?

At present we simply do not know what people are doing in terms of restricted grazing and why or the implications for the horses. A survey of this kind has not previously been done and I aim to discover what practices people seem to find most effective. This can then be used to help produce advice for horse owners/carers so that equine welfare can be optimised.

Will my taking part in this study be kept confidential?

- All the answers you provide will remain anonymous.
- However, as your data is anonymous you will not be able to withdraw it from the study once you have completed the questionnaire.
- If you decide to provide an email address so you may be contacted about having an interview, this will in no way be linked to the responses you provide to the questionnaire.
- My supervisor and I are the only ones who will have access to emails provided.
- Emails will be stored securely, and you may request that these be deleted at any time.

What will happen to the results of the research study?

The study results will be written up in the form of a masters project student dissertation. The aim is to publish the results in a journal and also present them at an equine conference. A short summary will be made available on the project Facebook page which participants and members of the public can view: https://www.facebook.com/RestrictedGrazing

This study has received ethical approval from the University of Bristol Faculty of Health Sciences Research Ethics Committee.

Further information and contact details

If you have any questions or concerns, please email me: amelia.cameron@bristol.ac.uk or my supervisor: jo.hockenhull@bristol.ac.uk

If you either currently or in the past have owned/loaned/shared/cared for a horse, or made a living from working with or managing horses in the UK, I would be very grateful if you could spare some time to take part in my study by completing this questionnaire.

You must be **at least 18 years old** to take part and live in the UK (or if you are answering questions about a horse you cared for in the past you must have been living in the UK during this time).

The majority of questions are aimed at people who have used a method of restricted grazing, but this is not required. There are also specific questions for those who have never done so.

Key Definitions

For the purposes of this questionnaire restricted grazing is defined as: limiting a horse's access to pasture in some way, with reduced access to pasture for whatever reason being the aim of the practice. This does not include instances such as an injured horse being kept on box rest or keeping a horse stabled for longer during summer to keep it away from flies or heat.

Do I have to take part?

No, this questionnaire is entirely voluntary. Once you have started you are also under no obligation to complete the questionnaire and may stop at any time without a reason.

What will happen to me if I take part and what will I have to do?

- You will answer the questions in this survey, which are divided into sections.
- You will not have to answer all the sections, some may not be relevant to you. If you choose to answer all possible sections, it may take you about 20 minutes to complete.
- There are no right or wrong answers so please just respond as honestly as you can.
- Once you have submitted your responses you will be asked whether you are happy to be contacted to be interviewed about this topic area.
- If you are happy for this to happen, please leave your email address in the box provided.
- Your email address will not be linked to your survey responses and will be stored in accordance with university policy.
- Your email address will not be distributed or used for any purpose other than to contact you about arranging an interview.

If you change your mind you may contact me at any time to request your email address be deleted.

1. I agree to participate under the conditions listed above: ¤ *Required*

- ○ Yes

Background Information

2. What is your main stake/interest in the horse world?

- ○ Horse owner/carer
- ○ Horse Loaner/Sharer
- ○ Earn/earnt a living from working with/managing horses
- ○ Other

2.a. If you selected Other, please specify:

3. How long (approximately) have you been involved in the horse world?

- Less than 6 months
- 1 year
- 2 years
- 3-5 years
- 6-9 years
- 10-15 years
- 16-20 years
- 21-25 years
- More than 25 years

4. Have you ever used any restricted grazing methods? *Required*

- Yes
- No

General Knowledge and Opinions

5. What methods of restricted grazing have you heard of?

6. Have you ever had to take measures to manage your horse's pasture (e.g. to stopit becoming too churned up, to preserve grass)? If yes what were these measures?

8. Are there any restrictions on how you can manage your horse due to rules or thesituation at the place you keep/kept your horse? (please answer about the horse you cared for most recently)

- Yes
- No

8.a. If you selected Yes, please specify:

9. Have you ever cared for a horse with any of these conditions? (select all thatapply)

- Laminitis
- Overweight/Obese
- Required weight management to prevent becoming overweight/obese
- PPID (Cushing's Disease)
- Equine Metabolic Syndrome
- Diabetes
- None of the above

10. If you selected any of the conditions above, what methods do/did you use to helpmanage them? Please specify which condition you are talking about when describing the methods used.

11. If in the future a horse you cared for required its access to grass to be restrictedfor any reason, what method(s) do you think you would try first?

12. How good do you believe each of these restricted grazing methods are in termsof equine welfare? *(Assume in each case that the horse has at least some access*

7. Where is/was your horse kept? (please answer about the horse you cared formost recently)

- Livery Yard
- Riding School
- Your own land
- Land you rent and manage yourself
- A friend/family's land
- Other

7.a. If you selected Other, please specify:

to forage e.g. some provision of hay in the starvation paddock.) Please don't select more than 1 answer(s) per row.

	Very Good	Good	Neither Good nor Bad	Bad	Very Bad
Grazing Muzzle	☐	☐	☐	☐	☐
Stabling to keep off grass (for longer than horse would be otherwise)	☐	☐	☐	☐	☐
Starvation paddock (bare patch of land with no/very little grass)	☐	☐	☐	☐	☐
Turn out in a crew yard, arena or similar to keep off grass	☐	☐	☐	☐	☐
Strip Grazing	☐	☐	☐	☐	☐

13. Please explain the reasons you gave each method the rating you did:

14. To continue to the final page of the questionnaire: *Required*

- Please select here

Experience With Restricted Grazing

15. Why have you practised restricted grazing? (select all that apply)

- Pasture management
- To help prevent/manage laminitis
- To help prevent horse becoming overweight/obese
- Horse was overweight/obese
- Horse had PPID (Cushing's disease)
- Horse had Equine Metabolic Syndrome
- Horse had diabetes
- Other

15.a. If you selected Other, please specify:

Questions 16-24 of this section ask about one specific horse you cared for that requires/d restricted grazing. If you care or have cared for more than one horse requiring restricted grazing, please answer these questions about the one you cared for most recently. If you cared for 2 or more simultaneously please select the horse whose name is first in the alphabet. Please also answer all future specific questions about this horse.

16. If your horse has/had a condition e.g. PPID/laminitis that needs managing orpreventing from occurring, are there any methods you use/d other than restricted grazing to help do so (not including prescribed medication)?

17. If your horse's body condition needs/ed managing so it does not becomeoverweight or so that it will lose weight, are there any methods you use/d other than restricted grazing to do so?

18. What role do/did you have in the day to day care for this horse?

- Main person responsible for caring for the horse
- Shared caring responsibility
- Minor responsibility in caring for the horse No responsibility for the care of the horse

19. Where is/was your horse kept?

- Livery Yard
- Riding School
- Your own land
- Land you rent and manage yourself
- A friend/family's land
- Other

19.a. If you selected Other, please specify:

20. Are there any restrictions on how you can manage your horse (including whichrestricted grazing methods you can use) due to rules or the situation at your yard e.g. set turnout hours?

- Yes
- No

20.a. If you selected Yes, please specify:

21. What methods of restricted grazing have you ever used or tried on your horse? (select all that apply)

- Grazing muzzle
- Stabling to keep off grass (for longer than horse would be otherwise)
- Starvation paddock (bare patch of land with no/very little grass)
- Turn out in a crew yard, arena or similar to keep off grass
- Strip grazing
- Other

21.a. If you selected Other, please specify:

22. If you use/have used stabling, a starvation paddock, turnout in a crew yard orsimilar, do/did you provide your horse with a source of forage e.g. hay when

using this method? If yes, please briefly describe *e.g. horse given a small haynet when first turned out for the day.*

23. If you used restricted grazing for any of the reasons listed below, which methodsdid you find effective for managing them? (select all that apply) Please don't select more than 1 answer(s) per row.

	Prevention/Control of Laminitis	Weight Management	Managing a Metabolic Disorder (EMS, PPID)
None	☐	☐	☐
Grazing muzzle	☐	☐	☐
Stabling to keep off grass (for longer than horse would be otherwise)	☐	☐	☐
Starvation paddock	☐	☐	☐
Turn out in a crew yard or similar	☐	☐	☐
Strip grazing	☐	☐	☐
Other	☐	☐	☐

24. How do/did you keep track of your horse's weight/condition and/orlaminitis/metabolic disorder (if necessary)? (select all that apply)

- N/A
- Weight tape
- Weigh bridge
- Body condition scoring
- Monitoring how cresty the horse's neck is/was
- By eye/feel
- Veterinary monitoring
- Blood tests
- Inspecting feet (e.g. temperature, hoof quality)
- Do/did not keep track
- Other

24.a. If you selected Other, please specify:

25. What influenced the initial decision of which method of restricted grazing to use? (select all that apply)

- Ease of implementation
- Cost/affordability of implementation
- Only method available
- Personal judgement/experience
- Advice from a veterinary professional
- Advice from other professional (e.g. nutritionist, behaviourist)
- Advice from friend's/family/acquintances
- Advice/research online
- Other

25.a. If you selected Other, please specify:

26. If anyone has ever offered advice on which restricted grazing methods youshould or should not use, who offered the advice and what did they say?

27. If you have done research or found advice online on restricted grazing, whatsources did you use? (select all that apply)

- ☐ General websites offering advice on restricted grazing
- ☐ Veterinary websites
- ☐ Websites offering a professional's opinions (e.g. reputable magazines or charities)
- ☐ Scientific papers/journals
- ☐ Forums
- ☐ Facebook groups
- ☐
- ☐ Other N/A

27.a. If you selected Other, please specify:

28. How much do you agree with these statements?

Please don't select more than 1 answer(s) per row.

	Strongly agree	Agree	Neither agree no disagree	Disagree	Strongly disagree	N/A
It is easy to find information about restricted grazing.	☐	☐	☐	☐	☐	☐
The information available is easy to implement in a practical situation.	☐	☐	☐	☐	☐	☐
The information available makes it easy to decide which method of restricted grazing is most appropriate for my situation.	☐	☐	☐	☐	☐	☐

29. Which of the methods of restricted grazing that you have tried would you useagain and why?

30. Which would you not use again and why?

31. Are there any other restricted grazing methods you would consider trying in thefuture and why?

32. Are there any you would not try and why?

33. If it was solely up to you, and it was affordable and practical to implement anymethod, how would you prefer to restrict your horse's grazing?

34. How good do you believe each of these restricted grazing methods are in termsof equine welfare? *(Assume in each case that the horse has at least some access to forage e.g. some provision of hay in the starvation paddock.)* Please don't select more than 1 answer(s) per row.

	Very Good	Good	Neither Good nor Bad	Bad	Very Bad
Grazing Muzzle	☐	☐	☐	☐	☐
Stabling to keep off grass (for longer than horse would be otherwise)	☐	☐	☐	☐	☐
Starvation paddock (bare patch of land with no/very little grass)	☐	☐	☐	☐	☐
Turn out in a crew yard, arena or similar to keep off grass	☐	☐	☐	☐	☐
Strip Grazing	☐	☐	☐	☐	☐

35. Please explain the reasons you gave each method the rating you did:

You have now completed this section. If you have tried using either grazing muzzles, strip grazing or both and are happy to share your experiences of these methods in more detail that would be greatly appreciated, and you will be directed to the relevant section(s). If not, when you answer 'no' to the following 2 questions you will be directed to the end of the survey.

36. Have you used strip grazing and would be happy to answer some furtherquestions on this? *Required*

- Yes
- No

Grazing Muzzle Filter Question

37. Have you used a grazing muzzle and would be happy to answer some further questions on this? *Required*

- Yes
- No

Strip Grazing

Please answer the questions in this section regarding one specific horse.

38. What times of year do you usually strip graze? (select all that apply)

- Spring
- Summer
- Autumn
- Winter
- It varies a lot depending on how much grass is available that year

39. Do you strip graze for different reasons in different seasons e.g. pasturemanagement vs weight control?

- Yes
- No

39.a. If you selected Yes, please specify:

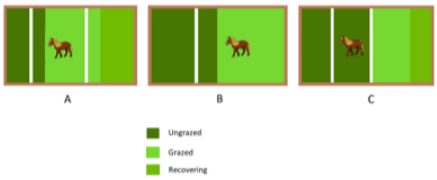
41. How do you decide how **often** to move the strip?

- I always do it after the same interval
- The speed the grass gets eaten down/grows
- How muddy/churned up the field is getting
- Advice from your veterinarian
- Advice form another equine professional
- Advice from friends/family
- Advice found online
- Other

41.a. If you selected Other, please specify:

42. How do you decide how **much** you move the strip by each time?

40. Which of these descriptions/diagrams best represents the type of strip grazingyou normally practise? Each diagram shows the pasture just after the strip has been moved.



- A - 2 mobile (often parallel) fences move the same distance up the field each time, so the paddock size stays approximately the same. Each time the fence is moved the paddock will comprise of some new ungrazed grass as well as some previously grazed grass.
- B - Only one mobile fence which travels up the field while all others remain inplace, so the paddock size increases.
- C - The entire strip is moved so the whole paddock is made up of fresh grasseach time.
- Other

40.a. If you selected Other, please specify:

- I always move it the same amount
- The speed the grass gets eaten down/grows
- How muddy/churned up the field is getting
- Advice from your veterinarian
- Advice form another equine professional
- Advice from friends/family
- Advice found online
- Other

42.a. If you selected Other, please specify:

43. When strip grazed, how many other horses are in the same strip as your horse?

My horse is strip grazed individually

1

2

3

4

5

6+

It varies

44. Is this the usual number of horses turned out with your horse when you are notstrip grazing? If not how is it different?

- Yes
- No
- My horse is always strip grazed

44.a. If you selected No, please describe:

45. Please briefly outline the general daily management routine of your horse duringa period that it is being strip grazed. . ...*(For example: stabled overnight, given a hard feed then turned out around 8am onto strip grazed field, ridden for approx. 2 hours in the day, brought into stable with hay around 6pm etc.)*

46. Have you ever had any problems with strip grazing?

47. Do you think there are any other potential issues that could occur with stripgrazing?

53. What times of year do you usually use a grazing muzzle on your horse? (selectall that apply)

- Spring
- Summer
- Autumn
- Winter
- It varies a lot depending on how much grass is available that year

54. When muzzled, how many other horses is your horse usually turned out with?

My horse is turned out individually

1

2

48. Do you ever use a grazing muzzle on your horse while also strip grazing? (please pick the option that best applies to you)

- Yes, my horse always wears a grazing muzzle whilst being strip grazed
- Yes, but just for the first day/few days after moving the strip
- Most of the time
- About half the time
- Sometimes
- Occasionally
- Only if the grass is growing especially quickly/there is more grass then usual

Never

49. Have you used a grazing muzzle and would be happy to answer some furtherquestions on this? *Required*

- Yes
- No

Grazing Muzzle

Please answer the questions in this section regarding one specific horse.

50. When restricting grazing how many days a week does your horse usually weara muzzle?

- Less than once a week
- 1-2 days a
- week 3-4 days
- a week
- 5-6 days a week

Every day

51. On a day your horse is wearing a muzzle, how long does it normally have it onfor?

- Less than 1 hour
- 1-3
- hours 4-
- 6 hours
- 7-9 hours
- 10-12 hours
- 13-18 hours

19-24 hours

52. Please briefly outline the general daily management routine of your horse duringa period that it is being muzzled. . ...*(For example: stabled overnight, given a hard feed then turned out around 8am wearing a muzzle, ridden for approx. 2 hours in the day, brought into stable with hay and muzzle removed around 6pm. Horse muzzled every other day, otherwise allowed to graze freely etc.)*

3

4

5

6+

It varies

55. Is this also the usual number of horses turned out with your horse when it is notmuzzled? If not how is it different?

- Yes
- No
- My horse is always turned out muzzled

55.a. If you selected No, please describe:

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56. If your horse is turned out with others, are any of them usually muzzled too?

- Yes
- No
- N/A

56.a. If you selected Yes, please specify how many:

57. If your horse is kept in the same social group, did you notice any differences inhow the horses interacted when one or more were muzzled?

- Yes
- No
- N/A

57.a. If you selected Yes, please briefly describe:

58. What style muzzle do you normally use on your horse? (select the option that ismost similar to the muzzle you use)

- Solid plastic bucket style with either one or a few small holes in the bottom through which the horse can eat
- Woven basket style sides and solid base with small hole in the centre through which the horse can eat
- Solid base has multiple slats/holes through which the horse can eat (Greenguard style)
- Full exclusion muzzle – horse cannot eat at all when wearing it
- Other

58.a. If you selected Other, please specify:

64. Do you think there are any other potential issues with grazing muzzles?

65. Has anyone ever advised you either for or against using a muzzle and if so, whowas it (e.g. a friend, your vet) and what were their reasons?

59. How did you introduce your horse to wearing the muzzle?

60. How did your horse react initially when turned out wearing the muzzle?

61. How long did it take for your horse to learn to eat through the muzzle?

- My horse was able to eat through the muzzle straight away
- Less than 1 hour
- Within 1 day/the first session it wore it
- After a few days/sessions of wearing it
- Within a week of wearing it
- Within 2 weeks of wearing it
- Within a month of wearing it
- My horse never learnt to eat through it
- I don't know

62. How long did it take for your horse to learn to drink through the muzzle?

- My horse was able to drink through the muzzle straight away
- Less than 1 hour
- Within 1 day/the first session it wore it
- After a few days/sessions of wearing it
- Within a week of wearing it
- Within 2 weeks of wearing it
- Within a month of wearing it
- My horse never learnt to drink through it
- I don't know

63. Have you ever found any problems with using a grazing muzzle?

Further Comments

66. If you have any further comments you would like to add please do so here:

Further Information

Thank you for taking the time to answer this questionnaire!

The links below provide information and advice on some of the areas covered by the questionnaire.

Laminitis - Redwings:
https://www.redwings.org.uk/sites/default/files/Laminitis-Leaflet.pdf

Grazing Muzzles - National Equine Welfare Council: http://www.newc.co.uk/advice/horse-and-donkey-care/grazing-muzzles-2/

Obesity - Blue Cross:
https://www.bluecross.org.uk/sites/default/files/downloads/H15_OBESITY.pdf

The next part of my project will be in the form of interviews, to explore people's views expressed in the questionnaire in more depth. If you are interested in being contacted about the possibility of being interviewed, please click on the link at the bottom of this page. This will take you to a separate survey where you can enter your email address.

Your email will **not be linked to your responses** to this survey and will be stored in accordance with university policy. It will **not be distributed** or used for any purpose other than to contact you about arranging an interview. If you change your mind you may contact me at any time to request your email address be deleted.

Contact: amelia.cameron@bristol.ac.uk

Link for email address submission: https://svs.onlinesurveys.ac.uk/collecting-email-addresses-for-interviews

Appendix B: List of Facebook pages and groups where the questionnaire was shared

Animal Health Trust

Bleakholt Animal Sanctuary

Blue Cross

Bransby Horses – Rescue and Welfare

Bristol Animal Behaviour and Welfare Alumni

Bristol Equestrian

Bristol horse riders

Bristol Horse Riders

British Horse Society

Cecil's Horse Sanctuary

Centaur Society

Donkey Sanctuary

Equine cushings disease support group for horse owners

Equine Referral Hospital Langford Vets University of Bristol

Eventing – UK

Everything Equine Bristol

Gloucestershire Horse Riders: Wanted/Selling

Greenguard Equine

Horse Haven UK

Horsecom

Horses & Tack for sale UK

HorseWorld

Laminitis chit chat

Laminitis: understanding, cure, prevention

Langford need a lift

Laris Farm

LAW Equestrian

Leahurst Equine Practice

New bristol and South West horse group

Redwings Horse Sanctuary

Richardson Equine Weight Loss and Laminitis Support Group

Seven Acre Horse Sanctuary

Surrey Horse & Pony (over 18's only)

Surrey Horses & Ponies (Administrated)

Talk About Laminitis

The Farm Animal Sanctuary

The Horse.com

The Laminitis Site

THE 'NEW' BRISTOL AND SOUTH WEST EQUESTRIAN SITE

Trickle Net

University of Bristol Polo Club

University of Bristol Riding Club

UWE and UOB Polo Lifts 2018-2019