CODE OF PRACTICE FOR THE CARE AND HANDLING OF EQUINES: REVIEW OF SCIENTIFIC RESEARCH ON PRIORITY ISSUES

July 2012

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Excerpt from Scientists' Committee Terms of Reference

Background

It is widely accepted that animal welfare codes, guidelines, standards or legislation should take advantage of the best available knowledge. This knowledge is often generated from the scientific literature, hence the term "science-based".

In re-establishing a Code of Practice development process, NFACC recognized the need for a more formal means of integrating scientific input into the Code of Practice process. A Scientists' Committee review of priority animal welfare issues for the species being addressed will provide valuable information to the Code Development Committee in developing or revising a Code of Practice. As the Scientists' Committee report is publicly available, the transparency and credibility of the Code process and the recommendations within are enhanced.

For each Code of Practice being developed or revised, NFACC will identify a Scientists' Committee. This committee will consist of 4-6 scientists familiar with research on the care and management of the animals under consideration. NFACC will request one or two nominations from each of 1) Canadian Veterinary Medical Association, 2) Canadian Society of Animal Science, and 3) Canadian Chapter of the International Society for Applied Ethology.

Purpose & Goals

The Scientists' Committee will develop a report synthesizing the results of research relating to key animal welfare issues, as identified by the Scientists' Committee and the Code Development Committee. The report will be used by the Code Development Committee in drafting a Code of Practice for the species in question.

The full Terms of Reference for the Scientists' Committee can be found within the NFACC Development Process for Codes of Practice for the Care and Handling of Farm Animals, available at www.nfacc.ca/scientists-committee.

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1. FACILITY DESIGN AND HOUSING

SHELTER AND SHADE

Conclusions:

1. **Horses are highly adaptable to many weather conditions; however, they benefit from from having access to a windbreak, shade or shelter especially during extremely hot or cold weather conditions, and particularly when it is windy.**
2. **Under particular weather conditions, horses will seek shelter or shade; therefore, having a shade/shelter/windbreak area that is large enough to accommodate all animals in a given turnout area is ideal.**

Horses can adapt to a wide range of environmental conditions, in part because they have the ability to adjust their behaviour to achieve more comfortable states during unfavorable conditions (Keiper & Berger, 1982). Domestic and feral horses, donkeys and zebras have been described to stand with their backs to natural windbreaks of vegetation or terrain. Similarly, they have been noted to stand or graze with their hindquarters oriented into the wind during heavy rain or wind (McDonnell, 2003).

All outdoor environments are suggested to provide shade and windbreak, in addition to providing for the other biological needs of horses (e.g. feed and water, exercise, ability to avoid direct contact with excreta). In temperate climates, horses may be kept in paddocks without shelter other than that provided by the natural landscape, wind fences, or sunshades (Federation of Animal Science Societies [FASS], 2010). However, in extremely hot, cold, or wet environments, shelter has been recommended (FASS, 2010). It is estimated that horses' thermoneutral zone[1] lies between the lower critical temperature of 5°C (41°F) and the upper critical temperature of 20°C to 30°C (68°F to 86°F) (Morgan, 1998).

Autio and Heiskanen (2005) observed the effect of weather conditions (temperature, humidity and wind speed) on the daily time budget and behaviour of foals. The foals spent 43% of the time in the sleeping hall (an insulated building with a deep-litter bed), 51% in the open paddock and 5% in the shelter (a two-sided, roofed shelter in front of the sleeping hall). In addition, the behaviour of the foals did not significantly change as the temperature dropped from 0 to -20˚C. The time spent in the sleeping hall did not significantly increase, nor did the time spent eating, resting or huddling. Based on the behaviour, the authors concluded that the cold weather did not negatively affect the horses' welfare.

In Przewalski's horses, it has been said that a windbreak is often sufficient shelter in bad weather. These wild horses have been seen out in pasture away from shelter with their tails to the wind in cold winter weather with heavy wind and snow. However, frail or injured individuals are likely to require shelter and additional heat. On extremely hot, sunny days, Przewalski's horses will often seek shade. In an open pasture setting, trees can provide natural shelter and may be sufficient for both summer and winter (LaRue, 1994).

[1] The term "thermoneutral zone" is defined in the section on Thermal Impacts on Nutritional and Energy Needs.

Heleski and Murtazashvili (2010) observed domestic horses housed outside and related their shelter-seeking behaviour with temperature, precipitation and wind speed. Shelter usage ranged from <10% to 62%. When wind speed was less than 2.2m/s, there was a significant effect of rain on shelter usage, meaning more horses used shelters under rainy, breezy conditions. When wind was more than 2.2m/s, there was a significant effect of snow on shelter usage, meaning more horses used shelters in snowy, breezy weather. Horses were often observed using shelters as wind breaks even though not all horses would actually go inside the sheds. Although overall shelter usage was generally low (<10%), the authors concluded that access to shelter is nevertheless important depending on weather conditions. Shelter use in hot, sunny conditions was low for the majority of the on-farm Arabian horses, but considerably higher for the on-farm draft horses. The authors were unsure whether this related more to the horses' inherent levels of heat tolerance or the fact that the draft horses had docked tails and therefore more challenges from insect harassment.

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FORAGING BEHAVIOUR

Conclusions:

1. **Foraging behaviour (e.g. eating hay, grazing pasture, browsing) forms the majority of the horse's daily time budget.**
2. **Reduced opportunities for foraging may be a source of stress.**
3. **Several studies have linked a reduced risk of stereotypic behaviour (e.g. cribbing or weaving) to increased opportunities to engage in foraging behaviour[2].**

In the wild, horses would spend 16 to 18 hours per day foraging a high fibre and low starch diet and they rarely fast voluntarily for more than 2 to 4 hours at a time (Harris, 2005). Budiansky (1997) cites horses as animals that have evolved to spend over half of their day grazing. Crowell-Davis et al. (1985) observed that lactating mares on pasture will spend about 70% of their daily time budget on feeding and their foals, about 41% to 53%, making feeding the biggest category in terms of time spent in an activity. It has been noted that temperature can play a role in the horse's foraging behaviour. Salter and Hudson (1978) studied feral horses in Alberta and noted that diurnal feeding decreased during the summer with a simultaneous increase of horses spending time under shady, sheltered areas. Likewise, in his study of Camargue horses, Duncan (1980) observed that mares spent more time foraging in the fall and winter as opposed to the spring and summer.

These studies support the hypothesis of Benhajali et al. (2009) that reduced opportunities for foraging in captivity may be a source of stress for domestic horses. In their study, where individually box-housed horses were turned out into a bare paddock for 6 hours per day, and given the chance to forage ad libitum on hay, the horses showed significantly different behaviours compared to the control group horses that were turned out but given no foraging opportunities. Horses that foraged on hay showed more positive social interactions (i.e., behaviours indicative of bonding) than the control group; conversely, social interactions in the control group were primarily agonistic. The experimental group also showed less time spent in locomotion and in alert standing, which Benhajali et al. (2009) take as a sign of lower levels of stress because limited grazing opportunity has been linked to increased activity (Hogan et al., 1988). Benhajali and colleagues argue that the increase of foraging behaviour led to a decrease in the level of agonistic behaviour mimicking that is found in pastured and free-ranging horses.

The recognition of potential advantages to horse welfare by allowing the expression of foraging has led to some research into foraging enrichment to stabled horses. Winskill et al. (1996) studied whether the use of a foraging device (a 'foodball') would have any effect on horses' overall time budget. When given access to the feeding device, they used it in a manner resembling normal foraging behaviour of about 14% of their overall time budget and its use was correlated with a decrease in ingesting concentrates, moving, standing, and nosing bedding. Similar to Benhajali et al.'s (2009) study, the change in daily time budget became more comparable to those of free-ranging horses, which Winskill and colleagues (1996) interpreted as an increase in animal welfare.

[2] Stereotypic behaviour is covered in more detail in the section on Stereotypic Behaviour.

Many competition horses experience restricted access to pasture and this restriction is believed to be linked to stereotypic and redirected behaviours. It has been suggested that the provision of more than one source of forage may decrease the expression of these undesirable behaviour patterns. Goodwin et al. (2002) set up an experiment where horses were given brief access into each of two identical stables, one containing a single forage and the other containing six forages. When given the single forage, horses looked over the stable door more often, moved more often, foraged on straw bedding more, and displayed behaviours indicative of searching for alternative resources more frequently than when given multiple forages. Interestingly, when the previously preferred forage type (from the multiple forage treatment) was given as a single forage, horses still looked over stable doors more frequently and foraged more in their straw bedding. Goodwin et al.'s (2002) study concluded that multiple forages reduce straw consumption and allow the expression of the highly motivated behaviour of foraging. Archer (1971, 1973) observed that when horses grazed on preferred species of herbs and grasses, they would regularly leave to graze on sites containing less preferred species. This was interpreted as horses' need for multiple forages. In a similar study, Thorne et al. (2005) offered horses both single and multiple forage diets and found that while on the multiple forage diet, horses performed foraging behaviour significantly more frequently and for longer than when they were given a single forage. Although horses demonstrated preferences for particular components in the multiple forage treatment, they sampled all forage components, consistent with Archer's (1971, 1973) findings. Thorne et al. (2005) suggest that a multiple forage diet acts as a means of environmental enrichment and is a practical method easily adoptable by horse owners by providing different types of hay or other roughage.

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TURNOUT, EXERCISE AND SOCIAL OPPORTUNITIES

Conclusions:

1. **Horses derive behavioural and physiological benefits from turnout time.**
2. **Several studies have shown that horses with minimal turnout time are at an increased risk for engaging in stereotypic behaviours.**
3. **Horses with increased turnout and social opportunities have shown themselves easier to train and handle.**
4. **Horses with turnout time have demonstrated greater bone density than those who are strictly stalled.**

In this section, “exercise” refers to physical activity that can include riding and does not necessarily mean the horse is outdoors. The term “turnout” involves free pasture time that may or may not involve exercise or human interferences. “Social opportunities” refer to occasions when horses can interact with other horses via auditory, visual and/or tactile means.

In a study to determine the influence of housing on the third metacarpal bone mass, Arabian weanlings were separated into pasture, stall and partial pasture groups (Bell et al., 2001). After measuring a multitude of variables including radiographs, serum and different body mass indexes, both the pasture and partial pasture weanlings had greater cannon bone circumference than stall weanlings. Bell et al. (2001) state that pasture rearing or 12 hour daily turnout is beneficial to maintaining and increasing bone mineral content, even though endurance training and intense exercise have sometimes yielded equivocal results regarding increases in bone strength and density (Hiney et al., 2004; Spooner et al., 2008).

Chaya et al. (2006) examined the influence of time spent in turnout on the behaviour of horses that are maintained in stalls then given either 2 or 12 hours of turnout per week. The 2-hour group was more likely than the 12-hour group to trot, canter, and buck, and they also grazed less. The authors maintain that their results of increased activity when out of confinement have welfare implications as Houpt et al. (2001) consider higher levels of trotting and galloping to be compensatory locomotor activity in response to exercise deprivation.

Similarly, when Rivera et al. (2002) kept horses either on pasture or in individual stalls then subjected them to training procedures, they found that training time for stalled horses was significantly greater than for the pastured horses. Stalled horses also more frequently performed unwanted behaviours like bucking and jumping. While physiological data like heart rate and cortisol did not differ between the two groups, behavioural data suggests that pasture-kept horses more readily adapt to training procedures than stalled horses. These results were supported when Søndergaard and Ladewig (2004) obtained almost identical outcomes when they studied group housing effects on horse behaviour during training. They found that group housed horses learned training tasks more efficiently than their stalled counterparts, and that stalled horses bit and kicked trainers more frequently than the socially housed group. Generally, stalled horses without turnout display more restless behaviour (Werhahn et al. 2011). Søndergaard and Ladewig (2004) believe that the social environment teaches horses how to react to other individuals so when it comes time for training, it is easier for horses to understand signals from the trainer.

Jorgensen and Boe (2007) examined the effect of exercise allowance (by use of circular walker) in combination with paddock size. During the non-exercise period, horses walked more and travelled longer distances, explored more and stood more alert compared to the exercise period. As far as paddock size was concerned, horses spent less time standing passively and were more active in the large compared to the small and medium paddocks. The increase in activity was due to horses eating more grass from under the fence. The authors point out that even though their results showed that forced exercise was able to reduce the motivation for activity, it does not imply that horses do not have the need for free exercise (i.e. turnout into paddocks and pasture). This idea was supported in Freire et al.'s (2009) study of restricting horses' opportunities to exercise often resulted in intense post-confinement locomotory behaviour (termed 'rebound') when released into a large enclosure. In addition to the control treatment, where horses received no exercise, the researchers examined rebound and unwanted behaviours following four different exercise regimes, which included being walked by a walker, a treadmill, a rider or being turned-out. Results showed that regardless of exercise type, the intensity of locomotor behaviours in the turn out sessions following forced exercise was reduced. However, despite the fact that horses took the fewest number of steps during the turnout treatment compared to the other three, turn-out was most effective at reducing the amount of cantering, bucks and rolling when released into arena for measurement of rebound effects. In general, all exercise treatments also reduced the amount of undesirable behaviours and handler commands during handling and routine weighing procedures, which, in Freire et al.'s (2009) view, reduces reactivity and improves obedience.

In a study of housing type on horse behaviour (Heleski et al., 2002), foals were either weaned in box stalls or in groups in a paddock. Paddock-housed weanlings showed a time budget similar to feral horses, where they spent more time moving, grazing and less time lying down as well as choosing to be near conspecifics. Stalled weanlings on the other hand, spent more time performing aberrant behaviours such as licking, chewing and kicking at stall walls and also pawing and bucking. Although the authors concluded that the paddock-reared group-housed horses had better welfare, they acknowledged that there was insufficient evidence to conclude that the stalled horses had poor welfare.

In a multi-part preference study comparing motivation to access exercise, companionship or food when made to work for each commodity at increasing costs, Lee et al. (2011) found that horses in stalls chose to be released into a paddock alone, but chose to return to their stalls rather than engage in a 20-minute forced treadmill exercise. To see how long horses prefer to stay in a paddock, they were re-tested every 15 minutes until they chose to return to their stalls. They chose to stay out on average 17± 2 minutes if alone; however, chose to stay out longer, 35± 6 minutes, if other horses were in the paddock. Interestingly, if horses were deprived of stall release for 48 hours, they chose to stay in the paddock with other horses 54±6 minutes, but showed no compensatory time preference if released into the paddock alone. Lee et al. (2011) conclude that horses are not motivated to exercise alone, do not choose forced exercise on a treadmill and that the social context of voluntary exercise is an important factor.

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VENTILATION, BEDDING AND BOX SIZE

Conclusions:

1. **Respiratory problems can be created or exacerbated by poor bedding practices and poor air quality in stables.**
2. **Ideally, stalls should be cleaned and bedding refreshed when horses are turned out as this is when the most particulate matter is in the air.**
3. **Different types of bedding have different advantages and disadvantages depending on horse comfort, absorption abilities, breakdown properties, etc.**
4. **While there is limited research on stall size, North American recommendations state that box stalls should accommodate behaviours like lying down, standing up, rolling and turning around suggesting 3.7 by 3.7m or 1.8m^2 /100 kg body weight. The recommended dimensions for a tie or straight stall including the manger is 1.5 by 2.7m or 0.82m^2/100 kg body weight. Ideal dimensions likely also depend on the amount of turnout/exercise the horse has available. Until more research is available, providing as much turnout area as circumstances allow is advisable.**
5. **Based on findings in horses and other species, an ammonia concentration of 20-25ppm is considered high, and, at this concentration, acts as an irritant**.

Recurrent airway obstruction (RAO) is provoked in horses by breathing in dust and fungal spores in the stable air. This causes an allergic response and irritates the lower respiratory tract (Webster et al., 1987). Since air quality influences horses' respiratory health there is much interest in stable ventilation. In a mathematical study to understand the interactive effects of stable design, natural ventilation, management and bedding materials, Webster et al. (1987) found that when release rates (the rate at which dust particles are released into the air) of fungal spores are low, ventilation rates over 4 air-changes/hour are satisfactory (as anything above 4 air-changes/hour had no appreciable effect on concentration of respirable dust). The authors found that ventilation was generally satisfactory for individual boxes but unsatisfactory in barns. In addition, they found that stables with clean, well-managed bedding showed only minute differences between straw, wood shavings and paper and also that hay tended to be the major contributor of respirable spores. When horses stand still in the stable with no access to hay, the concentration of dust was low; however, bedding was disturbed during 'bedding down' and dust increased significantly, about 3 to 6-fold. Most importantly, Webster et al. (1987) explained a chief principle that there is a curvilinear relationship between concentration of respirable dust and ventilation rate in that at low ventilation rates, the concentration ('dirtiness') drastically increases.

In a study where high (27 air-changes/hour) and low (5 air-changes/hour) ventilation rates were combined with paper or straw bedding, it was found that the number of airborne particles generated during stall mucking was higher with the straw bedding type regardless of the ventilation rate. However, particles were more easily cleared at the higher ventilation rate. Also, regardless of bedding type, the low air change treatment generated significantly higher ammonia levels than that of the high air-change treatment (Curtis et al., 1996). Clarke et al. (1987) investigated the relationship between air hygiene within two identically managed housing types and the occurrence of respiratory disease by comparing well-ventilated boxes under still air conditions with well-insulated, poorly ventilated boxes. In the well-insulated boxes, there was significant fungal and actinomycete contamination of wood shavings compared to the well-ventilated treatment. Consequently, there was a higher frequency and severity of mucopus in the tracheas of horses kept in the contaminated housing condition.

It seems that stabling in general can expose horses to high levels of organic dusts containing harmful moulds. Holcombe et al. (2001) took horses that had been pastured since birth and divided them into a group that was stabled for 3 months and another group left at pasture. Groups were then switched over for another 3 months during which time a battery of physiological tests were performed. Their upper airway inflammation score decreased during horses' time at pasture and stabling was associated with significantly higher neutrophil count in bronchoalveolar lavage fluid and lower percentage of lymphocytes. The study concluded that stabling is associated with inflammation of both upper and lower airways of the young horses. However, Buechner-Maxwell et al. (1996) carried out a similar study investigating the relationship between airway inflammation and housing and failed to find comparable results. Horses in this study were housed on pasture for 1 month, moved to a barn for 1 month and finally returned back to the pasture for 2 months. At the end of each phase, endoscopic, cytological and histological measurements were evaluated for indications of respiratory disease. Yet, there was no evidence of significant changes in any of the measured parameters, indicating that housing horses in a barn for 4 weeks does not cause tracheobronchial mucosal inflammation.

In addition to housing environment, studies have shown that the type of bedding plays a major role in the overall air quality in the stable. Fleming et al. (2008a) analyzed wheat straw, dry wood shavings, hemp shives, linen shives, wheat straw pellets and paper cuttings for airborne particle concentrations as well as particle fractions. In the laboratory portion of the experiment, hemp and linen yielded the highest generation of airborne particles at all fractions. However, with the in-barn experiment, the mean particle generation of straw pellets averaged $111.2 \pm 149.2 \mu g/m^3$ which was significantly lower than that of wheat straw, which generated $227.5 \pm 280.8 \mu g/m^3$. Wood shavings fell in between at $140.9 \pm 141.9 \mu g/m^3$, which was also significantly lower than generation by wheat straw. Straw pellets were suggested as suitable bedding for horse stables as a means to improve air quality. The same research group delved into another bedding material study, but this time concentrated specifically on air quality with respect to ammonia formation as ammonia is a noxious gas present in stable air and can damage horses' respiratory tracts (Fleming et al., 2008b). In this study, the same bedding materials were used as before, but, this time, materials were placed into containers and a horse manure/urine mixture was added daily to each container for 14 days. Ammonia, carbon dioxide, nitrous oxide, and water vapor were measured continuously above the bedding inside the containers. Mean gaseous ammonia was $178.0 mg/m^3$ for wheat straw, whereas the lowest level of $60.3 mg/m^3$ was generated by the straw pellets. The other 4 bedding materials registered levels that fell in between these numbers. Ammonia at concentrations of 20-25 mg/m^3 is considered high (Von Borell et al., 2007) and acts as an irritant on the epithelium and mucosa of the airways (Fleming et al., 2008b). Results from the authors' ammonia study yielded similar conclusions as their previous study in that straw pellets can improve air quality in its ammonia binding ability. In addition, compared with the other bedding types, straw pellets had the highest water-binding capacity. However, it did show an increased level of carbon dioxide, water vapour values, and high substrate temperature compared to the other materials, giving straw pellets a favourable environment in which to grow pathologic germs. However, a recent comparable gas emissions study found conflicting results showing that straw emitted the highest concentration of ammonia and wood shavings emitted the lowest (Garlipp et al., 2011).

Aside from potential effects of bedding on the respiratory health of horses, the presence and type of bedding also affects the animals' behaviour. In a preference study, it was found that horses preferred to lie down in areas that offered bedding material compared to areas without bedding (Hunter & Houpt, 1989). However, some studies have failed to show any significant preferences in bedding type (Hunter & Houpt, 1989; Thompson, 1995). Werhahn et al. (2010) noted that when given a choice between different bedding materials, horses showed a higher frequency and longer duration of interaction with straw bedding compared to wood shavings and straw pellets. Time spent lying was also longer on straw than on straw pellets. Mills et al. (2000) found a similar preference for straw over wood shavings. Straw pellets also yielded the least amount of recumbency time. Pedersen et al. (2004) investigated the influence of bedding on the time horses spent in recumbency as a recumbent position plays a crucial role in achieving paradoxical sleep. Results from their study showed that horses would lie in a lateral recumbent position 3 times longer than on shavings. However, time spent in sternal recumbency did not differ. Because lateral recumbency is the preferable position in which to achieve paradoxical sleep, the researchers suggested that the type of bedding material could affect the horses' well-being and performance. Though it is commonly believed that horses *need* bedding, especially if bedded upon hard surfaces, such as cement, we were unable to find scientific references to back this up. Anecdotally, horses in stalls with insufficient bedding will develop lesions from friction between their hide and the surface and show fatigue behaviours likely due to insufficient lying down time.

Recumbent behaviour can also be affected by the space allowance of their enclosure. One study found that the dimensions of a loose housing system influence recumbency behaviour (Zeitler-Feicht & Prantner, 2000). When given a small recumbence area, it significantly reduced resting time. However, it was noted that time spent recumbent was dependent on animals' social rank; horses with lower rank spent shorter periods of time in recumbency than horses with higher rank. It was proposed that dimension of an area is therefore not the only parameter in determining recumbency. Nonetheless, Pedersen et al. (2004) noted that horses showed rolling behaviour before getting up in their enclosure. It was hypothesized by the authors that this behaviour was indicative of horses having difficulty getting up due to too little space in the box stalls.

European recommendations of box area are generally twice the height of the horse (at the withers) squared by 1.5 times the height of the horse (Raabymagle & Ladewig, 2006). North American recommendations state that box stalls should accommodate behaviours like lying down, standing up, rolling and turning around suggesting 3.7 x 3.7m or 1.8m^2 /100 kg body weight. The recommended dimensions for a tie or straight stall including the manger is 1.5 x 3.7m or 0.82m^2/100kg body weight (Federation of Animal Science Societies [FASS], 2010). However, Raabymagle and Ladewig (2006) noted that recommendations on housing dimensions have largely been based on practical experience rather than objective understanding of horse behaviour and therefore studied lying behaviour in relation to box size. Results found that horses spent more time in sternal recumbency when kept in large (2.5 x horse height)m^2 versus small (1.5 x horse height)m^2 boxes. Interestingly, when first kept in large boxes then moved to smaller boxes, horses showed a 3-fold increase in post-recumbency rolling behaviour in the smaller boxes. However when moved from smaller to larger boxes, horses showed no difference in the performance of post-recumbency rolling. Raabymagle and Ladewig (2006) hypothesized that horses that were not accustomed to smaller box areas, have a greater chance of lying near walls or corners, which necessitates post recumbency rolling behaviour.

Other general information related to temperature, humidity and ventilation is reviewed in the Husbandry, Housing and Biosecurity chapter of the 2010 *FASS Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching*. However, none of the reviewed studies specifically pertain to horses.

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STEREOTYPIC BEHAVIOUR

Conclusions:

1. **Stereotypic behaviours (previously referred to as stable vices) include such behaviours as cribbing and weaving. They are considered apparently functionless, repetitive and invariant behaviours. Newer research suggests that they may serve as a coping mechanism.**

2. **Factors linked with an increased risk of stereotypic behaviour are: insufficient forage, lack of social opportunities/isolation and lack of sufficient turnout time.**

3. **Horses that have already developed stereotypic behaviour will be difficult or impossible to keep from performing the behaviour. This does not necessarily indicate their current welfare status is poor.**

4. **Artificial remedies to prevent stereotypies *may* cause more harm as horses will experience higher levels of frustration, rebound activity or redirected activity. Research in this area is still limited.**

Stabled horses sometimes show abnormal behavioural patterns not seen in wild or free-ranging horses. Abnormal behaviours that are apparently functionless, repetitive and invariant in form are termed 'stereotypies' (Cooper & Mason, 1998) and in horses are often referred to as 'stable vices (Nicol, 1999a). Common examples of equine stereotypies are weaving, cribbing/wind-sucking and box-walking. These behaviours affect approximately 10 to 40% of stabled horses (Nicol, 1999b). In McGreevy and colleagues' (1995) survey of management factors associated with stereotypic behaviour, they defined several of these behaviours. Weaving was described as lateral swaying of the head, neck and forequarters and sometimes the hindquarters. Cribbing/wind-sucking happens when the horse grasps a fixed object with its incisor teeth and engulfs air with an audible grunt. Box-walking is a circular or patterned route tracing inside the stable. Wood-chewing, although not usually classified as a true stereotypy, is a variable abnormal behaviour and can precede the development of oral stereotypies like cribbing. It involves stripping and apparently ingesting wooden surfaces in the stable (Krzak et al., 1991).

Stables differ from a free-ranging environment with respect to nutrition, space, social environment, and environmental substrate. These factors may individually or in combination contribute to the development of stereotypic behaviours (Cooper & McGreevy, 2002). There are many reasons associated with these factors which researchers have proposed as the root cause of specific stereotypies. It is often claimed that boredom is a cause of stereotypies (Kiley-Worthington, 1987). It is hypothesized that in the absence of environmental challenges faced by their wild counterparts in free-range conditions, stabled horses develop stereotypies to compensate for low environmental stimulation. However, there is little scientific evidence to support the boredom hypothesis. As Nicol (1999a) explains, it is not known whether horses have the capacity to feel bored. Also, 'boredom' suggests to horse owners that any attempt to increase sensory stimulation is beneficial, whether that means playing the radio or offering horses toys. However, the majority of stereotypic behaviour tends not to occur during quiet times of day but rather during times of high stimulation, such as right before feeding (Henderson & Waran, 2001). Another explanation of stereotypy is that of 'behavioural frustration', where a highly motivated activity is inhibited or cannot be adequately expressed. These include the prevention of exercise, diet and forage restriction, limitation on social environment and predator avoidance activities (Cooper & McGreevy, 2002).

Many researchers have implicated the feeding of concentrates as a major contributor of stereotypies. Although diets are formulated to meet horses' nutritional needs, they do not meet their behavioural need to forage. Stable rations are eaten quickly and are typically low in dietary fibre. Providing less concentrated feed or more fibrous forages may reduce the intensity of oral stereotypies (Cooper & McGreevy, 2002). McGreevy et al. (1995) stated that low forage is a risk factor for stereotypies. Marsden (1993) found that offering soaked hay reduced post-feeding oral stereotypies and Henderson and Waran (2001) noted a decrease in stereotypic behaviour when horses were given their feed from the Equiball™, a foraging device. Johnson et al. (1998) observed that horses fed a predominantly concentrate diet showed an increase in wood-chewing compared to those given 8 kg hay/day and believed the behaviour was correlated to lactic acid production in the hindgut and high hindgut pH.

Another factor associated with the performance of stereotypies is that of the social environment. McGreevy et al. (1995) noted that stereotypies were less common in horses kept in large yards in large groups where they had visual contact with other horses. Allowing visual and tactile contact between neighbouring horses (through the grill separating stables) has been associated with a reduction in weaving when compared to horses in conventional, solid-sided stables (Cooper et al., 2000). In a study to reduce transportation stress, Kay and Hall (2009) noted that travelling with a live companion or with a mirror visible to the horse reduced the amount of vocalizing, head-turning, head-tossing and increased the amount of eating, compared to travelling alone. The study showed that isolation is stressful in horses. A Swiss survey found a 2.5-fold higher incidence of stereotypic behaviour in horses that were singly housed with no visual or tactile contact to other horses, versus horses that were group housed (Bachmann & Stauffacher, 1998 cited in Cooper & Mason, 1998).

It has also been found that factors associated with weaning are linked to the development of stereotypic and redirected behaviours. In a 4-year study on weaning practices, it was found that foals of low- or middle-ranking mares were less likely to develop abnormal behaviour than foals of dominant mares (Waters et al., 2002). Weaning in a stable or barn was associated with an increased development of abnormal behaviour compared to paddock-weaning. Also, housing in barns rather than in paddocks post-weaning was associated with an even further increase. Cribbing, weaving, box-walking and wood-chewing all developed between 20 and 64 weeks of age. The study also found that post-weaning feeding of concentrates increased the development of cribbing by 4 times. Waters et al. (2002) explain that there might be a relationship between gut acidity and oral activity like cribbing, in that oral activity may increase salivary flow thereby reducing gastric acidity associated with concentrate feeding. With respect to foal behaviour and social status of mares, the authors theorize that there may be an influence of mare behaviour towards foals prior to weaning, genetic factors, or factors associated with the mare-foal bond and/or effects of the separation at weaning.

There is limited information concerning genetic factors that may predispose horses to the development of stereotypical behaviours. Kiley-Worthington (1983) states that "All behavior is the result of both genetics and environment" and warns against trying to completely separate the two. Having said this, the following information concerning potential genetic influences on the development of stereotypies could be found:

Horses as opposed to other equids may be predisposed; however, this impression may be influenced by the usually different environmental and management conditions applied to horses as compared to ponies, donkeys etc.. Wickens and Heleski (2010) state that there are very limited if any reports of cribbing in donkeys, which may be attributable to inherent temperament differences or differences in management of these animals. The inherent ability of equids to develop stereotypies, however, may be illustrated by references to cribbing, wood chewing and coprophagy (the latter probably not being a true stereotypy) in Przewalski horses, probably in relationship to maintenance in enclosures rather than pasture situations (Boyd, 1986 & 1991).

Breed predisposition is cited by several authors: Albright et al. (2009) reported that Thoroughbreds in the U.S. were more likely to display cribbing behaviour than Quarter Horses and Arabians. Thoroughbreds were also found to be at higher risk for cribbing and weaving in previous studies (Luescher et al., 1998; Redbo et al., 1998). Thoroughbreds as well as Warmbloods were reported to be at greater risk of exhibiting stereotypies in a Swiss study (Bachmann et al., 2003) while Arabians and Warmbloods were reported to be more affected by stall walking and stall kicking, respectively (Luescher et al.,1998). Most authors mention the difficulty in differentiating the effects of breed itself versus management conditions of sport horse breeds (i.e., a higher likelihood of those breeds being kept under predisposing conditions) as well as, potentially, the impact of a more nervous temperament of certain breeds such as the Thoroughbred.

Familial predisposition has also been reported although inheritance patterns are poorly understood. Vecchiotti and Galanti (1986) showed increased performance of cribbing, weaving or stall-walking in certain Thoroughbred families in Italy and suggested involvement of a genetic component. Hosoda suggested a recessive mode of inheritance for traits associated with windsucking in Thoroughbreds (Hosoda, 1950) while Steele suggested interaction between genetic and environmental factors based on a study of Kentucky horses (Steele, 1960).

There have been many attempts to stop stereotypic behaviour, including pharmaceuticals, surgery and hardware devices. Specific examples include excision of neck muscles or the application of cribbing-collars for the control of cribbing. McGreevy and Nicol (1998) found that removing a favoured cribbing surface increased plasma cortisol levels significantly (suggesting a physiological response to frustration), but this rise in cortisol was not seen if horses were provided hay. Cooper and McGreevy (2002) warn against the dangers of physically preventing stereotypies as it only rids the behavioural symptoms, but does nothing to address the underlying cause. In fact, they argue that prevention of the behaviour may serve only to increase the internal motivation to express the behaviour and will show post-inhibitory rebound when possible to perform the behaviour again. In addition, horses may perform more than one type of stereotypy and elimination of one type may encourage the emergence or performance of another. For example, cribbers prevented from grasping may begin to wind-suck or perform cribbing on their own limbs. Lastly, prevention of stereotypies could lead to distress if the performance of the activity is a coping response to the causal factor. There is evidence that preventing specific stereotypies can cause physiological stress responses like elevated levels of corticosteroids and heart rate, which can be detrimental to the horses' welfare. Cooper and McGreevy (2002) instead propose focusing on resolving the underlying problems. They have suggested management practices like sympathetic weaning (e.g. group weaning), environmental enrichment and dietary management, for example, feeding less concentrate and more hay or haylage. Another example would be to use a feeding device that delivers small amount of feed at a time while the horse has to “play” with the device to obtain the feed.

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2. HEALTH AND WELFARE

PAINFUL PRACTICES

Conclusions:

1. **All methods of permanent identification cause some degree of pain to horses. There is some evidence that freeze-branding is less painful than hot-iron branding.**

2. **Tradition, cosmetic reasons and perceived safety benefits have brought about equine tail modifications, including tail-docking, -blocking and -nicking. Tail-docking has limited rationale for its usefulness, and, in general, there is no scientific evidence to justify that any of these practices are in the horse's best interest. Wrapping or braiding tails are an alternative to docking, but are time consuming and the tail does not stay safely in place if the wrapping or braiding is not performed correctly.**

3. **There is little to no scientific evidence that the use of firing is beneficial in treating lameness in horses. If a veterinarian determines that firing treatment is warranted, freeze-firing appears more welfare appropriate than hot-firing.**

4. **Castration is a painful procedure. In horses, it is generally considered a veterinary procedure and appropriate pain management is provided.**

5. **More research on painful practices and pain control are needed.**

Branding: There are many different methods of marking horses for identification, and both hot-iron and freeze-branding are among the most widely used methods. Hot-iron branding involves the use of an iron that burns the skin and creates a permanent mark on which no hair will grow. Freeze-branding is intended to cause depigmentation of the skin and hairs, but can cause hair loss (Anonymous, 1994) swelling or even scarring of the skin upon prolonged contact with the cold (below freezing) instrument (Östblom, 1970). Therefore, there have been concerns regarding the level and duration of pain these procedures may cause.

Recently, the Scottish Parliament banned the use of hot-iron branding of horses and ponies in Scotland (Veterinary Record, 2010). In part, this is due to the availability of microchip transponders. In an evaluation of pain and inflammation associated with hot-iron branding and microchip transponder injection in horses, Lindegaard et al. (2009) found that hot-iron branding caused significantly stronger behavioural responses indicative of pain than did injection with the microchip transponder. Skin was also more sensitive to touch, had a higher temperature and swelling after hot-iron branding. However, neither treatment induced increased levels of serum cortisol. It was concluded that because microchip transponder injection caused no long-term problems, and showed fewer signs of pain and inflammation than did the hot-iron brand method, hot-iron branding caused more pain. These results were in agreement with Pollmann's (1998) study of transponder tagging compared to heat-branding, where he found no long term repercussions on foal welfare with either method, but during the process, hot-iron branding caused more pain than tagging.

In their comparison of hot-iron branding and microchip tagging in foals, Erber et al. (2012) found that both methods caused an increase in heart rate and heart rate variability. Both techniques also caused an increase in cortisol; however, the salivary cortisol response 1 hour after treatment was significantly greater in foals that were hot-iron branded than in those implanted with a microchip. While there was no pathological response in the site of microchip implantation, a necrotizing skin burn was observed at the site of the branding and this persisted for at least 7 days. Further, hot-iron branding, but not microchipping, caused an open wound, exudation, and an increase in skin temperature.

Östblom's (1970) study of freeze-branding concluded that this method was not likely to cause pain as horses did not show signs of pain upon contact with the cold instrument and the procedure resulted in very little tissue damage. The slight swelling that results shortly after the freezing limits itself to the area of contact and disappears within a few hours. Although Östblom does caution that longer freezing results in wounds, scarring and the permanent loss of hair, similar to hot-iron branding. Although Östblom (1970) did not make recommendations on what amount of time would yield a safe or damaging freeze brand, it was suggested that 30 seconds with CO_2 ice and 17 to 20 seconds with liquid nitrogen were sufficient to produce a clear, permanent brand.

Extensive work in beef cattle evaluating behavioural and physiological indicators of pain compared hot-iron branding, freeze-branding, and sham-branding (Schwartzkopf-Genswein et al., 1998). This study examined the amount and intensity of head movements, exertion force and behaviours believed to indicate pain, including tail-flicking, kicking, falling and vocalizations. Sham branded steers were caught in the headgate and held in the squeeze chute for approximately the same duration required to complete a brand, and a brand at ambient temperature was applied. These authors found that hot-iron branding elicited greater indicators of discomfort than freeze-branding, and freeze branding elicited greater indicators of discomfort than sham-branding.

As an alternative to traditional freeze-branding, Householder et al. (1993) developed a freeze-branding technique that involves spraying coolant (chlorodiflouromethane, dimethyl ether) from an aerosol can through a stencil placed on to the horse. Although the researchers investigated different variations of using this technique on brand clarity (e.g. whether or not the area to be branded was pre-treated with alcohol, the number of spray applications, the length of spray bursts, drying methods between spray applications etc.), they did not have a control group where horses were not freeze branded at all. Nonetheless, results showed that horses showed no behavioural indications of pain while subjected to the coolant spray method of freeze-branding.

Tail alterations: The following three types of tail alterations are discussed in this review: tail-docking, tail-nicking and tail-blocking. Tail-docking is a surgical procedure where the horse's tailbone is cut, leaving it significantly shorter. A normal tailbone has between 15 to 21 vertebrae and is approximately 1 foot in length. Docking removes a majority of these vertebrae, leaving only a few inches (reviewed in Tozzini, 2003). Docking horses' tails is a traditional practice that was originally done to prevent the tails of draft horses from interfering with the harness equipment and machinery. In addition, owners appreciated the fact that shortened tails stayed cleaner.

In a Belgian review of tail-docking in horses, the biological, ethical and socio-economic aspects of this procedure were evaluated (Lefebvre et al., 2007). With respect to horses' ability to cope with insect harassment, hygiene, and communication with conspecifics, the authors conclude that there is no benefit for horses in tail-docking. Wrapping or braiding tails are an alternative to docking, but are more time consuming and the tail does not stay safely in place if the wrapping or braiding is not performed correctly (Tozzini, 2003).

The level of pain due to the process of tail amputation, either with or without anesthesia has not been studied in horses. However, studies on other mammalian species (e.g. dogs, sheep, cattle and pigs) show that this operation is painful, especially when carried out without anesthesia (reviewed in Lefebvre et al., 2007). Tail docking of horses has been questioned on ethical and welfare grounds, and has been legislated against in many parts of the world. Almost a dozen American jurisdictions specifically prohibit cosmetic tail alterations as do many European countries and Australian states (Tozzini, 2003). In Canada, tail-docking for cosmetic reasons is considered unacceptable by the Canadian Veterinary Medical Association (CVMA) (2007) and the *Recommended Code of Practice for the Care and Handling of Farm Animals - Horses* (Canadian Agri-Food Research Council [CARC], 1998). However, this position is not legally enforced (Alberta Farm Animal Care [AFAC], 2003).

Tail-nicking is the procedure whereby the horse’s tail tendons are cut resulting in an artificially high tail carriage. Certain breeds are more likely to undergo this procedure for show purposes. There is currently a lack of scientific studies on tail-nicking in horses. However, like tail-docking, some American jurisdictions also ban tail-nicking. Ireland, Great Britain and some Australian states also prohibit tail nicking (Tozzini, 2003). Although there is no explicit legislation with regards to this procedure in Canada, the Canadian Veterinary Medical Association is “opposed to the surgical alteration of the tail of the horse for cosmetic or competitive purposes. This includes, but is not limited to, docking, nicking and blocking. These procedures do not contribute to the health of the horse and are used primarily for gain in the show ring (nicking, blocking and docking) or because of historical custom (docking)" (CVMA, 2007).

Lastly, tail-blocking is another form of tail alteration whereby the major nerves of the tail are injected with alcohol, affecting the horse’s ability to lift, swish or control its tail. Tail-blocking is more difficult to detect as the tail does not display any obvious physical evidence of alteration as do surgical procedures like nicking (e.g. scarring) or docking. Blocking has been said to be done almost exclusively in Western riding horses, where it is desirable to display a flat tail with minimal movements laterally. Although the effect of the injection is not usually permanent, this non-surgical procedure is not without risks. There have been cases of horses that develop ataxia or hardened/crooked/kinked tails post-procedure. In some cases, nerve damage may result, leaving the animal with only partial use of its tail (Tozzini, 2003). Again, like tail docking and nicking, there is a lack of scientific work from which to draw conclusions about its effects on animal welfare. However, unlike tail docking and tail nicking, tail blocking is not specifically prohibited in some countries. Nonetheless, the American Quarter Horse Association (AQHA) and the American Paint Horse Association (APHA) have banned the procedure. The AQHA policy statement reports that “the Executive Committee has taken action - including investigation, prosecution, suspension of privileges and/or fines being levied - on all cases where substantial evidence existed of violations of AQHA’s drug and tail alteration rules. Since 1980, 350 people have been fined, suspended or placed on probation for violations of AQHA’s drug and tail alteration rules” (AQHA, 2012). Moreover, several veterinary associations are opposed to this alteration (Tozzini, 2003).

Pin Firing: Pin firing or thermocautery is a procedure whereby a hot iron is used to burn or destroy the injured tissue surrounding damaged flexor tendons on a horse's legs distal to carpi and tarsi. This is thought to stimulate local inflammation supporting tendon repair, thereby helping the healing process. In 1987, Britain's Royal College of Veterinary Surgeons took the position that the practice of firing of tendon ought to be discontinued. Over the next several years, a vigorous exchange of arguments took place. Whereas, some supported the ruling declaring the practice to be inhumane and lacking scientific proof of its effectiveness (Borthwick, 1983; Taylor; 1983) some strongly opposed the ruling (Chandler, 1991) and some believed the practice must have benefits otherwise it would not have been in use for so long by so many (Prole, 1991).

The scientific literature regarding the practice of firing is scarce; however, there was one 5-year study by Silver et al. (1983) that not only explored the clinical use, but also experimental manipulation of several treatments (including firing) on horse leg injuries. For the clinical portion, a survey inquiring about types of injuries and treatments was collected from veterinary surgeons, trainers and owners. The survey revealed that there was no evidence that firing increased healing efficacy and that it caused severe distress to the horses during the first 24 to 36 hours but then subsided thereafter. During the experimental portion of the study, a lesion resembling that of clinical tendonitis was produced in ponies by injecting collagenase into horses' tendons. Ponies were then treated with either nothing/rest, tendon splitting or firing. Results showed that the control group given nothing but rest showed almost complete recovery whereas the line fired group had more variable response and showed no improved performance compared to the control group. It was concluded that firing does not improve tendon healing and any effect that does take place tends to be deleterious. It was found that 'fired' skin caused initial acute inflammation and swelling then produced local areas where the skin was thinner and weaker than the original normal skin. Although this study explored line firing, it was hypothesized that by extrapolation, pin firing would have similar effects (Silver et al., 1983).

However, when studying the effects of cryosurgery (or 'freeze-firing'), McKibbin and Paraschak (1985) found different results. When horses with bone spavin, splint and fractured splint bone injuries were treated with cryosurgery they found that horses with each type of injury all raced with similar or faster times compared to their pretreatment form. The authors argue that the low temperatures achieved by using liquid nitrogen destroy C nerve fibers responsible for chronic pain, and neuromas do not form after cryosurgery. The researchers also found that during the procedure horses generally did not show signs of discomfort such as kicking.

Because the science is not completely clear, it is difficult to offer scientific explanations to the cases where horses seem to benefit from firing. However, Sweeney (1991) contends that when horses seem to heal after firing procedures, it is only because the practice enforces a necessary rest and it is the period of rest (rather than the procedure itself) that is the factor responsible for the ultimate healing. Clearly, like many painful practices, this particular veterinary practice of firing requires more scientific study.

Castration: Studies in lambs (Molony et al., 1997), calves (Molony et al., 1995**),** and piglets (Hay et al., 2003) have shown that these mammalian species feel pain and discomfort both acutely and chronically after undergoing castration. While the research in horses is relatively limited, studies show that the procedure causes pain and swelling that persist for several days

(Love et al., 2009; Maaβen & Gerhards, 2009). There is little scientific information regarding the effects of castration on pain levels in horses, but it is reasonable to extrapolate that castration is similarly painful in horses. In some species, castration can be carried out using various techniques from rubber rings to clamp devices. In most farm animal species, the animals do not typically receive anesthesia or analgesia for the procedure. In horses, castration is generally performed by a veterinarian using the surgical method and pain control is provided.

Castration performed by veterinarians has been reported to have a complication rate of more than 20%, ranging from mild swelling to evisceration, a condition which is potentially fatal (Moll et al., 1995; Shoemaker et al., 2004). Indeed, the Canadian Veterinary Medical Association states "Castration of horses, donkeys and mules is an elective procedure involving significant risk to the animal…[t]his surgery is often performed for the benefit of the owner and to facilitate management of the animal. Elective surgeries on animals for human benefit carry the highest moral obligation for professionalism and humane methods including pain mitigation… [a] drug protocol using analgesic medications for pain control is an essential component of such elective surgical procedures in the horse" (CVMA, 2006). Though an elective procedure, castration enhances the safety of humans who work with horses and also facilitates greater ease of turning horses out in groups. Additionally, it reduces the number of unplanned matings.

Local anaesthetics (such as lidocaine) are normally effective at mitigating, but not necessarily eliminating, the immediate pain due to castration. Portier et al. (2009) found that the addition of lidocaine to traditional pain management protocols reduced pain scores and reduced the number of additional doses of sedative required to complete the castration procedure. Nonsteroidal anti-inflammatory drugs (NSAIDs) are effective for treating pain following castration. In a study by Prügner et al. (1991) post-operative pain scores and wound swelling scores were less pronounced when eltenac, an NSAID, was added to the traditional protocol. Further, in a study by Maaβen and Gerhards (2009), the addition of the NSAID phenylbutazone before the procedure, 6 hours post procedure and then daily for 6 days following castration was found to reduce swelling, body temperature and skin temperature of the preputial and scrotal areas.

Similar to other painful practices, there is a need for more controlled experimental studies on castration so we can better understand how this procedure is perceived by the animal in terms of pain and distress.

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LAMINITIS AND PAIN MANAGEMENT OF OSTEOARTHRITIS

Conclusions:

1. **Laminitis is a multi-factorial condition that has numerous causative factors that require different treatment options.**

2. **The pain associated with osteoarthritis can be managed with NSAIDs, steroids, or intraarticular/intramuscular injections and/or rest.**

Although the exact number of horses afflicted with laminitis is not known, it is a relatively common disorder and there are few horse owners who do not eventually have to deal with this disease (Hunt & Wharton, 2010). Laminitis is a condition that follows, and often overlaps, a systemic or local insult. Acute laminitis often lasts around 24 to 72 hours before it resolves or worsens. Cases that worsen either become subacute or chronic. Subacute laminitis does not involve digital collapse whereas chronic laminitis involves laminar morphological changes that result in digital collapse. Some horses with chronic laminitis display minimal signs of lameness, whereas others suffer with severe pain ultimately necessitating euthanasia (Hunt & Wharton, 2010). This condition is tremendously complex and has a multitude of causes and variable clinical presentations. Causes can range from grain (carbohydrate) overload to equine metabolic syndrome (‘fat horse syndrome’) to excessive concussion of the hooves (‘road founder’).

In a ten-year study, University of Kentucky researchers reviewed 585 cases of laminitis and were able to identify the cause in 57% of those cases. Gastrointestinal disease was most commonly associated with laminitis (33%) closely followed by musculoskeletal problems (28%). Other less common causes included endocrine problems as well as drug/toxin-induced laminitis. The phase of initial onset of chronic laminitis is marked by several changes including laminar detachment and shearing as well as distal phalanx displacement. During the transition between the acute and chronic phase, pain often lessens. The decrease in pain can be associated with loss of sensation, effect of medication or the horse habituating to pain. Although it is possible that treatment may increase comfort, it is suggested that the horse not be allowed to increase exercise prematurely (Hunt & Wharton, 2010).

Determination of the cause of laminitis is important because different forms can manifest in different ways. For example, corticosterioid-associated laminitis generally shows no distal phalanx rotation; however, the horse may have persistent foot soreness disabling it from athletic performance. When the disorder does result in distal phalanx rotation, it is generally severe and may result in sloughing of the hoof capsule in a matter of days to weeks. Compare this to physical overload-induced laminitis, which often progresses very slowly up to a certain point when extreme displacement occurs over a period of days. In metabolic syndrome-induced laminitis, moderate to severe pain is evident and rotation and deterioration of the distal phalanx progresses in a slow and subtle manner, sometimes taking months to progress (Hunt & Wharton, 2010). Research shows that laminitis can be induced within 24 to 40 hours of high carbohydrate loading, causing lameness where horses are reluctant to move and resist attempts to lift a forefoot (Garner et al., 1975). Therefore, diet can play a role in the development of this disease.

In many cases, the assessment of laminitis can be done by observation of the stance and gait. Stilted, “camped-out” front legs are indicators of pain. Gait is usually evaluated by methods such as the visual analogue scale (e.g. Obel score or clinical grading system) (Viñuela-Fernández et al., 2011). Gait is easily evaluated from a walk, moving in a straight line and turning in both directions. A trot may be necessary if the lameness is mild. This should be followed by the full physical assessment of the affected feet to determine the source, cause and location of pain within the foot (Hunt & Wharton, 2010). A study by Pollitt and Davies (1998) found that experimentally-induced laminitic horses showed an increase in hoof temperature 16 to 40 hours after alimentary carbohydrate overload. Hoof temperature increased from about 14˚C to 25˚C then decreased sharply after 40 hours. Horses that do not have laminitis did not show such digital vasodilation and never had hoof temperatures higher than that of control group horses. Therefore, the authors concluded that a sublamellar vasodilation 12 to 40 hours after alimentary carbohydrate overload precedes the onset of laminitis. However, if digital circulation can sustain vasoconstriction during this period then laminitis will not occur. They also conjecture that in laminitis-positive horses, increased digital blood flow along with severe metabolic stress brought on by carbohydrate overload, may expose lamellar tissues to a level of blood borne factors sufficient to prompt lamellar separation. All horses dosed with carbohydrates also displayed decreased appetite and drinking, prolonged oral mucous membrane capillary refill time and diarrhea.

Lameness can also be caused by osteoarthritis. Osteoarthritis is one of the most prevalent conditions seen in horses by equine practitioners. In the horse racing industry, lameness due to joint injury and disease is the most common reason for diminished athletic performance (Goodrich & Nixon, 2006). Most joint conditions have the potential ultimately to lead to osteoarthritis, which often has a poor prognosis for return to full normal performance. Damage to and loss of articular cartilage characterizes the process of osteoarthritis (Clegg, 2006). Medical treatments of osteoarthritis are many. The administration of nonsteroidal anti-inflammatory drugs (NSAIDs) is a common treatment. Examples of NSAIDs include phenylbutazone, flunixin meglumine, ketoprofen, naproxen, and carprofen. A study by Owens et al. (1995) compared ketoprofen and phenylbutazone in horses with chronic laminitis, which is believed to cause hoof pain. An electronic hoof tester and Obel scale lameness score were used as objective measurements of hoof pain. Ketoprofen at a dose of 1.65 times the recommended therapeutic dose was found to reduce pain and lameness to a greater extent than phenylbutazone.

Alternatively, there are steroids and compounds that can be given by intraarticular (IA) administration as some horses compete in events regulated by bodies that do not allow NSAIDs (Caron, 2005). Anti-inflammatory glucocorticoids can be given IA and can be beneficial if used judiciously. Caution must be taken as corticosteroids can have a detrimental effect on cartilage. Therefore, many factors must be taken into consideration such as type of corticosteroid used, concentration, duration of exposure and other cell and tissue variables (Goodrich & Nixon, 2006). The controversy surrounding the use of intraarticular corticosteroids revolves around the concern that a pain-free limb could result in overuse and subsequently result in accelerated cartilage degeneration. It is also believed that corticosteroids particularly at high concentrations can also damage cartilage cells. However, research studies have also shown that horses treated with betamethasone and triamcinolone acetonide, and exercised on a treadmill, had cartilage damage that did not differ from those of the control group (Caron, 2005).

Hyaluronan (HA), a glycosaminoglycan is an important component of articular cartilage, and its intraarticular injection is a yet another option that compares favourably to NSAIDs and corticosteroids. HA has been reported to have direct analgesic properties that may be due to reductions in the articular nerve sensitivity (Caron, 2005). HA can even be administered intravenously and is considered a non-invasive mode of administration and a method for treating multiple joints simultaneously (Goodrich & Nixon, 2006).

Lastly, joint pain can also be treated with polysulfated glycosaminoglycan (PSGAG). This is a semisynthetic preparation from bovine trachea composed principally of chondroitin sulfate and is proposed to stimulate the synthesis of proteoglycans and collagen by chondrocytes, thereby aiding in the healing of injured cartilage (Caron, 2005). Verde et al. (2010) experimentally induced carpitis in horses and gave half of the subjects intramuscular injections of either saline or PSGAG. Horses were measured for lameness score, carpal circumference and carpal flexion. Results showed that there was less joint circumference enlargement and lameness and greater carpal flexion in the PSGAG group compared to the controls.

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HOOF CARE

Conclusions:

1. **Trimming and shoeing need to be done on a regular basis (approximately every 6 to 8 weeks) or according to the workload and wear of the hoof.**
2. **Shoes are necessary when wear exceeds growth, for protection of the hoof, or as an aid in the correction of abnormal wear due to poor conformation or gait.**
3. **Regular cleaning of the hoof is important particularly the removal of mud that covers or that has impacted the feet. If shoeing, cleaning is ideally done before the hoof is shod.**
4. **Thrush is an infection potentially caused by several bacterial and fungal yeast-type organisms living in anaerobic environments. Regular cleaning of the hoof prevents thrush from growing by aerating the exposed area.**

The hooves of most horses grow 6 to 9mm per month and thus require trimming or shoeing approximately every 6 to 8 weeks (Balch et al., 1997). According to Butler (1974), horseshoes are unnecessary under ideal conditions where the growth of the hoof equals or exceeds hoof wear. The hooves of barefoot horses must be checked regularly and trimmed as often as needed. Hoof growth varies with factors such as age, level of activity, nutrition, and breed (Butler, 1991). Butler (1991) cited studies where hoof growth of Standardbred foals has been reported to be on average 0.506mm/d as opposed to 0.238mm/d for an average 3-year-old Quarter Horse. The frequency of trimming depends on the growth and changes in the horse's hoof. It has been suggested that the ideal front hoof conformation is a hoof axis angle of 50 to 55 degrees front and hind, respectively (Butler, 1991). However, the 'ideal' conformation varies according to many factors (Lyle, 2003). Most suggest obtaining a balanced hoof and heel for healthy horses (Balch et al., 1995; Keegan et al., 1998; O'Grady, 2003; Page & Hagen, 2002) as well as for lame horses (Curtis et al., 1999; Dunne et al., 2002).

The hoof needs to be cleaned as well and, if the feet are covered or the sulci are impacted with mud, the mud should be removed before the hoof is shod. Dry mud caked on the foot can be scraped off. A hoof pick is used to clean out the bottom of the foot of all foreign materials. Cleaning the foot is crucial as it can help prevent thrush. Thrush is an infection potentially caused by several bacterial and fungal yeast-type organisms living in anaerobic environments. Most manure and dirt contain these organisms which may grow on the hoof under certain conditions. A thrush overgrowth causes a foul-smelling odour and a cheesy appearance of the frog. Regular cleaning of the hoof prevents thrush from growing by aerating the exposed area (Butler, 1974).

Although some horses are successfully managed unshod, shoeing is generally necessary. Horseshoeing serves multiple purposes including: protecting the foot from excessive wear and associated tenderness; providing traction; correcting the stance and/or gait; and preventing abnormal wear due to abnormal conditions of the legs. The basic principles of horseshoeing are crucial in maintaining hoof health and soundness. Physiologic horseshoeing is marked by promoting a healthy functional foot, biomechanical efficiency and preventing lameness. Fitting the shoe to the hoof requires the hoof to be properly trimmed and dressed. A shoe is then shaped so that its outside circumference matches the outside circumference of the hoof at the toe and quarters (Balch et al., 1997). O'Grady and Poupard's (2001) review of physiological horseshoeing covers, among other topics, hoof balance, hoof length, and hoof angle. They proposed that trimming and shoeing may affect a list of important parameters including, the manner in which the foot lands; the duration of the stance phase of the stride and breakover; normal foot function and injuries related to landing and weight bearing. The authors explain that hoof balance can be subdivided into geometric, dynamic and natural balance. Geometric balance means the foot should be symmetrical and applies to the horse at rest. The problem with relying on geometric balance alone is that it does not take into consideration the landing pattern of the hoof. Dynamic balance applies to the horse when it is in motion. The foot should land flat with the goal that it places uniform force on the solar surface of the hoof wall. This approach also comes with problems in that it is not always possible to achieve a flat strike pattern due to leg conformation. In addition, it could be detrimental if the hoof is trimmed to land in a flat strike pattern if the horse has abnormal leg conformation. The more recent term of natural balance suggests that the hoof conformation should be modeled after the foot in its natural state (i.e. on wild or feral horses). However, this does not take into account the individual's athletic state or activities. Balance also encompasses both dorsal palmar/plantar balance and mediolateral balance. A hoof that is mediolaterally off balance is associated with sheared heels, distorted hoof walls and hoof cracks.

Hoof length is a measure of the length of the hoof wall. Lengthening of the hoof increases torque on the distal portion of the limb and increases pressure on the navicular bursa by the deep digital flexor tendon at the end of the stance phase. As the hoof lengthens, the toe moves away from the axis of the coffin joint and it increases the tendency of the horse to stumble, display awkward gaits and become injured from increases in limb contact (Balch et al., 1997).

According to Balch et al. (1997) hoof angle is the dorsal to solar angulation of the hoof measured at the toe. A broken forward or club foot occurs when the angle of the hoof is too steep for its associated pastern; the converse is termed broken backward. Radiographic studies have shown that lowering the angle of the hoof extends the distal interphalangeal (coffin) joint, the proximal interphalangeal (pastern) joint slightly and flexes the fetlock joint. Conversely, increasing the hoof angle produces the opposite effects on the joints of the distal limb. Therefore, altering the angle of the hoof affects limb kinematics and kinetics through alterations in the suspensory apparatus.

Another important consideration of hoof movement is the concept of breakover. Breakover is the phase of the stride between the time the heel lifts off the ground and the time the toe lifts off the ground. The toe acts as a fulcrum around which the heel rotates with the help of the deep digital flexor tendon. The suspensory ligament to the navicular bone and the impar ligament are under maximal stress immediately prior to breakover (O'Grady & Poupard, 2001). Generally, breakover is delayed with a long toe and acute hoof angle because the long toe acts as a long lever arm, requiring more time and force around which the heel rotates. Also, the tension exerted by the deep digital flexor tendon against extremely long toe length results in laminar tearing.

Great care must be taken with hoof trimming. According to O'Grady and Poupard (2001), the objectives of trimming and shoeing are to facilitate breakover, ensure solar protection and provide palmar/plantar heel support. Decreasing toe length by trimming can facilitate breakover, as can applying the correct type of shoe. The function of the sole is to protect the underlying structures and to help bear weight around its border with the hoof wall. Inadequate sole depth is a common cause of solar bruising. Hence, sole depth can be maintained by trimming back the toe and by not removing excess live sole. Lastly, it is essential to provide palmar/plantar support to the foot because of the weight put on the heel during the landing and stance phases of a stride. It has been suggested to trim the heels to the widest part of the frog in order to support this area. However, it might not be possible to trim a low or underrun heel in this manner. On the contrary, a heel may be trimmed excessively to reach the preferred ground surface at the expense of affecting foot angulation. If the heel cannot be trimmed to provide optimal ground surface, the branch of the shoe can be extended to compensate for the lack of bearing surface (O'Grady & Poupard, 2001).

Unshod horses regularly wear away the outer sole and bars as those structures become dry and flakey. This exfoliation is accompanied by a semi-annual moulting of the frog. Shoes diminish the abrasiveness of the ground and subsequent thinning of these epidermal structures (Balch et al., 1997). Proper farriery is of the utmost importance and it is crucial to remember that what is done to the external hoof through trimming and shoeing affects the internal foot structure as well as the limb (O'Grady & Poupard, 2001).

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DEWORMING AND VACCINATIONS

Conclusions:

1. **The traditional approach to worming horses every 6 to 8 weeks with rotating products may be detrimental to effective parasite control. If well managed, selective therapy (based on faecal parasitic egg counts and effective pasture management) may be an effective alternative method to the traditional approach to parasite control.**
2. **The idea of frost killing parasite larvae is a myth.**
3. **Guidelines for the vaccination of horses are available from the American Association of Equine Practitioners.**

Parasite management: Parasite control is important in maintaining healthy, productive horses allowing optimal athletic performance and efficient breeding herd performance. Parasites negatively affect the optimal utilization of nutrients and thus effective control of parasites is a key factor for feed efficiency, immune status and gastrointestinal health. In the horse, signs of parasitism are poor body condition, mild to moderate abdominal distension, and, in severe cases, stunted growth. Internal parasites are a potential big threat to equine health in young foals and in geriatric horses.

Historically, equine parasite control has been based on the assumption that eradication was possible and feasible. Therapeutic rather than prophylactic approaches, such as traditional control practices, were the norm. Owners were advised to deworm all horses every 8 weeks and this was widely adopted. Initially with the development of newer anthelmintic drugs this greatly reduced morbidity and mortality due to parasitism. Since the 1960s, internal parasite control of horses has been almost exclusively based on routine administration of anthelmintics to remove adult parasites in order to prevent environmental contamination with eggs or larvae. The traditional common practice called the “interval dose regimen” is to treat every horse in the herd every 6 to 8 weeks and rotate between drug classes to ensure that different types of parasites would be targeted (Mercier et al., 2001). The intensive use of anthelmintics has led to drug resistance in some types of parasites. For instance, studies have shown that the egg reappearance periods (ERP) (i.e. the time between treatment and reappearance of eggs in faeces) in cyathostomins, commonly known as small strongyles, after ivermectin treatment has decreased from about 8 weeks to 4 weeks (Nielsen, 2009).

Recently, researchers have begun to discourage the traditional program of treating at randomly chosen regular intervals or treatments timed with management routines such as farrier visits, neither of which is related to parasite biology (Reinemeyer, 2009). Instead, a different strategy called selective therapy (targeted treatments) is being recommended as an alternative. This is based on determining, through faecal egg counts, the individual horses with high parasite load and treating those horses while leaving the rest of the herd untreated. The principle is based on the fact that only a few animals harbour the majority of the parasite load and that horses have a strong propensity for remaining at the same level of egg shedding over time. Hence, a small proportion of horses are shedding the majority of parasitic eggs while the majority of the herd remains at very low or undetectable egg counts (Nielsen, 2009). Parasite load in the herd can be monitored by checking faecal counts on all horses on a regular basis. Checking faecal counts pre and post (i.e. 2 weeks later) worming will provide information as to the efficacy of the medication being used.

In addition to selective therapy, Nielsen (2009) advocates ‘prescription-only’ restrictions. Currently, anthelmintics are freely obtainable as over-the-counter medication. It is suggested that requiring a prescription for anthelmintics may be a way to ensure veterinary involvement in parasite management and to prevent the over-use of anthelmintics. Some European countries have made anthelmintics available only upon veterinary diagnosis and prescription. Thus far, Quebec is the only province in Canada to have also adopted this legislation. However, Nielson (2009) states that more research is needed before conclusions can be made as to whether this would improve parasite control efficacy in the long-term.

Indeed although, Mercier et al. (2001) found that the mean number of days to egg recurrence of 200 eggs/g faeces (the most widely cited value for an acceptable limit) was about 60 days for various anthelmintics. Nevertheless, the researchers caution against drug overuse leading to resistance. They too encouraged finding a balance between the need to reduce faecal egg counts with the development of resistant parasites. They suggested assessing risk factors including pasture type, grazing history, time of year, stocking density and weather. In addition, pasture management was proposed as a possible method of reducing parasite infection.

Most horse pastures are not uniformly affected by parasites. Areas of tall grasses, called roughs, are areas where horses defecate but generally do not graze. In contrast, lawns are areas where horses graze but do not defecate. Hence, pasture roughs have been found to have significantly higher numbers of larvae than in the lawns (Reinemeyer, 2009). Fleurance et al. (2007) studied the selection of feeding sites at pasture in order to gain a better understanding of pasture management. The authors found that almost all infective larvae were situated less than 1m from faeces. They also found that the major determining factor in site selection was the availability of different parasite risk and grass height. Horses had a low tendency to graze on tall grasses, regardless of whether it was contaminated; horses much preferred to eat from short patches that were more than 1m away from faeces, which had a lower risk of being contaminated by parasites. This supports the long-held belief that horses have a considerable tendency to select particular patches of grass when on pasture—generally avoiding areas soiled by faeces. However, this selective behaviour becomes compromised whenever the pasture is mowed, dragged or harrowed, or when stocking density is too high. These practices spread the parasitic risk into areas of relatively low levels of parasites. Therefore, if a pasture must be harrowed, it is recommended to be done during the hottest periods of the day and year and the pasture left vacant for several weeks thereafter (Reinemeyer, 2009).

In regions with cooler weather, harrowing is recommended at the end of the grazing season as this has been shown to reduce overwinter survival of the infective larval stages. Strongylid eggs pass in the faeces and hatch between 6^{o} to 30^{o}C (43 to 85˚F). Larvae then develop from L1 to L3 larval stages, where the last L3 stage is when larvae can infect a new host. At this point, larvae die at temperatures over 32^{o}C (90˚F) but yet can tolerate freezing temperatures. Hence, the notion of a “killing frost” is purely a myth (Reinemeyer, 2009).

Future parasite control on horse establishments should follow epidemiological approaches for nematode control, such as determination of which drugs are effective on a farm, use of the correct drug for the parasite developmental stage at the appropriate time of the year, and regularly perform fecal egg count of all horses to determine which need or do not need treatment. There is evidence emerging out of Europe that there are "high" and "low" egg shedding horses and that "high" shedders will remain "high" shedders for life (Kaplan & Nielsen, 2010). Education will be central to convince owners to implement such a strategic parasite control program.

Vaccinations: Having reviewed the research on vaccinations in the context of what would be of relevance to a national Code of Practice, the Scientific Committee advises that the Vaccination Guidelines from the American Association of Equine Practitioners (AAEP) (2008), which are based on the expert opinion of a scientific committee, provide the most suitable reference. As the guidelines are publicly available, they are not summarized here.

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3. FEEDING AND DRINKING BEHAVIOUR

FEEDING

Conclusions:

1. **When allowed to feed on a natural cycle, horses will spend more than half their day eating.**
2. **If allowed to feed ad libitum on high energy feedstuffs, some horses will eat to the point of obesity.**
3. **Horses do not appear to possess "nutritional wisdom" other than for salt.**
4. **Providing feed off the ground will limit the risk of sand colic for horses housed in sandy areas.**

In Ralston's reviews (1984, 1986) of feeding behaviour in horses, free-ranging horses spend more than half of their day eating. Grazing behaviour consists of constant forward movement, taking a mouthful of forage and then chewing while walking forward again. If forage is sparse or of poor quality, up to 80% of the day may be devoted to grazing. Horses confined to stalls or pens and given free access to hay or pelleted feed exhibit the same feeding patterns observed in free-ranging horses — eating an average of about 12 hours per day and never voluntarily fasting for more than 3 to 4 hours (Ralston, 1986). If given the choice between different feedstuffs like grasses, legumes and herbs, horses will show definite preferences for some, but will still sample from and eat different varieties (Archer, 1971, 1973)[3]. A recent study determined that horses spend significantly more time foraging when presented with up to six different types of forages, and although horses do show preferences for specific forages, all six of the forages were sampled. Additionally, horses only displayed stereotypic weaving behaviour when provided with a single forage (Thorne et al., 2005). An alternate study noted that horses displayed more forage-seeking behaviour (looking over stall door, foraging on straw bedding, movement in stall) when provided with a single variety of hay, even when it was their preferred forage type, indicating that provision of multiple forages provides environmental enrichment (Goodwin et al., 2002). A similar trial was done using concentrates varied in flavour and digestible energy. Horses showed similar results as with forages, preferring to feed from a variety of concentrates rather than a single concentrate, even if it was the preferred concentrate (Goodwin et al., 2005a). This resembles a natural patch-foraging strategy displayed by feral and pastured horses (Archer, 1973; Putman et al., 1987).

Horses and ponies are unable to associate energy content of particular types of feed with the way they taste (Ralston, 1984). The ingestion of minerals other than sodium chloride is not regulated by horses. For example, ponies do not develop a preference for calcium supplements when fed a calcium-deficient diet (Schryver et al., 1978). However, horses will develop a taste for salt if they are deficient in sodium (Jansson & Dahlborn, 1999). Olfaction also plays a significant role in feeding behaviour. When Ott et al. (1979) presented horses with non-pelleted grain concentrate to which citrus pulp had been added in the place of oats, most horses refused to eat

[3] For information on foraging behaviour, please refer to the section on Foraging Behaviour.

it. The authors proposed that the strong citrus odour may have been the cause of the feed rejection. It is also known that horses avoid feeding in areas within pastures that have been contaminated with manure and this avoidance has similarly been proposed to be due to odours horses find aversive (Oedberg & Francis-Smith, 1977). Horses have preferences for certain tastes that may affect their feeding behaviour. A taste preference study on foals revealed that sweet taste at the concentration of 1.25 to 10g/100 ml, is preferred over plain water, but concentrations of sucrose above or below this range were treated with indifference. Foals also showed no preference or aversion to low concentrations of salty, sour and bitter flavours, but rejected them when presented in higher concentrations (Randall et al., 1978). In a study of selection and acceptance of 15 different flavours in the diet of stabled horses, Goodwin et al. (2005b) found that horses readily accepted flavours like banana, carrot, cherry, cumin, fenugreek, oregano, peppermint and rosemary.

In addition to external oropharyngeal stimuli (i.e. social factors, taste, smell and appearance of food) controlling meal size and satiety, gastrointestinal stimuli seem to play an important role in the onset of feeding behaviour (Ralston, 1986). In a study of gastrointestinal stimuli in the control of feed intake, it was found that nutrient solutions delivered directly to the stomach or cecum of ponies 15 minutes prior to being allowed to access feed after a 4-hour fast, reliably decreased subsequent feed intake. It was also found that the onset of the feeding response was correlated with the time it took for nutrients to be digested and absorbed from the gastrointestinal tract. The effect was primarily a delayed onset of the next meal rather than a reduction in meal size (reviewed in Ralston, 1986).

Cues related to energy stores are correlated with blood variables like glucose and insulin levels. Like gastrointestinal cues, metabolic factors can also affect feeding behaviour. It was found that plasma glucose concentration 5 minutes prior to the beginning of a meal, after a 4-hour fast, was negatively correlated with the subsequent meal size and rate of eating (Ralston & Baile, 1982, 1983).

Feeding problems: Sometimes horses will have problems with feeding. Anorexia may result from many metabolic, viral and bacterial diseases. In the absence of clinical conditions that result in anorexia, hypophagia (i.e. low feed intake) may be caused by poor dentition, inadequate water intake, protein-deficient diets, social competition, slow eating habits and anxiety/stress. Treatments are many and include firstly checking water availability and quality, verifying that the horse is not dehydrated. A thirsty horse will be reluctant to eat. Following this, other strategies include: offering a variety of palatable feeds in small, frequent amounts; and avoiding putting medications in feed (Ralston, 1986).

On the other hand, horses can sometimes overeat. This can manifest itself either as the acute ingestion of palatable feed in large amounts or chronic over-ingestion. Horses may overeat when allowed to consume palatable feed free choice. Meals can last between 30 to 240 minutes and gastric distension only becomes a cue to stop eating if it becomes painful. To reduce the risk of acute engorgement, horses should generally not be allowed free access to grain or pelleted grain. If fed free choice high quality forage along with concentrate, many horses will stabilize their body condition at the level of obesity and may experience other health problems. Limiting access to feed or providing low-energy diets such as more mature grass hay, may aid in preventing chronic over-ingestion (Ralston, 1986). Traditional husbandry management is to feed hay before turning out to lush pastures to prevent engorgement and potential complications.

Some authors suggest that older, overweight, sedentary horses can develop a resistance to insulin, while the condition can degenerate to laminitis and other metabolic conditions. Therefore, a glycemic index was developed for horses and is being used on a commercial basis to formulated horse feeds (Rodiek & Stull, 2007).

Sometimes horses will eat non-feed items like dirt or stones. This is known as pica or allotriophagia in medicine. In foals this has been associated with imbalances in trace minerals. In some cases involving adult horses, it has been suggested it is a stereotypy. However, a nutritional check-up is suggested to investigate the cause. Coprophagia is the consumption of feces and is normal in young foals and is observed in mares as well, but the frequency of coprophagia decreases as the foal ages (Crowell-Davis & Houpt, 1985). Adult horses will generally avoid eating feces or grazing in areas contaminated with manure. However, fiber- or protein-deficient diets and starvation can induce coprophagia in adults (Ralston, 1986). Hence, for a sudden onset of coprophagia, a dietary analysis is suggested as a primary action before investigating the horse's level of exercise and social stimulation (Ralston, 1986).

Lastly, as horses prefer to eat at ground level (as opposed to buckets or bins) horses run the risk of ingesting excessive sand if feeding areas are directly on sandy ground. The risk of sand colic can be prevented by feeding only in non-sandy areas or building feeders on platforms or solid bottoms (Ralston, 1986).

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DRINKING

Conclusions:

1. **In very cold weather, horses will drink more tepid water than ice cold water. This has been suggested as a management tool to reduce the risk of impaction colic, though research evidence on that topic is very limited.**

2. **There is a limited amount of information in the refereed literature related to snow as a sole water source for horses. The available research findings do not provide sufficient data to extrapolate whether, in practical settings, snow can meet the water needs of horses. More research is needed before conclusions can be made.**

Horses drink in an episodic and circadian rhythm that is affected by water source, availability, diet, age, exercise intensity, lactation needs, gastrointestinal health, and climate/ambient temperature (National Research Council [NRC], 2007). Typically, a drinking episode consists of a single long draught followed by smaller, shorter sips (NRC, 2007). Normal drinking behaviour of adult, housed horses ranges from 2 to 8 times per day, with bouts lasting 10 to 60 seconds (McDonnell et al., 1999) to 16 to 21 bouts per day with similar bout lengths of 10 to 52 seconds (Nyman & Dahlborn, 2001). The type of water apparatus can influence the duration and amount of water consumed. When bowls hold a water depth of 2.5 to 5cm, drinking duration appears to increase presumably because the shallow depth restricts the horse's ability to consume the water quickly (McDonnell et al., 1999). In fact, when given the choice between water bowls and buckets, horses preferred drinking from buckets over pressure or float-valve bowls (Nyman & Dahlborn, 2001). With free access to water, horses and ponies will drink several times a day, generally during or after feeding (Ralston, 1986). Drinking that occurs during or after feeding is thought to be a response to increased plasma osmolality or total serum protein associated with feed consumption (NRC, 2007). The horse's diet will influence water intake. Water intake increases when forage replaces concentrate in the ration and when the diet is higher in salt and potassium (NRC, 2007).

Generally, adult horses at maintenance and in a thermo-neutral environment will drink approximately 5L of water/100kg body weight (BW)/day (NRC, 2007). So a 500kg (1100lb) horse would be expected to drink 25L per day of water. This amount will increase by up to 74% for lactating mares. Exercise (and the associated loss of water from sweating) will also result in increased water needs above maintenance. Horses in stalls have been noted to dip or wet hay in the manger and this behaviour is believed to make dry feed more palatable and easier to chew by moistening it (McDonnell et al., 1999). This behaviour can create hygiene problems in mangers (Freeman et al., 1999).

Ambient temperature also influences drinking behaviour. Cold weather reduces water consumption by 6 to 14%. Free water intake and its relationship to temperature (between -20 to 20˚C) can be mathematically explained by the equation $Y=2.25+0.016T$, where Y=L water/kg dry matter (DM) intake and T=ambient temperature in ˚C (Cymbaluk, 1990). Water temperature also influences water intake depending on environmental temperature. For example, cold weather alone reduces water intake, but, during cold weather, horses drink less cold water than warm water. Whether kept indoors or outdoors ponies drank 38 to 41% less near icy water (i.e. approaching a temperature of 0˚C) than water that had been heated to 19˚C (Kristula &

McDonnell, 1994). However, ponies kept indoors in warm ambient temperature (15 to 29˚C) drank similar amounts of icy or warm water (McDonnell & Kristula, 1996).

Snow as a water source: The effects of extreme weather conditions on drinking have led to the question as to whether snow is a sufficient source of water for horses. Studies on this topic are few, but the data on horses and other herbivores seem to suggest that snow can be considered as a water source. In a study of pregnant beef cows relying on snow as a water source during the winter months of Alberta, Canada, body mass change, water influx, metabolic heat production and rectal temperature did not differ between cows offered heated water and cows offered only snow (Degen & Young, 1990a). Therefore, cows consuming only snow were able to obtain enough water to satisfy their requirements and no added nutrient energy was required to melt the snow and bring the water to body temperature. The study concluded that withholding liquid water from pregnant beef cows when snow was readily available was not detrimental and therefore cows are able to use snow as their only source of water for lengthy periods of time. The same researchers also studied the use of snow as a sole water source for growing beef calves and found no differences in water intake or average daily gain between calves given access to water and those given access to snow (Degen & Young, 1990b). It is worth noting that animal behaviour and measures of welfare were not taken into account in the conclusions of this research group. Degen and Young (1981) found similar results in a study involving lactating ewes. Half the ewes in their study had free access to snow but were denied water during lactation, while the other ewes were offered water. The researchers noted that the ewes readily accepted snow as their source of water. In addition, the total water turnover (i.e. water utilization by the sheep) of snow-only ewes was 35% less than water ewes, but the reduced water intake did not affect their milk yield, total body water, or hemactocrit. Thus, Degen and Young (1981) concluded that there were no significant differences between the snow and water groups.

In one case report of Alaskan horses stranded over the winter months in a harsh environment with no liquid water, Dietrich and Holleman (1973) capitalized on the situation and recorded several hematologic, biochemical and physical parameters. Body water content and kinetics, blood volume and plasma iron clearance rates were determined. The same measurements were taken when horses were able to access liquid water again as opposed to snow. Results showed no differences in these measurements whether horses consumed snow or liquid water and fell within ranges reported in normal, non-stressed horses. In another case report (Mejdell et al., 2005), Icelandic horses fed grass silage had to manage for nine days with snow as their only source of water because of water equipment malfunction due to extreme winter conditions. After nine days, blood samples were taken and analyzed for plasma osmolality and horses underwent clinical examinations before being offered drinking water again. Osmolality levels were within normal limits and the general condition of the hoses was deemed to be normal, with no signs of dehydration or disease. Mejdell et al. (2005) noted that the horses showed little interest in the liquid water when it was offered. It was concluded that horses fed grass silage under cold winter conditions adjusted to eating snow without detriment to their welfare.

More research is needed to determine whether snow can be a sufficient sole water source for horses in the winter months. Given what is known generally about the water needs of horses and the factors influencing water intake, it seems that successful management of snow-only systems would, at a minimum, rely on attentive observation not only of the horses so managed but also of the quantity of snow and its quality (e.g. reasonably loose versus hard packed). Whether snow provides sufficient supply of water will also vary depending on several factors such as the relative quantity of water in the feed and the metabolic activity of individual horses, among other factors.

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OBESITY AND LAMINITIS – COMPONENTS OF EQUINE METABOLIC SYNDROME

Conclusions:

1. **Obese horses and/or horses with excess fat along the crest and tailhead regions are at increased risk for developing equine metabolic syndrome.**

2. **Grazing muzzles, close monitoring of weight and/or limited grazing opportunities can be important management tools to reduce risk for obesity and equine metabolic syndrome, particularly for "easy keepers".**

3. **Nutritional supplements are marketed to help manage horses at risk for equine metabolic syndrome, but there is limited research to support these claims.**

The term "equine metabolic syndrome" (EMS) describes a multi-faceted condition of obesity (generalized and/or regional), insulin resistance (IR) and prior or current laminitis (Johnson, 2002). EMS was adopted as the name for this condition because of similarities with the metabolic syndrome (MetS) in humans (Frank et al., 2010). A primary contributing factor to development of EMS is quantity of feed provided to these horses. There are no clear reports on the prevalence of obesity and hyperinsulinemia in populations of ponies and horses (Frank et al., 2010). EMS commonly presents as an obese horse showing regional adiposity that develops laminitis while grazing on pasture (Frank, 2009). Regional adiposity refers to the deposition of fat in specific regions of the body. In horses this usually appears in the crest of the neck and around the tailhead. Expansion of adipose tissues within the neck region and increased neck circumference, known as 'cresty neck', can be a good indicator of EMS in horses and ponies. Although EMS is less commonly seen in leaner horses, horses with lean body types can still be affected. Diet seems to play a key role in triggering laminitis with the EMS phenotype, particularly the consumption of pasture forage or other feeds high in non-structural carbohydrates (NSC) which are simple sugars, starches and fructans. (Geor & Harris, 2009). Regional adiposity may increase the risk for certain diseases. For example in humans, abdominal fat is associated with a higher risk for diabetes and cardiovascular disease compared to generalized obesity, and, in equids, there may be a similar association between neck crest adiposity and altered insulin sensitivity like insulin resistance (Carter et al., 2009a; Frank et al., 2010).

Although there is no universally accepted definition of obesity in horses, Henneke and colleagues (1983) developed a 9-point body condition scoring scale. According to this scale, horses with a body condition score of 7, 8 or 9 are considered overweight, fat or obese, respectively. Although useful, a limitation of this scoring system is that it fails to detect regional adiposity. Obesity can be induced by overfeeding and insulin sensitivity decreases as body fat mass increases (Carter et al., 2009b). Obesity should be corrected to improve insulin sensitivity (Frank, 2009). In most cases, obesity is associated with an imbalance between energy intake and expenditure. If there is a surplus in energy supplies, the horse's body will store it as fat (National Research Council [NRC], 2007). However a horse's energy requirements are influenced by various external factors such as environmental conditions and the work load/level of exercise in addition to internal factors, such as life stage and genetics (Geor & Harris, 2009). With regard to activity level, many horses spend most of their day in stalls or small dry lots with occasional riding activity. In these cases, daily energy requirements are generally no higher than maintenance levels, yet many horses are fed above their nutrient requirements for maintenance. Likewise, horses turned out to pasture may consume much more than their caloric requirements (Geor & Harris, 2009). Frank (2009) recommends a weight loss program that begins with the elimination of all grain from the diet. He also suggests limiting or eliminating access to pasture because pasture grazing allows horses an unregulated source of calories; therefore, limiting pasture access and feeding hay as the primary source of calories until weight loss is achieved is advisable. The amount of hay to be fed can be calculated based on the digestible energy value of the hay and the horse's energy requirements; otherwise they can generally be fed a dry matter equivalent of 2% of body weight (Frank, 2009). However, in order to avoid excess energy intake, the energy value of the hay should be considered (not just the amount of feed as a percentage of body weight). Alternative approaches in the reduction of pasture access include confining the horse to a small grass paddock, using a grazing muzzle to reduce grass consumption or limiting grazing time to only 1 hour, 2 to 3 times daily (Frank, 2009). In addition, increasing activity level can accelerate weight loss and improve insulin sensitivity. A study by Powell et al. (2002) found that short-term exercise improved insulin sensitivity in obese horses. It has been suggested to exercise otherwise sound horses by riding or lunging them at a trot for 30 to 60 minutes 5 times per week (Frank, 2009) provided the horse is accustomed to this exercise level or is conditioned to it over a period of several weeks.

A study by Carter and colleagues (2009a) showed that generalized obesity, hyperinsulinemia, and hyperlipidemia were predictors of pasture-associated laminitis in ponies. Although obesity has been correlated with laminitis, it is not known whether obesity directly increases the risk for laminitis or whether the increased risk is due to other factors such as insulin resistance and inflammation, which are also associated with obesity (Vick et al., 2007). Work by Bailey and colleagues (2007, 2008) suggests that the consumption of summer pasture, which is high in NSC, including fructans, may induce hyperinsulinemia in laminitis-prone ponies. The mechanisms triggering onset of laminitis with an insulin-resistant phenotype are still not known. However, because laminitis can be induced in healthy individuals by administering high levels of insulin, it suggests that hyperinsulinemia could be a direct factor in the manifestation of laminitis (Asplin et al., 2007). Geor (2010) recommends restricting grazing pasture with high NSC content, strict limitation of feeds rich in starch and sugars, and restricting general overfeeding leading to obesity. Pasture rich in NSC can be found in rapidly growing grass in spring, but also on a cold, sunny morning such as seen sometimes in the fall. Indeed, during a cold, sunny day the sun will initiate plant photosynthesis and therefore plant sugar production. But since the temperature is low the plant metabolism is slow and sugar is accumulating within the plant. It has been shown however, that plant sugar will accumulate at the base of the plant. If an affected horse is returned to pasture, a grazing muzzle can limit grass intake. It is important that horses wearing grazing muzzles are able to consume the necessary amount of water (Geor, 2010). Furthermore, grazing muzzles need to be removed from time to time to check for rubbing, and breakaway designs should be used in most grazing situations. Grazing muzzles can be worn every day or during times when pasture grass contains higher concentrations of starches, sugars, and fructans (Frank, 2009). Although laminitis can be triggered in animals with and without the insulin-resistant phenotypes, it appears that the threshold for laminitis induction is lower in insulin-resistant horses compared to those having normal insulin response (Geor, 2010).

Lastly, there are various supplements that are purported to improve insulin sensitivity and reduce the risk of laminitis. Most of these products contain chromium and magnesium, and/or cinnamon. However, the scientific evidence to support such claims is not substantial and more controlled experimental research is needed before specific recommendations can be made. Although virginiamycin (a streptogrammin antibiotic) has proven successful in the prevention of pasture-induced laminitis; the underlying mechanism was purported to be the prevention of overgrowth of gram-positive cecal bacteria (Bailey et al., 2004).

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THERMAL IMPACTS ON NUTRITIONAL AND ENERGY NEEDS

Conclusions:

1. **Research related to the impact of high temperatures on horses' feed intake is limited, but it appears that horses will decrease feed intake at temperatures above their thermo-neutral zone (TNZ). Substituting fat (up to 10% of the diet) will reduce internal heat load over forages or concentrates in horses exposed to extreme high temperatures.**

2. **Horses will increase feed intake at temperatures below their TNZ; however, more readily digestible feeds may be required for horses to maintain their body condition.**

3. **Most research suggests that horses adapt well to cold climates when provided sufficient digestible energy.**

Horses respond to cold or heat with acute or chronic physiologic, metabolic and behavioural responses (National Research Council [NRC], 2007). The thermo-neutral zone (TNZ) refers to the ambient temperature range where metabolic heat production (Hp) does not need to increase in order to maintain internal thermostability. The lower critical temperature (LCT) is the lower limit of the TNZ and refers to the temperature below which metabolic Hp is increased to maintain core body temperature. Conversely, the upper critical temperature (UCT) is the upper end of the TNZ and refers to the temperature at which evaporative heat loss needs to increase in order to lower body temperature (Curtis, 1983). Although horses are very adaptable to a wide range of ambient temperatures, the TNZ and LCT varies with age, body condition, breed, season, climate and digestible energy (DE) intake (Cymbaluk, 1994). It is estimated that horses' thermoneutral zone lies between the lower critical temperature of 5°C (41°F) and the upper critical temperature of 20°C to 30°C (68°F to 86°F) (Morgan, 1998).

According to the NRC (2007) a sudden reduction in ambient temperature causes horses to eat more to increase metabolic heat production, whereas acute exposure to increased ambient temperature causes decreased feed intake along with an increased water intake. Indeed, Autio et al. (2008) found that voluntary intake of hay increased over the course of cold winter months from 3.7 ± 1.1kg DM/day in November to 5.6±1.1kg dry matter (DM)/day in March; whereas Ott (2005) noted that high temperatures resulted in reduced feed intake in horses.

In a study on the effects of diet and climate on growing horses, Cymbaluk and Christison (1989) found that digestible energy (DE) intakes were reduced by 6.1% at temperatures below -10˚C compared with temperatures above -10˚C. Temperature effects on DE intake, when below -20˚C, were no different than at temperatures between -10 to -20˚C. Feed to gain ratios in ad libitum-fed foals were unaffected at temperatures as low as -11˚C, but average daily gain declined at temperatures below -11˚C suggesting that energy distribution could be redistributed from tissue building to maintenance. Further results from this experiment suggested that horses housed under cold conditions may need to be fed readily digestible and higher nutritive value diets to compensate for reduced feed intake or higher maintenance energy needs. Feed intake reduction (especially if the feed has low energy content) could cause negative energy balance and/or reduced gut fill, which could lead to acute weight loss. Cymbaluk and Christison (1989) concluded that horses fed readily digested diets ad libitum gained weight at or above expected values even at extremely cold ambient temperatures. They did however, caution that the horses in their study were of moderate to fleshy body condition at the time of extremely cold weather and were given diets containing a relatively high DE content in a readily consumable form and therefore, cold stress could affect thin horses fed poorer quality feeds differently. In a more controlled study (Cymbaluk, 1990) colts were housed either in a heated barn (about 10˚C) or a cold barn (average -5˚C). Colts housed in the warm environment gained weight 29% faster than their cold-housed counterparts. Maintenance energy needs were estimated to be 34.6kcal/kg body weight (BW) for cold-housed colts and 26.3 kcal/kg BW for warm-housed colts. It has been noted that weanling horses' body condition often decreases in cold housing conditions (Autio et al., 2008). Cymbaluk (1990) advises that for every Celsius degree decrease in temperature below 0˚C, young horses require 1.3% more maintenance energy.

Autio et al. (2008) studied energy intake and growth of weanling horses in a cold housing system and found similar results. The researchers measured the horses for body condition and weight on a weekly basis over the course of November through March. The metabolizable energy (ME) was compared to Finnish (MTT, 2006) and Swedish (SLU, 2004) nutrient requirements for weanling horses. Autio et al. (2008) found that ME intake was on average 24.6% higher than the MTT and SLU recommendations. However, intake varied in a non-linear fashion as the winter progressed. Cold ambient temperature increased metabolizable energy needs by 1.8% in November, 0.5% in December and then 0.2% in January per 1˚C decrease in ambient temperature when compared to the nutrient requirements. However, this did not apply to February or March. Autio and colleagues (2008) explained that the amount of extra energy needed decreased as the winter months progressed because the horses' body insulation increased and helped them to acclimatize to their cold environment. The authors concluded that horses gained weight at or above the expected rates in cold weather as long as the increased energy need was accounted for in their feed.

On the other hand, horses can also encounter heat stress. When horses are in high ambient temperatures, feed intake can be reduced. Forages have a high heat increment (the heat produced when feed is ingested and utilized). This is because they must be fermented in the hind gut to convert carbohydrates to absorbable and utilizable products (Ott, 2005). Heat increment is defined as the elevation of metabolic rate in response to consumption of a meal (Hindle et al., 2003). Ott (2005) suggested minimizing forage intake and maximizing concentrate energy density. Instead, a high fat concentrate is recommended as fat reduces heat load and has a lower heat increment. At a minimum, horses need to consume 1% of their BW as forage (NRC, 2007). The more digestible the forage the less heat increment it will produce, since it has less fiber. Therefore, in a high heat environment, high nutritive forage should be fed, such as very young, leafy hay or grass. Replacing carbohydrates with fats can be beneficial up to the horse's upper tolerance limit of fat. Also according to Ott (2005), acclimation to high fat levels of up to 10% of the diet can take up to 30 days. In addition, sweating may result in nitrogen loss, necessitating additional protein intake. Nevertheless, diets generally contain enough extra protein to compensate for this. Furthermore, protein intake above a horse's requirement may have negative effects on body heat production and athletic performance. So, adding particular amino acids like lysine and threonine to a lower protein diet may be a useful method in striking a balance (Ott, 2005). Essentially, when horses face high temperatures or heat stress, the diet can be adjusted to lower the heat increment. On the other hand, there seems to be no evidence of adverse effects of high protein intake on horses that are exposed to cold temperatures. The added heat increment could be useful in keeping them warm (Ott, 2005).

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4. FEEDLOT HORSES

STOCKING DENSITY

Conclusions:

1. **There is a scarcity of information in the refereed literature related to feedlot horses. Therefore, no conclusions regarding stocking density can be made at this time.**
2. **Based on limited studies during the past year, no significant welfare concerns have been identified that would be different than for non-feedlot horses.**
3. **Given the number of horses that are part of the horse processing industry, there is a definite need for more research in this area.**

According to the Alberta Farm Animal Care (AFAC) (2008), there are an estimated 20,000 horses in Alberta feedlots at any one time. Horses are generally kept for 60 to 80 days before going to the abattoir, with some groups staying from 90 to 120 days or longer depending on the customer/market demands for drug withdrawal requirement (AFAC, 2008). There is an existing market for Canadian horse meat both domestically and internationally. Therefore, there is also a responsibility to ensure the welfare of horses kept on feedlots.

Currently, there are almost no scientific studies on the welfare of feedlot horses. However, one particular group led by Dr. Derek Haley, from the University of Guelph, has recently begun to investigate feedlot horse welfare. Observation of horses from two feedlots in Alberta, Canada, included stocking density as well as general activity and daily time budgets.

The 8-week observation period took place over the summer months. Over that time, the two pens contained an average of 162.00±9.90 horses and 176.30±20.30 horses (mean ± SD); this amounted to a stocking density of 41.25±68.25 and 25.38±36.25m^2 /horse, respectively (Robertshaw et al., 2011). There was a large variation in stocking density between these feedlots.

Robertshaw et al. (2011) also observed for several behaviours. In particular, horses were 1.75 times more likely to be lying in the morning compared to the afternoon and were less likely to be lying when it was raining. Similarly, horses were half as likely to be walking or running in the rain and 3 times more likely to be grooming if it was not raining. However, temperature and the pen condition (i.e. how muddy the pens were) did not have any significant effect on lying.

No significant observations were seen with respect to the number of horses feeding at any one time. The researchers suggested that this could have been due to limited feeding space and the inability to accommodate all horses at once, making the number of horses eating relatively static over time.

Robertshaw et al. (2011) concluded that general daily time budget results for feedlot horses were similar to other equine studies. Most noteworthy was that rainy weather had a number of effects, which may be of significance as many feedlot horses in western Canada have no overhead shelter. However, since the study was done during the summer months, these conclusions cannot apply for spring, fall and winter months. More studies need to be undertaken to account for the effects of adverse environmental and variable seasonal conditions.

Clearly, there is a scarcity of information on the behaviour and welfare of feedlot horses. At this time, the aforementioned study undertaken by Dr. Haley's group is the only scientific study that is attempting to assess feedlot horse welfare, specifically. Upcoming data from this group's work will be very useful in answering basic questions as well as identifying issues requiring further investigation.

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MUD SCORING

Conclusions:

1. **To date, there has been no research on the impact of muddy conditions in horse feedlots.**

2. **The section below extrapolates potential welfare concerns from limited research in the beef cattle feedlot industry.**

3. **Limited data published on cattle propose that a dirty and wet coat condition will lower the insulation capacity of the hair coat and thus will increase energy needs of the animal for maintenance. This may have an indirect effect on animal welfare, particularly if the energy density of the ration is not adequate.**

Although there is no scientific evidence thus far that mud scores directly affect the welfare of feedlot horses, it is possible that there may be some association based on extrapolation of data used by Dr. Temple Grandin and others in the beef cattle industry.

Dr. Grandin's beef feedlot audit form (www.grandin.com) contains many animal-based measures of welfare. One measurement is that of mud scoring. Horses and cattle are significantly different animals and extrapolating measures designed for one species on to the other should be done with caution. For example, in general horses do not lie down as often as cattle. However, in the case of the feedlot environment, there may be enough similarities between horses and cattle to warrant a careful comparison.

According to the audit, there are two separate scores for mud in pens and mud on cattle. The Pen Mud Score includes an automatic fail if mud is over ankle deep in most parts of the pen. For the animal mud score, cows are ranked 1 to 4 according to the degree of mud soiling where:

1 = Clean animals with some mud on feet and ankles (ankle deep is approximately 4 inches/12 cm or just over the top of the hoof)
2 = Mud on the legs above the knees. Sides and belly clean
3 = Belly of the animals has mud cakes on them. Sides are clean
4 = Belly and sides of body have mud cakes on them

According to the National Research Council (NRC) (1996), optimum nutrient requirements for beef cattle can be calculated by taking into account the physiological state, activity and heat loss/heat production. Heat loss is affected by animal insulation factors as well as environmental factors. Therefore, computer models have incorporated mud as a factor in their prediction equations. For example, a mud adjustment factor for the calculation of external insulation runs on a 4-point scale where:

1 = Dry and Clean; no adjustment for external insulation
2 = Some mud on lower body; 80% of external insulation by the animal with this score
3 = Wet and matted; only 50% of external insulation with this condition
4 = Covered with wet snow or mud; this animal gets only 20% external insulation as compared to the one with a score of 1

Along with internal insulation, external insulation on beef cattle has a direct effect on the lower critical temperature, and this has a direct effect on energy needs for maintenance in a cold environment (NRC, 1996). Therefore, the less insulation for a group of animals, the higher is their energy needs only to maintain vital activities. If the energy of the ration is not adjusted accordingly, the animal may spend more energy only for maintenance than it will ingest. This, in turn, may lead to a decrease of internal insulation since the animal's reserves are used as an energy source for maintenance. This will increase the energy demand for maintenance up to a point where the animal can no longer cope with the environment resulting in reduced animal welfare.

It seems that mud has an impact on body condition and is at least indirectly associated with animal welfare. Although there is no available literature on the effect of mud on the welfare of horses in a feedlot environment, the importance of this factor in the feedlot beef cattle literature (reviewed in NRC, 1996) suggests that it may be beneficial to investigate this topic in feedlot horses as well.

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5. HANDLING AND TRAINING

LEARNING THEORY AND TRAINING PSYCHOLOGY

Conclusions:

1. **Many problem behaviours (such as bucking under saddle, rearing when ridden or kicking at a handler) can be avoided by understanding the correct use of learning theory and integrating this concept into the training program.**
2. **Many of the dangers of working with horses (e.g. being kicked by a startled horse) can be avoided by understanding how horses think and react.**
3. **Horse welfare can be enhanced by appropriate and "fair" horse training.**
4. **Horse welfare can also be reduced by the improper use of training psychology. For example, learning can be inhibited by fear and ill-timing of reinforcement or inappropriate use of punishment.**
5. **Horse wastage due to behavioural or physical problems is a major welfare concern for the equine industry. Owners have an obligation to understand horse behaviour and consult with a professional as needed to minimize this problem.**

Modern training practices are largely based on traditional methods that were developed and used since early domestication of the horse. Some historical methods relied heavily on punishment and 'flooding' (see below). In a review of the history of taming and training horses, Waran et al. (2002) noted how early cultures caught wild horses by chasing them down and lassoing them around the neck or leg. The horse was then ridden until all attempts to escape or buck off the rider would stop. This was repeated until the horse learned that resistance to restraint under any circumstance was unsuccessful. Traditional horse 'breaking' essentially used/uses the method known as 'flooding'. The erroneous belief is that the horse no longer attempts to rid itself of the saddle/rider and ceases to respond because it is no longer fearful. In reality, the horse has no control over the situation and learns instead that it is helpless to respond (McGreevy, 2004).

Humans have regularly used the strategy of dominance over horses in an attempt to elicit a desired behavioural response; however, this strategy may be ineffective given that the natural response to dominance in horses is avoidance. More recently, training has been shown to be more effective when the trainer has a good understanding of equine behaviour and learning processes (Murphy & Arkins, 2007).

Domesticated horses are required to learn a variety of artificial tasks, accept all sorts of stimuli and be exposed to environments that they find aversive. As examples, the natural tendency of horses facing jumps/obstacles is to go around them, not jump over them, but this is a behaviour required of show jumpers. Horses will also instinctively avoid dark, narrow areas, yet we require horse to suppress this natural fear reaction in order to load them into trailers (McCall, 1990). The list of tasks expected of today's horses is extensive and varied depending on the type of work the horse is used for. However, correct application of learning theory can address the majority of issues related to safely training and handling horses. Different forms of learning are described below.

Associative learning: The more modern methods of training are starting to focus on the correct use of learning theory. Broadly, there is classical conditioning (also known as Pavlovian conditioning), a kind of associative learning where the two events that are paired together are a neutral conditioned stimulus (CS) (like the sound of a clicker) and a biologically significant unconditioned stimulus (US) (e.g. food reward) (Pearce, 1997). Hence the animal anticipates the US (food reward) upon CS presentation (hearing the clicker); there is no need to do anything or manifest a behavioural response. An example of classical conditioning is when racetrack grooms whistle each time they see their horses urinate. The horse associates urinating with the sound of the whistle and as a result, grooms can get horses to urinate on cue at post-race urine tests (McGreevy, 2004).

The other type of associative learning happens through operant conditioning, in which a response made by an animal constitutes one event, and the outcome of that response constitutes the second event (Pearce, 1997). The second event is the reinforcing consequence of the response. This is sometimes called trial and error learning. Operant conditioning not only allows the animal the ability to associate events, but it gives the animal control over its environment; this is the main difference between classical and operant conditioning– in classical conditioning, rewards become associated with stimuli whereas in operant conditioning, rewards become associated with their own behavioural responses (McGreevy, 2004).

Discrimination: Learning research in horses has also included the animal's ability to learn discriminations. For example when Voith (1975, as cited in McCall, 1990), investigated discriminative ability, she discovered that horses learned spatial (left versus right) tasks much easier than visual tasks (black versus white stimuli). Horses have also demonstrated the ability to discriminate using auditory cues (Cruz-Becerra et al., 2009) and visual stimuli (Smith & Goldman, 1999). More recent studies have shown some evidence that horses are capable of categorization learning (i.e. discriminate 'triangles' from 'squares') (Nicol, 2002).

Habituation: Then there are the non-associative types of learning. Habituation, happens when a decline in the responsiveness to a stimulus is a result of its repeated presentation (Pearce, 1997). When habituating a horse to a particular stimulus, it is important to repeat exposure to the stimulus well beyond the point where the horse seems to be no longer reactive to it. Terminating the procedure too early can teach the horse the opposite of what is desired. Responses that have been trained to habituation may spontaneously recover when the stimulus is withheld. Hence continued exposure to the stimulus at certain intervals is required to prevent the original response from occurring (McGreevy, 2004). Desensitization is closely related and works by weakening or extinguishing an undesirable response (e.g. fear response) to a stimulus using a step-by-step process. By exposing the horse to the barely perceptible stimulus while in a relaxed state, the horse will not react fearfully, but remain unperturbed. The offending stimulus is then increased very gradually. If the process is forced too quickly, the undesirable response will return. If this should happen, the horse requires exposure to the stimulus again, but at the last level at which the horse responded successfully. A step beyond desensitization is counter-conditioning, whereby the horse is exposed to pleasant stimuli on top of habituating it to aversive stimuli. This may facilitate more appropriate responses to the aversive stimuli (McGreevy, 2004).

Sensitization: The opposite of habituation is sensitization in that there is an increase in response after repeated exposure to a particular stimulus. The stimulus is usually one that is intrinsically aversive and sensitization happens when the horse is unable to avoid or remove itself from its exposure. McGreevy (2004) gives the example of a police horse that is involved in road traffic accidents every day for a month could become hypersensitive to vehicles and even develop a phobia to the sight or sounds of vehicles. Sensitization is also required in most things we ask of horses. For instance, we need to desensitize horses to our leg, but also sensitize them to slight pressures in different areas to effect a desired response (e.g. to move sideways, forward, backward).

Reinforcers: A negative or positive reinforcer is anything that will make a response more likely to occur in the future. The word ‘negative’ has an unpleasant connotation, however ‘negative’ refers to the removal of something from the horse’s environment, whereas ‘positive’ refers to an addition. When a trainer reinforces a behaviour by removing something unpleasant, they are making the behaviour more likely to be repeated in the future. Negative reinforcement is the foundation of all pressure-release type training. For example, a rider that squeezes her legs to cue the horse forward, will release the leg pressure immediately once the horse moves forward. McGreevy (2004) gives the example of a horse trainer that stops tapping the horse with a whip as soon as it moves in the desired direction. This will make the horse more likely to move away from the whip the next time the tapping resumes. One can also use highly palatable food as positive reinforcement; or in some cases, wither scratching appears to serve as a positive reinforce. Likewise, being turned loose into a paddock may be considered rewarding by a horse that has been stabled, but returning to the stable may be rewarding if the weather is bad or it is time for feeding (Cooper, 1998).

Reinforcers can be either primary or secondary. Primary reinforcers are anything the animal is naturally motivated to seek, such as food, companionship, sex, turnout, etc. Secondary reinforcers are stimuli that have been paired with the primary reinforcer, and so become reinforcers, even though they have no intrinsically rewarding properties originally; for example uttering the words “good horse” becomes rewarding only because it was trained to associate it with something pleasant, like being given a carrot (McCall, 1990).

Punishment: A negative or positive punishment will act to make a response less likely to occur in the future. In punishment the trainer presents the aversive stimulus after the horse has made the undesirable response. This differs from negative reinforcement where it is the conditioning of preceding signals that predict the potential negative reinforcer.

Trainers and all handlers must exercise caution when using punishment because unintentional associations may be learned by the horse causing it to express new undesirable behaviour or confusion. McGreevy (2004) provides an example of a horse being punished for knocking down a fence, but then risks that the horse may develop a fear of jumping over fences. Rather than associating the fence being knocked down with the punishment, per se, the horse may learn to fear the trainer or fences in general. Learning can also be inhibited by fear and ill-timing of reinforcement or inappropriate use of punishment (McGreevy & McLean, 2009).

Shaping: ‘Shaping’ behaviour happens by reinforcing ‘successive approximations’ of the final behavioural response (Waran et al., 2002). For example, when training a horse to approach a target like a stick, a reward is only given when the horse moves closer to the stick or moves faster than the previous time. Training in this method requires the trainer to have patience and ability to recognize each improvement no matter how small and reinforce at those opportunities; that is the way to progress towards the final desired response (McGreevy, 2004).

Extinction: If a horse's learned response is presented but is no longer reinforced or if the conditioned stimulus is always presented without the unconditioned stimulus, extinction typically occurs. For example if a horse no longer receives its expected reward for a certain behavioural response, it will eventually stop producing the response or is less likely to behave in ways that have previously been rewarded (McGreevy, 2004). This is important when dealing with fearful responses that were modified by counter-conditioning because they can show spontaneous recovery if reinforcement is withheld.

Rate of reinforcement: Certain requirements must be met in order for training to be successful. One of them is the rate and schedule of reinforcement during training. Especially in the early phases of training, signals and rewards must be consistently paired with the desired response. Inconsistent delivery of signals can lead to horse confusion or unintentional conditioning of behavioural responses to random factors/stimuli during training. In order to avoid this it is recommended to use a fixed ratio of reinforcement such as continuous reinforcement –where the horse is rewarded for each and every response (Cooper, 1998). Specificity and consistency with regards to presentation of cues is of utmost importance. If a specific cue is not similar in presentation method and timing every time it is used, the horse may start to generalize to continue responding to that cue. Eventually, stronger or more salient cues will be needed in order to elicit the original response (McCall, 1990). McCall (1990) uses the example of horses employed for riding lessons– these animals become habituated to accidental stimuli put forth by inexperienced riders and may learn to become unresponsive to subtle cues. The horse will respond more quickly to a stimulus if the stimulus is presented at the instant when the horse is able to respond. Timing of stimulus delivery is imperative.

Once a behaviour can be produced consistently, it can be enhanced by means of a variable reward schedule, where the behaviour can be rewarded randomly and unpredictably from the horse's perspective. Myers and Mesker (1960) showed that horses can learn tasks according to different fixed-ratio positive reinforcement schedules (where reinforcement is given after a certain number of correct responses) and fixed-interval positive reinforcement schedules (where reinforcement is given only after a certain amount of time has elapsed). However, different schedules can be used for different results. Cooper (1998) suggests that fixed ratios of reinforcement (especially continuous reinforcement) lead to rapid acquisition of behavioural responses, but are prone to extinction in the absence of even occasional rewards. Variable reinforcement schedules, like randomly rewarding one response for every few produced, increases the strength of the conditioned response because of some unpredictability between response and reward. Cooper (1998) therefore recommends continuous or fixed reward ratios during initial training, but then switching to a variable reward schedule in maintaining the desired behaviour in order to guard against its extinction.

Social learning: There are different types of learning/behaviours that happen in the presence of conspecifics– social facilitation, stimulus enhancement and cultural transmission. With social facilitation, behaviours are produced by the presence of another animal that is carrying out those same behaviours (horses drink when they see other horses drinking). Stimulus enhancement is when one animal simply draws attention to an object/area rather than the activity that another horse is performing with the object or in the area. It is suggested that these types of copying behaviours are not what's known as true cultural transmission, which is believed to be a higher cognitive ability. True cultural transmission describes a type of learning whereby one animal observes another animal and produces spontaneous novel behaviour without the use of trial-and-error (McGreevy, 2004). Clarke et al. (1996) found that the behaviour of a demonstrator horse as it approached and interacted with an experimental object acted to draw attention to the object, thus employed ‘stimulus enhancement’. This explained why horses with prior exposure to a demonstrator were quicker to approach a food bucket and also eat from the correct food bucket. Lindberg et al. (1999), however, found that the opportunity for observational learning did not enhance a horse’s ability to perform an operant task. In several experiments into the social acquisition of behaviour, naïve horses exposed to a trained demonstrator horse, took as many trials to learn a novel task as horses that were not given the opportunity to watch a demonstrator (Baer et al. 1983; Baker & Crawford, 1986; Lindberg et al., 1999).

Constraints: Learning ability can be impaired by fear (Fiske & Potter, 1979), thus limiting induction of fear within training regimes may be beneficial. Nicol (2002) suggested that trainers using negative reinforcement should therefore use small numbers of trials within a session and space training sessions over time.

Food reward is most often used as a primary reinforcer when studying equine learning under experimental conditions, yet it is rarely employed by horse trainers (Nicol, 2002). This might be due to the practical difficulty of delivering food immediately after the horse has produced a correct response. In McGreevy’s (2004) book of equine behaviour, it is stated that devices that instantly deliver rewards straight to the horse’s mouth would enhance the speed and efficacy of learning as it minimizes the time between the performance of the behaviour and its reinforcement. Horses do not learn effectively when there is a delay as they do not relate the reinforcement to the behaviour (McGreevy, 2004). The practical constraints of using positive reinforcements may be one of the reasons why horse training customarily employs negative reinforcement. Heleski et al. (2008) investigated whether the addition of positive reinforcement to negative reinforcement would enhance learning in horses being taught to walk over a tarp; no difference in time to first tarp crossing or time to achieve calmness criterion (crossing without exhibiting anxiety) was detected. Thus, adding positive reinforcement did not significantly enhance this learning task. However, the authors claimed that adding the positive element into their training made the task safer/less fatiguing for the handler, which adds practical value to using positive reinforcement.

Conclusion: Many trainers and other horse personnel may not be familiar with the term “learning theory” but may be quite skilled in their application of the primary principles. The correct application of negative reinforcement, positive reinforcement, and, in some cases, punishment is essential to good horse welfare and also safety in working with horses. Horses who are well trained in ground skills, under saddle skills and/or in harness skills are safer for everyone to work with and are more likely to have good welfare for their entire life. Much of the horse wastage in the industry relates to behavioural problems that are often the result of poor training methods (Ödberg & Bouissou, 1999).

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HYPERFLEXION

Conclusions:

1. **Hyperflexion (sometimes referred to as Rollkür) is a controversial training technique used in various riding disciplines, but currently receiving considerable attention in dressage training. It involves forcibly riding the horse (or lungeing) in a head:neck position that is considerably behind the vertical.**
2. **The research related to hyperflexion/ Rollkür is equivocal, sometimes showing no measurable effect of this training practice on the horse and other times showing a negative effect.**
3. **More research is needed on this topic.**

Horse riding in the domain of dressage, as well as other disciplines, has employed a particular training technique called hyperflexion (also known as Rollkür), which has come under scrutiny by those concerned for horse welfare. Hyperflexion used in other horse competition disciplines has not received the level of attention it has in the dressage world. Hyperflexion is sometimes used during warm-up or training, but this practice is criticized based on its supposed tendency to interfere with proper vision, breathing and head movements. McLean and McGreevy (2010) defined it as "a technique in which the horse's neck is dorsoventrally hyperflexed as a result of bit pressure to the point where the horse's chin may touch its pectoral region". In a workshop to specifically address the welfare implications of hyperflexion, the Fédération Equestre Internationale (FEI) defined hyperflexion as: "a technique of working/training to provide a degree of longitudinal flexion of the mid-region of the neck that cannot be self-maintained by the horse for a prolonged time without welfare implications." They also stated that "There must be an understanding that hyperflexion as a training aid must be used correctly, as the technique can be an abuse when attempted by an inexperienced/unskilled rider/trainer" (FEI, 2006). After much debate at the FEI workshop the "evidence was presented that indicated in experienced hands there was no apparent abuse, improper welfare or clinical side effects associated from the use of hyperflexion. However, if not practiced correctly, there are serious concerns for welfare and possible clinical injury that will affect a horse's wellbeing and performance" (FEI, 2006). Many questions remained unanswered, namely at what stage does hyperflexion "use" become "abuse" and what constitutes "too much" hyperflexion; also what constitutes "experienced hands"? In closing, the workshop and its resulting report acknowledged that much research is needed to address these questions (FEI, 2006). However, at the 2010 FEI round table, it was agreed that whereas the 'low, deep and round', technique (which achieves flexion without undue force) is acceptable, hyperflexion/Rollkür (defined as flexion of the horse's neck achieved through aggressive force) is not permitted (FEI, 2010).

There has been much vigorous exchange of opinions regarding Rollkür. Some argue that it could have beneficial effects on locomotion (van Weeren et al., 2006) while some argue that it stresses the intervertebral discs in the nuchal area and the withers causing lesions or pain in horses with pre-existing conditions (Denoix, 2006). Some even argued that Rollkür significantly restricts horses' vision as it is known that horses regularly adjust their head and neck positions in order to focus on objects at different distances (Harman et al., 1999, McGreevy, 2004). However, the idea that vision is impaired during the hyperflexed position was refuted by Bartos et al. (2008).

Lastly, in a study to determine the effect of head and neck position on upper airway flow mechanics in exercising horses, Petsche et al. (1995) noted that compared to unrestrained and extended necks, head and neck flexion caused some upper airway obstruction. This is potentially stressful to horses as they are experiencing less than optimal air intake during exercise/physical exertion.

Further studies by van Breda (2006) and van Oldruitenborgh-Oosterbaan et al. (2006) interpreted their physiological results as Rollkür being non-stressful. However, von Borstel et al. (2009) investigated the behaviour associated with this practice. These authors looked for indications of stress, discomfort and fear when horses were ridden in Rollkür compared to regular poll flexion. In addition, horses were observed for preferences between the two riding styles when given the choice. When the two different styles were associated with specific arms of a Y-maze, horses significantly chose more often the maze-arm associated with the regular poll-flexion. When ridden in Rollkür, horses showed more behavioural signs of discomfort such as tail-swishing, head-tossing or attempted bucks. In addition, a subset of their subjects were subjected to two fear tests following a short ride using both methods. During Rollkür, horses reacted more to the fear stimuli.

Clearly more research focusing on the direct impact of hyperflexion on various aspects of horse welfare is needed.

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HEADSHAKING[4]

Conclusions:

1. **Headshaking is more appropriately classified as a patho-physiological problem than a stereotypic problem; however, identifying the source of the problem is still challenging.**
2. **Headshaking can only be considered idiopathic after all physical reasons have been ruled out.**
3. **There are several possible treatments for headshaking ranging from non-invasive, nasal occlusal masks to invasive surgery techniques.**
4. **Headshakers that cannot be treated pose a danger to the rider and are hard to manage; once again, this may result in horse wastage.**

Recognizing headshaking: Headshaking is described as uncontrollable, persistent or intermittent, sometimes seasonal, repetitive, vertical, horizontal or rotational movements of the head or neck, and can occur with such frequency and vigour that it appears distressing to the horse and also makes it dangerous or difficult to ride (Newton, 2005). It seems to affect all types of horses and has been documented to have an age onset of about 7 years, although it can affect horses of any age (Mills et al., 2002). Rubbing the sides of the face, rubbing the nose into the ground or on objects, striking at the face/nose area with the foreleg, low head carriage, sneezing, snorting and moving the head as if a bee had flown up its nostrils are also common features of head shaking (Lane & Mair, 1987; Madigan & Bell, 1998). The rubbing and violent flicking response suggests that the horse feels some sort of sensation or pain (Newton, 2005). Additional signs of nasal irritation seen in horses with idiopathic headshaking include coughing, excessive lacrimation (tearing of the eyes) and nasal discharge (Lane & Mair, 1987).

Cases are classified as idiopathic only after excluding a host of other problems that may be causing the headshaking. When Lane and Mair (1987) studied 100 cases of headshaking, possible causes were identified in only 11 horses. These included ear mite infestation, otitis interna, cranial nerve dysfunction, cervical injury, ocular disease, guttural pouch mycosis, dental periapical osteitis and suspected vasomotor rhinitis. Hence it is important to run thorough diagnostic tests, paying particular attention to the head/neck region, and then trying different avenues of treatment before labeling headshaking as idiopathic. Diagnostic tests include radiography, videoendoscopy, biopsies, endoscopy and serology (Newton, 2005). Although there is no one consistently successful treatment for idiopathic headshaking there are many different techniques that could provide horses some relief of their condition.

Triggers and treatment: Although it is a recognized condition within the equine field, headshaking remains poorly understood and its overall prevalence is still not known, though it appears to be relatively infrequent overall (Newton, 2005). Therefore, there currently is no consistently successful treatment (Newton, 2005). That is not to say that there are no treatments. There are several methods of treating this condition. Once considered primarily a behavioural

[4] This patho-physiological problem should not be confused with more common types of head tossing that may be caused by wolf teeth, poor dental care, or a poor choice of the bit being used, as several examples.

problem, headshaking is now considered a medical disease and cases are referred to equine hospitals (Newton, 2005).

The non-invasive technique of using a nasal occlusal mask/nose net has proven to be useful in many cases of idiopathic headshaking. The theory behind wearing a mask is that it slows down the passage and/or lessens the impact of air flow entering the nostrils and blocks the entrance of any particulate matter. This decreases any irritation to the caudal nasopharyngeal region (Newton, 2005). Mills and Taylor (2003) studied the efficacy of three types of nose nets for the treatment of seasonally affected headshakers and found the nets significantly reduced the overall headshaking score. Results of Mills and Taylor’s (2003) study propose that nose nets can be a useful, safe and convenient intervention for horses displaying certain types of headshaking.

Horse owners generally notice headshaking during exercise, but as the condition worsens, it can be seen even during rest (Newton et al., 2000). According to Lane and Mair’s (1987) records, the majority of horses exhibit headshaking behaviour at exercise. The authors also believe that many of the undiagnosed idiopathic cases show signs suggestive of some sort of allergic rhinitis. However, attempts at treatment for allergy with corticosteroid and antihistamines have been mostly ineffective (Lane & Mair, 1987; Mair et al., 1992). Instead, Newton et al. (2000) believes that the causal root of headshaking lies within the hypersensitivity of the caudal nasal branch of the trigeminal nerve, and is not likely an allergic disorder. Local anesthesia of this specific site results in an 80 to 100% reduction in headshaking response (Newton, 2005).

Another method of controlling the perception of pain is by limiting input from the trigeminal nerve. This can be done through caudal compression of the infraorbital nerve. Roberts et al. (2009) hypothesized that caudal compression of the infraorbital nerve by insertion of platinum embolisation coils would decrease clinical signs of headshaking and indeed the authors reported a successful outcome of this surgical technique. It is possible, though, that the signs would recur due to nerve re-growth.

Because Newton et al. (2000) saw some clinical features in common with trigeminal neuralgia in humans, the authors tried treating headshaking with carbemazepine, a drug used to treat human trigeminal neuralgia. Carbemazepine significantly improved signs of headshaking and the study concluded that a trigeminal neuritis or neuralgia may be the basis of the underlying aetiopathology of some cases of equine headshaking.

Madigan and Bell (1998) found that 76% of headshaking horses treated with cyproheptadine, showed moderate (lessened symptoms), to significant improvement (completely asymptomatic). Cyproheptadine is an H-1 receptor antihistamine that also possesses serotonin-antagonist properties. It is hypothesized to be efficacious due to its serotonergic blocking properties and serotonin plays a role in pain sensation (Bell, 2004).

Some researchers also report that headshaking is worse in bright light. Madigan et al. (1995) believed many cases to have a photic component as their study showed blindfolding, wearing dark grey contact lenses and being in the dark significantly reduced or eliminated headshaking. Similarly, Madigan and Bell (1998) demonstrated that blindfolding horses from bright conditions decreased the severity of headshaking and suggested a mechanism similar to the ‘photic sneeze’ in humans, where stimulation of the cranial nerve II (optic nerve) triggers nasal stimulation and results in a sneeze. It is suggested that photic stimulation should be viewed as one of many different means to trigger headshaking or alter the threshold for neuropathically mediated trigeminal nerve pain (Madigan & Bell, 1998).

There is also a component of seasonality, where initial occurrence and subsequence recurrence is seen mainly in spring/summer with regression of signs during fall/winter (Lane & Mair, 1987; Newton et al., 2000). There are characteristics about the spring and summer season that are likely to explain the high proportion of horses being affected during this time, including the increase in day length and light intensity, the tendency for horses to be ridden out for longer and increased levels of pollen and other irritants (Mills et al., 2002). In an experiment on three seasonal headshakers, Stalin et al. (2008) tried treating the horses with cromoglycate eye drops after finding no effect of dexamethasone/neomycin eye drops. Within three days of treatment, ocular discharge would resolve and headshaking would stop, allowing horses to be ridden again. However, headshaking would return upon treatment discontinuation.

Perhaps the most invasive method of treating headshaking is that of tracheostomy. This procedure has been done on a small sample of animals and is used as a last resort if nothing else helped the headshaking (Newton, 2005). The prevailing idea is that most cases of headshaking are in fact, idiopathic (Lane & Mair, 1987). Headshaking is likely to have multiple underlying aetiologies therefore finding an effective treatment may have to be dealt with on a case by case basis depending on the individual's history and symptoms.

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