



Review

Equine stereotypic behaviors: Causation, occurrence, and prevention

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ABSTRACT

There are strong suggestions that equine stereotypies are connected to poor welfare and a suboptimal management and/or stabling environment. Different forms of equine stereotypic behaviors have been described. Crib biting, weaving, and box walking are considered the most prevalent. Several studies have been conducted to establish links between the underlying causes and potential function of such behaviors. Both experimental and epidemiological studies have indicated management factors specifically feeding practices, housing conditions, and weaning method as crucial in the development of stereotypies in stabled horses. Some neurological studies on equine stereotypy demonstrated some forms of central nervous system dysfunction as being associated with the performance of stereotypic behaviors. Different researchers hypothesized that the functional significance of stereotypies is that they reduce stress in captive environments and should thus be considered as a coping mechanism. In contrast, the owner's perspective is often that a stereotypic horse has a "stable vice" that needs to be stopped, and different kinds of methods have been developed to control or regulate stereotypic behaviors. However, if the stress-reducing hypothesis is correct, controlling stereotypic behaviors particularly by physical and surgical approaches without addressing the underlying causes is of great concern to the horse's welfare. Although there is ongoing uncertainty about the exact function, the growing knowledge about causation should be applied: under all circumstances prevention is better than cure.

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Introduction

There are different indicators of welfare such as health, injury, production (e.g., growth rate and number of offspring), and physiological parameters, as well as behavioral indicators, for which there is good consensus among welfare scientists (Dawkins, 1998; Keeling and Jensen, 2009). Behavioral indicators appear to be advantageous because behavioral changes are often the earliest signs that can be found to indicate suboptimal conditions (Keeling and Jensen, 2009). Behavioral indicators include stereotypic behavior, and it is widely accepted that such behaviors are linked to poor welfare and are more likely to occur in suboptimal environments.

Stereotypies are defined as repetitive behaviors with no obvious goal and function (Clegg et al., 2008). Because they have never been observed in free-ranging feral horses and are reported in more than 15% of domesticated horses (Luescher et al., 1991), they are known as the disease of domestication (Marsden, 2002). Additionally,

various prevalences of stereotypic behaviors have been reported in horses from different horse competition disciplines. For example, in dressage, eventing, and endurance horses, the reported percentage of prevalence for stereotypic behaviors was 32.5, 30.8, and 19.5, respectively (McGreevy et al., 1995b). Stereotypies have been reported in a variety of other species in captivity. Specific examples include vacuum chewing and bar biting in sows (Whittaker et al., 1998; Stewart et al., 2011), tongue rolling in cattle, pacing, and other locomotory behavior in mink (Mason, 1993), as well as object licking in giraffes (Mason and Rushen, 2006).

It is not self-evident whether stereotypies are the representative of the current situation or of a previous suboptimal condition. This is because of the discovery that once a stereotypic behavior is established it will become a habit and is difficult to stop or rectify (Mason and Latham, 2004; Cooper and Albentosa, 2005; Henderson, 2007). Thus, stereotypies may have to be considered as a sign not only of earlier suffering but also as indicators of current poor welfare (Mason and Latham, 2004).

Although domestication occurred in wild horses more than 6000 years ago and the horse has been adapted to the human environment, evidence suggests that behavioral patterns and capacities of domestic horses are not so different from free-ranging

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feral horses in the wild. Comparative studies aiming to find differences between the behaviors of the Przewalski and domestic horses can provide useful insight for the management of stabled horse. Przewalski horses, *Equus przewalskii*, are the closest relative to the domestic horse, *Equus caballus*, and are the only free-ranging wild horses that exist in the nature (Boyd and Bandi, 2002).

A comparison between the time budget of free-ranging horses and those in the current stabling and managing systems may reveal potential problems of stable environment. Time budget is a term used to quantify the time that animals dedicate to perform different activities during a day (Keeling and Jensen, 2009). Analysis of natural behavior of horses based on scientific observations gives insight into important changes from a “natural” time budget, and this may be essential to identify risk factors associated with the development of abnormal behaviors.

The present review begins with an appraisal of what is considered typical behavior for the horse. Then, the common forms of equine stereotypies are described, and their biology explained in terms of scientific theories related to feeding practices, housing conditions, and weaning methods. Then, the underlying causes of stereotypic behaviors and improvements to the current stable situation will be addressed. Thereafter, the article focuses on different preventive methods and discusses if and how the underlying causes are addressed. Finally, some recommendations are given.

Some relevant aspects of natural behavior of the horse

Based on ethological research of domestic and Przewalski horses, this section is focused on those natural behaviors of the horse that are most likely to be affected under current housing and management practices.

Horses are herbivores. Feral horses have been observed to feed on mixed plant species, predominantly selected from grasslands (Fleurance et al., 2001). Environmental conditions and annual diet availability strongly affect their food selection patterns. Because of seasonal growth of some plant species, coping with dietary variety is an important function of the horse's digestive system because this will allow keeping the daily intake high, over the year (Putman, 1986; Houpt, 2005). Horses often feed on low energy and high-fiber plants. To compensate for low daily energy uptake, horses voluntarily increase daily intake and rate of gastrointestinal passage (Putman, 1986). In general, free-ranging horses spent a large proportion of their time budget (16–20 hours per day) grazing (Keiper, 1986). From a digestive physiological perspective, the horse's stomach should be always relatively full. Thus, although the horse's stomach is anatomically relatively small, it rarely empties completely under natural conditions. The large intestine has an important role in the horse's digestive tract because that is the place for fermentation of feed and also a large proportion of calories are obtained from cecal and colonic fermentations. To regulate proper fermentation of foods, consumption of high-fiber forage is necessary (Sneddon and Argenzio, 1998; Hoffman et al., 2001).

Feeding practices in captive domestic horses are far from the natural situation. Horses are often fed a combination of high-energy concentrates and relatively little forage. Concentrates and forage are often offered only 2 times per day, therefore placing the horses under relatively long periods of food deprivation (Sneddon and Argenzio, 1998; Henderson, 2007; Wickens and Heleski, 2010).

In natural conditions, horses live in social groups (Budiansky, 1997). Groups generally consist of a stallion with his harem, that is, females and their offspring. Because horses are considered prey species in nature, social living is beneficial in terms of predator avoidance and provides more safety when threatened. Dominance hierarchies are established within the group, and these seem to be remarkably stable over time (Boyd, 1991; Araba and Crowell-Davis,

1994; Miller, 1997). Social relationships within the herd are frequently reinforced by mutual grooming, food sharing, following behavior, and rest and play with each other (Boyd, 1988, 1991). Current housing conditions of domestic horses often limit social interactions with conspecifics (Cooper and Mason, 1998). Traditionally, stabled horses are individually housed to reduce the risk of infection, ease of management, prevent development of stereotypies copied from affected horses, and so on. Such situations would increase the chance of stereotypy performance (McBride and Long, 2001).

During a day in the natural situation, horses typically travel over their home range, which varies from 1–48 square kilometers (Keiper, 1986). A large proportion of their time budget is spent foraging. (Henderson, 2007). It has been estimated that horse will take more than 10,000 strides per day just as its natural feeding pattern (Houpt, 2005).

Today's domestic horses are often housed in a restricted environment with often quite severe restricting of locomotion compared with the natural situation. Inadequate physical exercise and the confinement of the stable environment can potentially lead to some forms of locomotion stereotypies.

Weaning is a crucial time of a horse's life during which different kinds of management practices and weaning methods have been reported to be associated with the onset of stereotypies in a captive situation (Apter and Householder, 1996; Waters et al., 2002). Artificial weaning of the foals within the current stable situations, including for instance postweaning confinement, has been reported to be associated with increased incidence of stereotypic behaviors (c.f. Waters et al., 2002), and partial gradual weaning techniques are least stressful (Apter and Householder, 1996). Weaning is further described in more detail in the later sections.

Different forms of stereotypic behaviors in the horse and their occurrence in practice

Several behaviors have been observed in stabled horses that match the definition of stereotypic behavior. Most frequently observed stereotypies in domestic horses are crib biting, weaving, box walking, wind sucking, and wood chewing (however, there is no scientific consensus as to whether wood chewing is definitely a stereotypy [Normando et al., 2011]). More recently, some morphological variations of these stereotypic activities have also been identified as equine stereotypies, such as licking the environment, lip licking, sham chewing or teeth grinding, self-biting, and rubbing self, as well as locomotion stereotypies, including pawing, tail swishing, door kicking or box kicking, and head tossing/nodding (Cooper and McGreevy, 2002; McGreevy, 2004; McBride and Hemmings, 2009). The most common forms of equine stereotypies within 2 general categories, oral and locomotion stereotypic behaviors, are described in greater detail in the following subsections.

Oral stereotypic behaviors

Crib biting

Crib biting is one of the most prevalent stereotypic behaviors in horses (2.4%–8.3% in Europe and Canada [McGreevy et al., 1995b] and 4.4% in the United States [Albright et al., 2009]). It is defined as grasping a fixed horizontal object (e.g., fence, stall, or building structures) with the incisor teeth while contracting the ventral neck muscles and pulling backward. Horses may or may not (depending on the individual horse) draw air into the upper esophagus (McGreevy et al., 1995a, 1995c; Wickens and Heleski, 2010; Normando et al., 2011). The movement of air produces an audible

grunt (Wickens and Heleski, 2010). Although horses often crib on wood rather than metal materials, they will crib on metal structures if a wooden substrate is not available (McGreevy, 2004). Clinical effects of crib biting have been observed as poor performance, abnormal wear of the incisor teeth (in severe cases resulting in dental disease), weight loss, and a specific form of colic resulting from entrapment of the small intestine in the epiploic foramen (Archer et al., 2004). Crib biters are also believed to have a lowered learning ability compared with nonstereotypic horses (Parker et al., 2008b; Nagy et al., 2010), which is further described in “The biology of stereotypic behaviors” section.

Wind sucking

In wind sucking, the horse opens its mouth, bends its neck and contracts the ventral neck muscles, and pulls air in the esophagus with the support of the neck muscles, without grasping any solid objects with its teeth (Normando et al., 2011). Wind sucking often occurs together with crib biting; however, it is performed without supporting the teeth on any solid material (Devereux, 2006; Wickens and Heleski, 2010). Wind sucking/crib biting behavior was reported to be significantly associated with colic (Malamed et al., 2010). The prevalence of wind sucking has been reported to be 3.8% for nonracing horses in North America (Christie et al., 2006).

Wood chewing

Wood chewing involves chewing on any materials made of wood or wooden objects without swallowing air (Normando et al., 2011). Some survey studies on occurrence of oral stereotypies have noted that wood chewing is often confused with crib biting and is difficult to define (Albright et al., 2009).

Locomotion stereotypic behaviors

Weaving

Weaving occurs when the horse swings its head and neck from side to side and shifts its weight from 1 foreleg to the other, sometimes in coordination with the hindquarters while standing in the same place (Mills and Riezebos, 2005; Normando et al., 2011). Weaving often leads to locomotory problems, for example, strained ligaments, poor performance, and reduced condition of the horse (McBride and Hemmings, 2009). It is also believed, by some owners, to be the cause of weight loss, uneven muscular development of the neck, and fatigue that may affect a horse's performance (Winskill et al., 1995). The mean percentage prevalence of weaving behavior has been reported to be 3.25% (Luescher et al., 1998; McGreevy, 2004).

Box walking

Walking around the box for hours on end, in a repeated pattern, irregular directions, or figure 8-shaped track are the telltale signs of box walking (Devereux, 2006; Normando et al., 2011). This may be associated with loss of condition and sometimes poor performance (Haupt, 1986). This stereotypic behavior also makes it difficult to keep the bedding clean and fresh, leading to further degradation of condition (Devereux, 2006). The prevalence of box walking has been reported as 2.20% in a study of 13 populations (McGreevy, 2004).

The biology of stereotypic behaviors

Both experimental and epidemiological studies commonly indicate frustration, boredom, and stress because of the husbandry

environment, where the horse is in a situation far from what one may consider natural, as causative factors of stereotypic behavior. Broadly speaking, stereotypic behaviors can develop when the animal is deprived of carrying out patterns of behavior that it is intrinsically motivated to perform, such as when the horse cannot avoid a stressful situation, cannot graze, or when it is prevented from social contact. Thus, the main causes of performing stereotypies in domestic horses are generally attributed to the following factors: feeding practices, limited social contact, and lack of locomotion because of restrictive stable environment (McBride and Cuddeford, 2001; Cooper and Albentosa, 2005; Henderson, 2007; McBride and Hemmings, 2009; Litva et al., 2010; Wickens and Heleski, 2010).

It is generally accepted that preventing stereotypies from developing is more effective than attempting to stop them, once they have been established. It is thought that they move into central control, become a habit, and become more resistant to eradicate over time. “Central control” refers to a need in animals with established stereotypic behaviors (see also “Neurobiological perspective of equine stereotypies” subsection). Ultimately, to prevent them from developing, it is necessary to understand the underlying causes and predisposition factors and deal with those (McBride and Cuddeford, 2001; McBride and Hemmings, 2009; Wickens and Heleski, 2010). Different theories have been put forward to explain the causation of equine stereotypies in relation to current housing and management practices. In this section, these theories will be addressed.

Theories of causation of equine stereotypy

Theories regarding feeding practices

Theory of gastrointestinal irritation

Current feeding practices in the equine industry, and particularly elite performance horses, consist of feeding high-quality concentrates and relatively low amounts of forage with limited access to pasture and in general a short feeding time. This leaves horses vulnerable to gastrointestinal problems. When the stomach is completely empty and there is no alkaline saliva in the gut to buffer the stomach acid, the pH of parts of the digestive system (stomach or large intestine) decreases and ulceration of the protective stomach and/or intestine tissue, squamous mucosal lining, occurs (Moeller et al., 2008; Wickens and Heleski, 2010). It has been observed that gastrin hormone stimulates the secretion of gastric acid in response to concentrate feeding and palatable diets. Oral stereotypies, such as crib biting and wood chewing, are suggested to be an adaptive response to stomach acidity aiming to raise pH by an increased flow of alkaline saliva (Moeller et al., 2008). However, a recent study (Haupt, 2012b) showed that saliva production was not increased during crib biting. Several studies have demonstrated an association between crib biting and production of saliva suggesting that gastrointestinal irritation (increased gastric acidity) could be the motivation and possible cause for the development of this stereotypic behavior (Nicol et al., 2002; Cooper and Albentosa, 2005; Henderson, 2007; Wickens and Heleski, 2010). This theory is supported by a study conducted by Johnson et al. (1998) who showed that supplemented concentrates with the nontherapeutic antibiotic virginimycin increased cecal pH and reduced abnormal oral behaviors. They suggested that virginimycin increased the hindgut pH and subsequently reduced oral stereotypies and improved the behavior. However, the authors commented that virginimycin also increased the feeding time because of a reduction of the palatability of the feed, and this could also have decreased the crib biting behavior (see also the “Theory of reduction of feeding time”). A similar study suggested that providing a diet with antacid

supplementation might be an effective means of reducing crib biting and wind sucking stereotypies because antacid supplementation decreases/buffers the stomach acidity and subsequently decreases gastrointestinal irritation (Mills and Macleod, 2002). However, in a recent study conducted by Freire et al. (2008), virginimycin had no effect on crib biting and weaving. Thus, the authors suggested that crib biting and weaving might not be influenced by hindgut acidosis.

Ghrelin has been identified as one of the gastrointestinal factors in gastric mucosa to control the food intake. Ghrelin was shown to have a higher plasma concentration in crib biting than the control horses (Hemmann et al., 2011).

Although, the studies aimed to find the association of stereotypies and gastrointestinal irritation revealed inconsistent results, there is convincing evidence indicating that concentrate feedings without appropriate access to forage are problematic.

Theory of reduction of feeding time

Concentrates are starch-rich cereal-based feeds that provide the nutritional requirements of the domestic horse quickly. They are consumed in a short period, although the psychological need of foraging for many hours per day may still exist. The prevalence of oral stereotypies in the immediate postfeeding period not only in horses but also in other species such as pigs shows that they are still food motivated. (McGreevy et al., 1995a; Cooper and Albentosa, 2005; Henderson, 2007; Wickens and Heleski, 2010; Stewart et al., 2011). Additionally, food restriction has been found as one of the main factors associated in the development of stereotypic behaviors in pigs. A positive correlation has been identified between certain stereotypies and increasing food restriction in sows (Spoolder et al., 1995; Whittaker et al., 1998; Stewart et al., 2011).

Theory of meal frequency

The horse's natural feeding pattern consists of 16–20 hours grazing per day whereas, within the current equine industry, foods are often delivered twice a day (including concentrate and forage ration). At the time of delivery, horses perform anticipatory appetitive activities, such as pawing, door kicking, or weaving. The theory is that such behaviors become then a conditioned response to repeated delivery of the meal. Crib biting or wood chewing is most apparent as a postprandial behavior in horses with little fiber, whereas weaving and nodding commonly occur before receiving a concentrated feed (McGreevy et al., 1995a; McBride and Cuddeford, 2001; Cooper and Albentosa, 2005; Henderson, 2007; McBride and Hemmings, 2009; Wickens and Heleski, 2010). A study investigating the effects of increasing meal frequency (with the same amount of daily intake) on stereotypic behaviors has revealed that oral stereotypies decreased, whereas locomotor stereotypies (weaving and nodding) increased (Cooper et al., 2005). In contrast, increased feeding frequency to 4 times a day without daily access to pasture has been associated with an increased chance of both oral and locomotor stereotypies (Bachmann et al., 2003a). Therefore, research aimed to find an association between feeding frequency and stereotypic behaviors showed contradictory results, and it did not consistently support the hypothesis “increasing meal frequency” as an appropriate alternative reduces stereotypic performance.

Theories regarding housing conditions

Social isolation and restrictive locomotion

Development of stereotypic behavior has been associated with the lack of social contact in several species, such as primates (Novak et al., 2006), laboratory birds (Henry et al., 2008), captive parrots (Meehan et al., 2003), and stalled horses (Cooper et al., 2000). Current housing conditions of domestic horses are often limiting

social interactions with conspecifics (Cooper and Mason, 1998). It has been reported that locomotion stereotypies, including weaving and box walking, are more frequently observed in response to the confinement of the stable environment, inadequate physical exercise, and motivation for social contact (McGreevy et al., 1995a; Nicol, 1999). Locomotion stereotypies have been found to be negatively correlated with social contact and daily turnout. Performing weaving activities in the hour before daily turnout can be because of lack of social contact and environmental activity (Clegg et al., 2008). Thus, increasing the opportunity for social interaction among stable mates may reduce the incidence of stereotypic behaviors (Cooper and Mason, 1998). Cooper et al. (2000) showed that visual and tactile contacts with the neighboring horses through a grille between stables reduced weaving and nodding. It has been demonstrated that using windows within the stables of horses, providing visual contact with conspecifics, was also associated with a reduction in performance of any abnormal behavior (Ninomiya et al., 2008). Pregnant mare urine (PMU) industry farms collect the PMU to make estrogen supplements. The welfare of pregnant mares in the PMU could be an area of concern because of restrictive housing system in which horses have limited opportunity for movement and exercise (Jongman et al., 2005). However, lower incidences of stereotypies in tie-stall situations (e.g., PMU farms) have been reported compared with stable housing systems. It may be explained by greater opportunity for social interaction (Flannigan and Stookey, 2002). In a similar study, the effect of 2 different housing conditions, individual stables versus pair housing, was compared. This demonstrated the effect of sudden isolated stabling of young horses, which resulted in a higher prevalence of stereotypies (Visser et al., 2008). Also the lower risk of stereotypy as observed on large yards may be related to increased visual contact and yard activities compared with smaller yards (McGreevy et al., 1995a). Increasing the chance of visual and/or tactile interaction with conspecifics may therefore decrease the development of stereotypies because of social isolation.

Stress and the performance of stereotypy

Previous studies have demonstrated that stereotypies are related to physiological indicators of chronic stress (Mason and Rushen, 2006). However, results from experimental studies on the association of stereotypic behavior and stress-coping function are contradictory (Wechsler, 1995; McGreevy, 2004). Heart rate as one of the measurements of stress was lowered during bouts of crib biting (Lebelt et al., 1998). Additionally, experiments in which equine stereotypies were prevented have been linked to an increase in stress-related factors including plasma cortisol concentration, providing further support that stereotypies may reduce stress (McBride and Cuddeford, 2001). In contrast, no significant differences were observed in plasma cortisol level and heart rate of the crib biters and weavers, compared with a control group (McGreevy and Nicol, 1998a; Clegg et al., 2008). Cortisol is an indirect measurement of stress and is present in blood plasma, saliva, and urine. It has also been observed that crib biters have lower basal parasympathetic and higher basal sympathetic activity than non-crib biting horses (Bachmann et al., 2003b). This might be an indication of higher mean heart rate in crib biting than the control horses (McGreevy, 2004).

However, one of the influential theories about the functional significance of stereotypies is coping with stress or reducing the stress in a captive situation (McGreevy, 2004; Cooper and Albentosa, 2005). Such a coping function may be diminished when stereotypies are inhibited (McGreevy and Nicol, 1998b; Nagy et al., 2009). If the stress-reducing hypothesis is correct, prevention

of stereotypic behaviors without addressing the underlying causes is a welfare issue (Houpt, 2012a).

Neurobiological perspective of equine stereotypies

The neurobiological consequences/regulation of equine stereotypies focuses on neurotransmitter systems, specifically the serotonergic and dopaminergic pathways (Rendon et al., 2001; McBride and Hemmings, 2009; Wickens and Heleski, 2010).

Serotonin is thought to be implicated in the underlying pathology of stereotypies, and a trend in blood plasma has been reported for lower basal levels in stereotypic, rather than non-stereotypic, horses (mean, 201.5 vs. 414.3 nmol/L) (Lebelt et al., 1998). Although administration of serotonergic drugs has been associated with the reduction of stereotypies, it was doubtful if such medications decreased stereotypic behaviors because of general sedative effects or selectively influenced stereotypic behavior. The precise function of serotonin in performance of equine stereotypies is still unclear, and additional studies are required to give a more accurate interpretation with regard to stereotypies (Wickens and Heleski, 2010).

Several studies have reported dopamine and reward systems as factors associated with the development and maintenance of stereotypies (Marsden, 2002; McBride and Hemmings, 2009; Wickens and Heleski, 2010). Stereotypies can act as a rewarding behavior and help a horse cope with a suboptimal environment. The higher production of beta-endorphin in crib biters than the control horses has been suggested a possible source of reinforcement for performing stereotypies. Crib biting was found to be significantly reduced by 84% in response to administration of the opioid antagonist, naloxone; however, a reduction in weaving behavior was not observed. Because of an increase in the resting behavior of crib biters, it was suggested that a generalized sedative effect of the opioid antagonist caused the reduction of crib biting (McBride and Cuddeford, 2001; McGreevy, 2004). Contrary to expectation, short-term prevention of crib biting was associated with higher level of beta-endorphin (McGreevy and Nicol, 1998a). In contrast, Pell and McGreevy (1999) observed no significant differences in plasma beta-endorphin levels of stereotypic and control horses.

In terms of the anatomical regions of the brain, the basal ganglia have been identified as being a critical region with regard to performance of stereotypies. Recent studies have focused on the striatum as the part of the basal ganglia to be linked with neurophysiological processes during stereotypic activities (McBride and Hemmings, 2009). Antelman and Szechtman (1975) showed that injection of the dopamine neurotoxin (6-hydroxydopamine) into the striatum region of the basal ganglia in rats significantly reduced environmentally induced stereotypies. Various models described stereotypic behaviors as stress-induced activities. Stress stimulates endorphin release, subsequently triggering the release of striatal dopamine. Dopamine is suggested as an activator of basal ganglia motor programs that reinforce the behavior through a reward system (Rendon et al., 2001). The striatum is divided into 3 main parts: putamen (dorsal striatum), caudate nucleus, and nucleus accumbens (ventral striatum). Neurological studies on crib biting horses have demonstrated that these horses had significantly higher dopamine D1 and D2 receptor subtypes in the nucleus accumbens (ventral striatum) and significantly lower D1 receptors in the caudatus (dorsomedial striatum) compared with control animals (McBride and Hemmings, 2005, 2009). Therefore, increased neural transmission within the striatal region of the basal ganglia seems to be associated with oral stereotypies including crib biting (McBride and Hemmings, 2009). Recent studies indicated an association of crib biting with a diminished capacity of learning; however, these results are as yet not widely accepted (Parker et al.,

2008b; Nagy et al., 2010). In the study conducted by Parker et al. (2008b), learning ability of crib biting horses within an operant instrumental choice were compared with that of nonstereotypic horses. Crib biting horses failed to succeed in a response–outcome learning task as they failed to learn more than 3 sessions, whereas nonstereotypic horses learned to choose the reinforcer sooner. The results supported the hypothesis in which crib biters have a dysfunction in the dorsomedial striatum that may mediate response–outcome learning. This suggests behavioral correlations for neurophysiological dysfunctions in crib biting horses (Mason and Rushen, 2006; Wickens and Heleski, 2010). However, estimations of trainability of the horses in a survey study did not support this hypothesis because trainability of the crib biter and control groups did not differ. However, the authors commented that training is a complex learning process that can be affected by individual characteristics (e.g., temperament and sensitivity to stress) and performance in the learning test (Nagy et al., 2010).

An alternative hypothesis from the neurobiological perspective of stereotypies is based on the activation of the mesoaccumbens pathway by highly motivated events. Restrictions of highly motivated activities are known to initiate high dopaminergic transmission of mesoaccumbens. Therefore, development with the stereotypies may happen in environments where goal-directed behaviors are restricted (Kusunose, 1992; McBride and Cuddeford, 2001; McBride and Hemmings, 2009).

Weaning time and other associated risk factors

Several studies have described different factors associated with equine abnormal behaviors. Many authors consider management factors including housing condition and feeding practice (as mentioned previously) as crucial for the development of abnormal behaviors in horses. However, it is generally accepted that weaning is a stressful event in a horse's life and may affect the initiation of stereotypies. Weaning methods and management around weaning time are important for the future development of stereotypic behaviors (Apter and Householder, 1996; Waters et al., 2002; Bachmann et al., 2003a; Parker et al., 2008a; Wickens and Heleski, 2010; Normando et al., 2011). A 4-fold increase of the incidence of crib biting behavior was found in foals fed on concentrates after weaning compared with foals not receiving concentrates (Waters et al., 2002). Postweaning confinement was also associated with increased risk of stereotypies compared with paddock weaning (Waters et al., 2002). Results of a survey study investigating the association of stereotypies and weaning method revealed a decrease in developing abnormal behaviors in foals that are naturally weaned, where the mare was allowed to wean the foal (Parker et al., 2008a). The decreased risk of developing abnormal behavior was also observed when the foals were kept on pasture during the postweaning period (Parker et al., 2008a). Heleski et al. (2002) indicated that the welfare of weanlings reared in a paddock was better than the ones kept in stalls. The paddock-housed weanlings showed a time budget more similar to feral horse time budget (e.g., spent more time moving, grazing, and in close contact with conspecifics) than the stalled weanlings. Therefore, period around weaning time has to be considered as crucial because it has been indicated as the initiation point of stereotypies in horse's life.

However, other factors, such as sex, age, breed, mother's position in the herd hierarchy, type of work, reproductive status of the mare, and riding style, have also been associated with the development of stereotypies (Hausberger et al., 2009; Normando et al., 2011). Higher prevalence of crib biting (13.3%) has been observed in thoroughbred horses (suggested a genetic predisposition), increasing with age and for stallions (Luescher et al., 1998; Albright et al., 2009). Stereotypic behaviors were less frequently observed in

nursing mares (Benhajali et al., 2010). Increased incidences of wood chewing were discovered in foals born to dominant mares (Waters et al., 2002). A recent study reported that stereotypies were more likely in horses ridden in the English style than in horses ridden with other styles (Normando et al., 2011), and a positive association was also observed between the prevalence of stereotypic behaviors and using nonstraw bedding. Although there are not enough scientific data to prove that stereotypic behaviors are learned/copied, many horse owners consider stereotypies as “contagious vices” (McGreevy et al., 1995b; McBride and Cuddeford, 2001; Nagy et al., 2008; Litva et al., 2010).

How to prevent stereotypic behaviors

Stereotypic behaviors are considered as undesirable and problematic; therefore, different methods have been used to prevent/stop these behaviors. Horse owners are often concerned about the stereotypic activities because of the reduction in performance, clinical effects on the animal, and decreased monetary value of the animal. So they attempt to prevent/treat these behaviors by using different procedures. In this section, various methods that can be used to prevent/rectify the affected horses are introduced (McGreevy and Nicol, 1998b; McBride and Long, 2001).

Physical means

Physical preventions are probably the most frequent treatment for different forms of equine stereotypies; however, they are not considered to be in the best interest of the horse (Cooper and Mason, 1998).

Crib biting is often prevented through the use of a cribbing strap and collar: a strap around the neck and ears with pieces of metal hinged at the ventral midpoint that prevents crib biting. When the horse tries to arch its neck, the strap tightens around the pharynx. Other physical preventive methods to stop crib biting include removal of cribbing surface, spreading unpleasant tasting substances onto the cribbing surface, muzzles, or application of electric wire and fences (McBride and Cuddeford, 2001; Devereux, 2006; Wickens and Heleski, 2010). Physical means could be used for example to prevent the epiploic foramen entrapment colic (Archer et al., 2004). However, none of these practices are successful in addressing the underlying cause and in some cases just impose serious welfare issues (Devereux, 2006; McBride and Hemmings, 2009; Nagy et al., 2009).

V-shaped antiweaving bars placed over the stable door are usually used to stop the performance of weaving behavior. These do nothing to address the cause and may increase the horse's frustration. Because the horse often continues to weave further back inside the stable or toss its head up and down (head tossing), this method can be considered as an unsuccessful preventive measure (McBride and Cuddeford, 2001; Devereux, 2006).

Box walking is rarely prevented because the immobilization of the horse within a stable environment is impractical (McBride and Hemmings, 2009).

Veterinary and pharmacological approach

Various surgical procedures to treat oral stereotypies in horses have been described and have given varying results. In 1926, Forssell introduced a surgical technique for crib biters that involved removal of a large part of the sternomandibularis muscle. However, the cosmetic appearance of the treated horses, which is of great importance, was not taken into consideration. Therefore, a technique was developed that modified Forssell's procedure to improve the cosmetic appearance of the neck. Although the outcome of the

modified Forssell's technique is successful, the surgical methods should no longer be recommended. Failure to address the underlying cause and reduction of the horse's welfare are the primary problems of the surgical approach (Fjeldborg, 1993; McGreevy and Nicol, 1998b; Schofield and Mulville, 1998; McBride and Cuddeford, 2001; Delacalle et al., 2002; Nagy et al., 2009).

Pharmacological treatment particularly targeted the neurotransmitters, dopamine and serotonin, and opioid systems. The use of drugs such as tryptophan (Bagshaw et al., 1994), naloxone, naltrexone (McBride and Cuddeford, 2001), dextromethorphan (Rendon et al. 2001), acepromazine maleate, and clomipramine (Marsden, 2002) has been reported in the treatment of stereotypic behaviors. Pharmacological therapy is, to some extent, successful in the reduction or prevention of the stereotypic activities (Rendon et al., 2001; McGreevy, 2004). However, these therapies impose additional cost and labor to the farm. Furthermore, more research is required to test the side effects and toxicity levels of pharmacological agents (McGreevy and Nicol, 1998b; Wickens and Heleski, 2010).

Environmental enrichment

Some researchers have suggested environmental enrichment as a successful technique for improving the captive situation of domestic horses (Henderson, 2007). To treat behavioral problems, it is important to address the causal factors, rather than preventing the display of the behavior by physical restraint. For instance, the use of mirrors in the stable seems to be a more effective treatment for some stereotypic locomotor activities than any physical intervention (McAfee et al., 2002). The authors propose that the image of the horse in the mirror may have a similar effect as social contact and reduce the feeling of confinement and isolation. It has also been observed that either a visual image of a horse or a true visual contact with a neighboring conspecific is associated with a significant reduction in weaving stereotypic behavior (Mills and Davenport, 2002). This notion was further investigated by Mills and Riezebos (2005) who provided an image of a horse in the box and found a significant reduction in weaving and nodding behaviors. Use of a window could also reduce abnormal behaviors because it provides visual contact with conspecifics (Ninomiya et al., 2008).

Foraging enrichment has also been suggested as a means to facilitate foraging behavior. For instance, by provision of a multiple forage diet to horses. It may have extended welfare benefits, in terms of either reducing straw bedding consumption, that can result in impaction colic and expression of highly motivated foraging behavior (Goodwin et al., 2002; Thorne et al., 2005). In addition, racehorses are less likely to perform stereotypies when provided with more than one source of forage (McGreevy et al., 1995a). One other strategy in environmental enrichment aimed to increase feeding time. It has been shown that time spent for feeding was negatively correlated with time spent performing stereotypic behaviors (Marsden, 2002; Henderson, 2007; Wickens and Heleski, 2010). The prolongation of chewing behavior may be an important factor to reduce the crib biting behavior (Whisher et al., 2011). A foraging device named “Equiball” has been suggested as an environmental enrichment tool that reduces performance of stereotypic behaviors by means of increasing feeding time (Henderson and Waran, 2001). Increasing feeding time can also be facilitated by means of small-holed hay nets, which are made of several bags placed inside each other. Providing forage in hay nets can significantly increase feeding time (Marsden, 2002).

Routine management change

As mentioned previously, one of the suggested problems associated with concentrate feeding is development of stomach ulcers.

Having access to pasture and temporarily reducing the training regime can be sufficient for the treatment and prevention of ulcers and subsequently for decreasing stereotypic behaviors. Alternatively, if pasture is not available, provision of free-choice hay together with turnout is the most effective preventive method (Henderson, 2007). Concentrates are often consumed readily, thereby reducing the feeding time, possibly leading to other, undesirable oral activities. Although pasture is still ideal, having access to *ad libitum* roughage with higher fiber content may be more realistic. Providing the horse with good quality but higher fiber roughage is the preferred choice compared with richer hay because the roughage requires more chewing and subsequently increases feeding time. This method more closely matches the horse's natural grazing patterns and ultimately reduces the time spent on stereotypic behavior (Cooper and Mason, 1998; Marsden, 2002; Henderson, 2007; Wickens and Heleski, 2010). It has also been demonstrated that feeding the horse with less than 6.8 kg forage per day is associated with increased risk of performing stereotypic activities (McGreevy et al., 1995a).

There may be reasons to isolate a horse from its conspecifics, such as ease of management routines, reduction of the risk of injury or infections, and preventing development of abnormal behaviors learnt from neighbors engaged in stereotypies (McBride and Long, 2001; Henderson, 2007). According to anecdotal evidence, stereotypies can be developed by exposure to affected horses; however, such beliefs have never been confirmed in neither experimental studies nor epidemiological studies (Cooper and Albentosa, 2005; Nagy et al., 2008; Albright et al., 2009). Although group turnout of horses places them at the potential risk of injury, it can be psychologically beneficial to prevent stereotypies from happening. There may be ways to decrease the risk of group turnout and make it more appealing. For instance, introducing potential herd mates gradually, and sharing neighboring stalls with visual contact, then turnout in double-fenced paddocks (Henderson, 2007; Nagy et al., 2008).

Ultimately, it seems logical to have a comparison of the reaction of control, stereotypic, and treated horses to evaluate the effect of the given treatment methods (Mason and Rushen, 2006).

Conclusions and recommendations

There are different indicators of welfare, such as health, injury, and physiological parameters, as well as behavioral indicators including stereotypic behaviors. Behavioral changes are often the earliest signs that can be found to indicate suboptimal conditions. Stereotypic behaviors are proposed as one of the appropriate welfare indicators because both experimental and survey studies have demonstrated associations between poor welfare through suboptimal environments and a prevalence of stereotypic behaviors. Research suggests that deviation from natural behaviors may be considered as risk factors for the prevalence of stereotypic behaviors in horses. Characteristics of the horse including age, sex, and breed, as well as routine management practices, such as feeding regime and housing condition, are suggested as risk factors. However, management factors are of great importance. Stressful conditions, such as restricted locomotion, feeding, and social contact, which are imposed from management routines to the horse in various stages of its life, are the most likely causal factors in the development of equine stereotypies. In particular, chronic stressors that occur early in the horse's life, especially around weaning time, are probably crucial predisposition factors for the development of equine stereotypies. Ultimately, it is strongly recommended to horse professionals and owners that any management system that places the horse in a situation far from its natural condition is a

potential risk factor and may result in the development of equine stereotypies.

Additionally, various preventive methods, particularly physical means, that are commonly used to stop equine stereotypies are of great concern because stereotypies have been suggested as a coping mechanism to reduce stress in suboptimal environments. Therefore, if the coping hypothesis is correct, such management practices compromise the horse's welfare. In contrast to physical prevention, routine changes in the horse's management and husbandry routines can be the optimal method that directly address the underlying causes and consequently enhance the current welfare for the horse. According to the scientific studies reviewed in this study, the following points can be considered as recommendations to horse owners and/or professionals to prevent or reduce stereotyped behavior and improve horse's welfare.

- Increase feeding time by using roughage and high-fiber contents.
- Increase social contact among the stable mates by providing visual and tactile contact.
- Facilitate the access to pasture or paddock together with conspecifics.
- Environmental enrichments, such as using a mirror, an image of conspecifics, foraging enrichment (e.g., hay net), and others, are recommended within the stable.
- Stereotypic horses should not be isolated from the stable mates because scientific evidence does not support that abnormal behaviors are learnt/copied by observation.
- Use straw bedding rather than any other types.
- Do not isolate the foal at weaning time.
- Do not feed the foal with concentrate feeds during the post-weaning period.
- Decrease the concentrate feeding for both weaned foals and adult horses as much as possible.
- Avoid physical and surgical approaches to stop stereotypic behaviors and rather change husbandry and management practices.

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