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Equine Stereotypic Behavior as Related to Horse Welfare: A Review

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There are strong suggestions that equine stereotypies are being connected to poor welfare and a sub-optimal management and/or stabling environment. Until today 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 neurologic studies on equine stereotypy demonstrated some forms of CNS dysfunction as the causal factor for 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.

Nyckelord/Keyword:

Horse, Stereotypy, Behavior, Welfare

Contents

1	Abstract.....	1
2	Introduction	1
3	Natural behaviors of the horse	3
4	Different forms of stereotypic behaviors in the horse and their occurrence in practice	5
	4.1 Oral stereotypic behaviors	6
	4.2 Locomotion stereotypic behaviors.....	7
5	The biology of stereotypic behaviors.....	7
	5.1 Theories of causation of equine stereotypy	8
	5.1.1 Theories regarding feeding practices.....	8
	5.1.2 Theories regarding housing conditions	10
	5.1.3 Stress and the performance of stereotypy.....	11
	5.2 Neurobiologic perspective of equine stereotypies.....	11
	5.3 Weaning time and other associated risk factors	13
6	How to prevent stereotypic behaviors.....	14
	6.1 Physical means.....	15
	6.2 Veterinary and pharmacological approach	15
	6.3 Environmental enrichment.....	16
	6.4 Routine management change.....	17
7	Conclusions and recommendations.....	18
8	Acknowledgement.....	19
9	References	19

1 Abstract

There are strong suggestions that equine stereotypies are being connected to poor welfare and a sub-optimal management and/or stabling environment. Until today 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 neurologic studies on equine stereotypy demonstrated some forms of CNS dysfunction as the causal factor for 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.

2 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 & Jensen 2009). Behavioral indicators appear to be advantageous since behavioral changes are often the earliest signs that can be found to indicate sub-optimal conditions (Keeling & 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 sub-optimal environments.

Stereotypies are defined as repetitive behaviors with no obvious goal and function (Clegg et al. 2008). Since 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), and object licking in giraffes (Mason & Rushen 2006).

It is not self-evident whether stereotypies are the representative of the current situation or of a previous sub-optimal condition. This is due to the discovery that once a stereotypic behavior is established it will become a habit, and is difficult to stop or rectify (Mason & Latham 2004, Cooper & Albentosa 2005, Henderson 2007). Thus, stereotypies may have to be considered as a sign of earlier suffering, not only as indicators of current poor welfare (Mason & 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 feral horses in the wild. Comparative studies aiming to find differences between the behaviors of the captive Przewalski and domestic horses can provide useful insight for the management of stabled horse. Presently the wild horse is believed to be extinct in nature and there are no truly wild horses out of captivity. Przewalski horses, *Equus przewalskii*, are the closest relative to the domestic horse, *Equus caballus*, and are the only captive wild horses that exist in private parks and zoos (Budiansky 1997).

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 & 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 paper focuses

on different preventive methods and discusses if and how the underlying causes are addressed. Finally some recommendations are given.

3 Natural behaviors of the horse

Based on ethological research of domestic and Przewalski horses I aim to focus in this section 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 (Fleurbaey et al. 2001). Environmental conditions and annual diet availability strongly affect their food selection patterns. Due to seasonal growth of some plant species, coping with dietary variety is an important function of the horse's digestive system since 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) for grazing (Keiper 1986). From a digestive physiologic perspective, the horse's stomach should be relatively full during the day. 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, since that is the place for fermentation of feed and also a large proportion of calories are obtained from caecal and colonic fermentation. In order to regulate proper fermentation of foods, consumption of high fiber forage is necessary (Sneddon & Argenzio 1998, Hoffman 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 few forage. Concentrates and forage are often offered only two times per day, therefore placing the horses under relatively long periods of food deprivation (Sneddon & Argenzio 1998, Henderson 2007, Wickens & Heleski 2010).

In natural conditions horses live in social groups (Budiansky 1997). Since 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 & Crowell-Davis 1994, Miller 1997). Age becomes the most important factor in determining rank position within a group (Lehmann et al. 2003). However, other factors such as size, aggressiveness, and length of

residence within the group were also found to be positively correlated with dominance in hierarchies. Stallions are usually the dominant animals within their herd, however, age is still considered the most important factor in determination of rank position (Haupt et al. 1978, Boyd 1991, Miller 1997, Lehmann et al. 2003). Social relationships within the herd are frequently reinforced by mutual grooming, food sharing, following behavior, and rest and play with each other (Boyd 1988a & 1991). Secretion of sexual hormones by the mares may also affect the social structure. The term “long-day breeder” is used for species that show estrous behaviors during late spring and summer when the duration of the days is considerably longer (Crowell-Davis 2007). Although mares are long-day breeders they show sexual behavior throughout the year, therefore a stallion will stay with a group of females maintaining the social structure of the group even during non-breeding season. Groups are generally consisting of one harem per stallion, i.e. females and their offspring. More commonly both young males and females leave their parental groups at approximately 3 years of age when they become sexually mature and are ready to breed. However males mature around 6 years of age when they have the ability to take control of their own harem. Adult males temporarily live alone or in bachelor groups until they form their own harem (Zharkikh & Andersen 2009). Dominant mares generally try to keep their reproductive fitness and they interrupt mating of subordinate mares. Stallions also prefer to mate with dominant mares rather than lower ranking adult females (Haupt et al. 1978, Miller 1997, McDonnell 2000, Curry et al. 2007). Stallions, even in a captive environment (Przewalski horses), spend considerable time defending the harem, showing aggressive behavior toward males that approach the harem (Boyd 1988a).

Current housing conditions of domestic horses are often limiting social interactions with conspecifics (Cooper & Mason 1998). Traditionally, stabled horses are individually housed to reduce the risk of infection, ease of management, prevent developing of stereotypies copied from affected horses, etc. Such situations would increase the chance of stereotypy performance (see subchapter 5.1 & 6.4).

During a day in the natural situation, horses typically travel over their home range, which is varying from 1-48 square kilometers (Keiper 1986). Large proportion of their time budget is spent moving over this large territory. This is due to forage, defend the harem and run periodically with sudden burst of speed to flee perceived or actual threats (Henderson 2007). It has been estimated that horse will take over 10,000 paces per day just as its natural feeding pattern (Haupt 2005).

Today's domestic horses are often housed in a restricted environment with often quite severe restricting of locomotion compared to the natural situation. Inadequate physical exercise and the confinement of the stable environment can potentially lead to some forms of locomotion stereotypies (see subchapter 5.1.2).

Although the normal gestation period is 340 days, parturition usually occurs within 20 days of this timeframe. Mares often deliver at night, likely in order to reduce the risk of predators and any other risks for disturbances in their surroundings. Such natural behaviors around birth have to be taken into consideration (under husbandry conditions) to minimize stress factors as much as possible, since any disturbance particularly at foaling time can subsequently impose additional stress to the mare. Postpartum mares usually show very protective behavior toward any approaches to their newborn offspring. However, the mare will lose interest in the foal's body within several hours. Intensive nursing will continue in the first week of the foal's life. Within the first month the foal starts social play with the other members of the group, including stallions (Mills & Redgate 2009, Boyd 1988b & 1991), but seldom moves more than five meters away from its mother (Boyd 1988b). Mares can breed within one week of foaling (foaling heat) (Mills & Redgate 2009). Natural weaning takes place prior to the next birth of offspring if the mare is pregnant, otherwise a mare will nurse her foal for about a year. Natural weaning is a gradual process during which the foal is denied to have access to its mother, resulting in independence and coping with significant frustration.

Weaning is a crucial time of horse's life during which different kind of management practices and weaning methods have been reported to associate with the onset of stereotypies in a captive situation (Apter & Householder 1996, Waters et al. 2002). Artificial weaning of the foals within the current stable situations such as post-weaning confinement and feed on concentrates has been reported to be associated with increased incidence of stereotypic behaviors, compared with natural weaning when the foals were kept on pasture (see also subchapter 5.3).

4 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 not enough scientific consensus if wood chewing is definitely a stereotypy (Normando et al. 2011)). More

recently, some morphologic 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 & McGreevy 2002, McGreevy 2004, McBride & Hemmings 2009). The most common forms of equine stereotypies within two general categories oral and locomotion stereotypic behaviors are described in greater detail in the following subsections.

4.1 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 US (Albright et al. 2009)). It is defined as grasping a fixed horizontal object (e.g. fence, stall or building structures) with the incisor teeth whilst contracting the underside neck muscles, pulling backwards. Horses may or may not (depending on the individual horse) draw air into the upper esophagus (McGreevy et al. 1995a & 1995c, Wickens & Heleski 2010, Normando et al. 2011). The movement of air produces an audible grunt (Wickens & 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 colic (a specific form of colic due to entrapment of the small intestine in the epiploic foramen (Delacalle et al. 2002)). Crib-biters are also believed to have a lowered learning ability compared to non-stereotypic horses, which is further described in Chapter 5 (Parker et al. 2008b, Nagy et al. 2010).

Wind sucking

The horse opens its mouth, bends its neck and contracts the muscles of the underside of the neck, and forces air in the esophagus with the support of the neck muscles, without grasping any solid objects by 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 (Wickens & Heleski 2010, Devereux 2006). The prevalence of wind sucking has been reported 3.8% for nonracing horses in North America (Christie et al. 2006).

Wood-chewing

Chewing on any fitting materials made out 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).

4.2 Locomotion stereotypic behaviors

Weaving

The horse swings its head and neck from side to side and shifts its weight from one foreleg to the other, sometimes in coordination with the hind quarters while standing in the same place (Mills & 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 & 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 3.25% (Luescher et al. 1998, McGreevy 2004).

Box-walking

Walking around the box for hours on end, in a repeated pattern, in irregular directions, or in a figure-eight shaped track are the tell tale signs of box-walking (Devereux 2006, Normando et al. 2011). This may be associated with loss of condition and sometimes poor performance (Houpt 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).

5 The biology of stereotypic behaviors

Both experimental and epidemiological studies commonly indicate frustration, boredom, and stress due to 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 from 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: 1) feeding practices, 2) limited social contact, and 3) lack of locomotion due to restrictive stable environment (McBride & Cuddeford

2001, Cooper & Albentosa 2005, Henderson 2007, McBride & Hemmings 2009, Wickens & 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 subchapter 5.2). Ultimately, to prevent them from developing, it is necessary to understand the underlying causes and predisposition factors and deal with those (McBride & Cuddeford 2001, McBride & Hemmings 2009, Wickens & 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.

5.1 Theories of causation of equine stereotypy

5.1.1 Theories regarding feeding practices

A) 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). 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. 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 & Albentosa 2005, Henderson 2007, Moeller et al. 2008, Wickens & Heleski 2010). This theory is supported by a study conducted by Johnson et al. (1998) that showed supplemented concentrates with the non-therapeutic antibiotic virginimycin increased cecal pH and reduced abnormal oral behaviors. They suggested that virginimycin increased the hindgut PH and subsequently reduced crib-biting and improved the behavior. However, the authors commented that

virginimycin also increased the feeding time due to a reduction of the palatability of the feed and this could also have decreased the crib-biting behavior (see also theory of reducing 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, since antacid supplementation decreases/buffers the stomach acidity and subsequently decreases gastrointestinal irritation. (Mills & 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 suggest that crib-biting and weaving might not be influenced by hindgut acidosis.

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 is problematic.

B) 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 of time, while the psychological need of foraging for a couple of hours per day may still exist. The prevalence of oral stereotypies in the immediate post-feeding 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 & Albentosa 2005, Henderson 2007, Wickens & 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 in certain stereotypies and increasing food restriction in sows (Spoolder et al. 1995, Whittaker et al. 1998, Stewart et al. 2011).

C) 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 while weaving and nodding commonly occur prior to receiving a concentrated feed (McGreevy et al. 1995a, McBride & Cuddeford 2001, Cooper & Albentosa 2005, Henderson 2007, McBride & Hemmings 2009, Wickens & 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 while 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 not consistently supported the hypothesis “increasing meal frequency” as an appropriate alternative of reduces stereotypic performance.

5.1.2 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), as well as stalled horses (Cooper et al. 2000). Current housing conditions of domestic horses are often limiting social interactions with conspecifics (Cooper & 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 of 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 prior to daily turnout can be due to 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 & Mason 1998). Cooper et al. (2000) showed that visual and tactile contact 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). PMU (pregnant mare urine industry) farms collect the pregnant mare urine to make estrogen supplements. The welfare of pregnant mares in the PMU could be an area of concern due to 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 & Stookey 2002). In a similar study, the effect of two different housing conditions, individual stables vs. 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 due to social isolation.

5.1.3 Stress and the performance of stereotypy

Previous studies have demonstrated that stereotypies are related to physiological indicators of chronic stress (Mason & 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 & 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 & 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 & Albentosa 2005). Such a coping function may be diminished when stereotypies are inhibited (McGreevy & Nicol 1998b, Nagy et al. 2009). If the stress-reducing hypothesis is correct, prevention of stereotypic behaviors without addressing the underlying causes is of great concern to the horse's welfare.

5.2 Neurobiologic 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 & Hemmings 2009, Wickens & Heleski 2010).

Serotonin is thought to be implicated in the underlying pathology of stereotypies and a trend has been reported for lower basal levels in

stereotypic, rather than non-stereotypic horses (mean 201.5 vs. 414.3 nmol/l). Although administration of serotonergic drugs has been associated with the reduction of stereotypies, it was dubious if such medications decreased stereotypic behaviors due to 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 (Lebelt et al. 1998, Wickens & Heleski 2010).

Several studies have reported dopamine and reward systems as the underlying mechanism for the development and maintenance of stereotypies (Marsden 2002, McBride & Hemmings 2009, Wickens & Heleski 2010). Stereotypies can act as a rewarding behavior and help a horse cope with a sub-optimal 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. Due to 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 & Cuddeford 2001, McGreevy 2004). Contrary to expectation, short-term prevention of crib-biting was associated with higher level of beta-endorphin (McGreevy & Nicol 1998a). In contrast Pell & 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 & Hemmings 2009). Antelman & Szechtman (1975) showed that injection of the dopamine neurotoxin (6-OHDA) 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 three main parts: putamen (dorsal striatum), caudate nucleus, and nucleus accumbens (ventral striatum). Neurological studies on crib-biting horses have demonstrated that dopamine D1 and D2 receptor subtypes in the nucleus accumbens were

significantly higher and D1 receptors in caudate putamen (dorsomedial striatum) were significantly lower when compared with control animals (McBride & Hemmings 2005, McBride & Hemmings 2009). Therefore, increased neural transmission within the striatal region of the basal ganglia seems to be associated with oral stereotypies including crib-biting (McBride & 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 non-stereotypic horses. Crib-biting horses failed to succeed in a response-outcome learning task as they failed to learn over three sessions, whereas non-stereotypic horses learned to choose the reinforcer more immediate. 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 & Rushen 2006, Wickens & Heleski 2010). However, estimations of trainability of the horses in a survey study did not support this hypothesis, since 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 neurobiologic 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 of stereotypies may happen in environments where goal-directed behaviors are restricted (Kusunose 1992, McBride & Guddeford 2001, McBride & Hemmings 2009).

5.3 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 before) 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 & Householder 1996, Waters et al. 2002, Bachmann et al. 2003a, Parker et al. 2008a, Wickens

& 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 to foals not receiving concentrates (Waters et al. 2002). Post-weaning confinement was also associated with increased risk of stereotypies compared to 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 post weaning period (Parker et al. 2008a). Heleski et al. (2002) indicated that the welfare of weanlings reared in a paddock-house was better than 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 be close to the conspecifics) than the stalled weanlings. Therefore, period around weaning time has to be considered as crucial since 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). The highest prevalence of crib-biting has been observed in Thoroughbred horses by 13.3% (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 foaling 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 horse ridden with other styles (Normando et al. 2011), and a positive association was also observed between the prevalence of stereotypic behaviors and using non-straw bedding. Although there are not enough scientific data that stereotypic behaviors are learned/copied, many horse owners consider stereotypies as "contagious vices" (McGreevy et al. 1995b, McBride & Cuddeford 2001, Nagy et al. 2008).

6 How to prevent stereotypic behaviors

Stereotypic behaviors are considered as undesirable and problematic, so different methods have been used to prevent/stop these behaviors. Horse owners are often concerned about the stereotypic activities due to 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 procedure. In this section various methods that can be used to prevent/rectify the affected horses are introduced. (McGreevy & Nicol 1998b, McBride & Long 2001).

6.1 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 & 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 mid-point 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, or application of electric wire and fences (McBride & Cuddeford 2001, Devereux 2006, Wickens & Heleski 2010). However, none of these practices are successful to address the underlying cause and in some cases just impose serious welfare issues (Devereux 2006, McBride & Hemmings 2009, Nagy et al. 2009).

V-shaped anti-weaving 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. Since 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 an unsuccessful preventive measure (McBride & Cuddeford 2001, Devereux 2006).

Box-walking is rarely prevented since the immobilization of the horse within a stable environment is impractical (McBride & Hemmings 2009).

6.2 Veterinary and pharmacological approach

Various surgical procedures to treat oral stereotypies in horses have been described and have given varying results. Forssell (1926) 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 which modified Forssell's procedure to improve the cosmetic appearance of the neck. Although, the outcome of the modified Forssell's technique is successful in that none of the horses perform crib-biting behavior after the surgery,

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 & Nicol 1998b, Schofield & Mulville 1998, McBride & 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), naloxon, naltrexone (McBride & 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 & Nicol 1998b, Wickens & Heleski 2010).

6.3 Environmental enrichment

Some researchers have suggested environmental enrichment as a successful technique for improving the captive situation of domestic horses (Henderson 2007). To treat any behavioral problems it is important to address the causal factor/s, rather than prevent or restrain the behavior physically. For instance the use of mirrors in the stable seems to be a more effective treatment for some stereotypic locomotor activities than any physical prevention (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 true visual contact with a neighboring conspecific is associated with a significant reduction in weaving stereotypic behavior (Mills & Davenport 2002). This notion was further investigated by Mills & 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, since 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 & Heleski 2010). 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 & Waran 2001). It can also be facilitated by means of small-holed hay nets, which made of several bags placed inside each other. Providing forage in hay nets can significantly increase feeding time (Marsden 2002).

6.4 Routine management change

As mentioned before, one of the suggested problems due to concentrate feeding is development of stomach ulcers. Having access to pasture and temporarily reducing the training regime can be sufficient in the treatment and prevention of ulcers and subsequently decreasing stereotypic behaviors. Alternatively, if pasture is not available, provision of free-choice hay together with turn-out is the most effective preventive method (Henderson 2007). Additionally, concentrates are often consumed readily, thereby reducing the feeding time. Perseverance of feeding motivation after consumption of concentrates may lead to 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 rather than richer hay, since it 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 upon stereotypic behavior (Cooper & Mason 1998, Marsden 2002, Henderson 2007, Wickens & 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, reduce the risk of injury or infections, and prevent developing of abnormal behaviors learnt from neighbors engaged in stereotypies (McBride & 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 experimental nor epidemiological studies (Cooper & Albentosa 2005, Nagy et al. 2008). Although group turn-out 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 herdmates gradually, and sharing neighboring stalls with visual contact, then turnout in double-fenced paddocks (Henderson 2007, Nagy et al. 2008).

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

7 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 sub-optimal conditions. Stereotypic behaviors are proposed as one of the appropriate welfare indicators since 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, that 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 since stereotypies have been suggested as a coping mechanism to reduce stress in sub-optimal 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 thesis, 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 mirror, image of the conspecifics, foraging enrichment (e.g. hay net), etc. are recommended within the stable.
- Stereotypic horses should not be isolated from the stable mates since 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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