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INVESTIGATION OF SPECIFIC STEREOTYPIC BEHAVIORS IN HORSES

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By

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ABSTRACT

INVESTIGATION OF SPECIFIC STEREOTYPIC BEHAVIORS IN HORSES

By

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Gastrointestinal irritation has been implicated in crib-biting (CB) in horses. Eighteen horses, 9 CB and 9 non crib-biting (NCB), were used to determine 1) prevalence and severity of gastric mucosal damage, and 2) effect of concentrate feeding on circulating gastrin concentrations in CB and NCB horses. Endoscopic examinations (EE) of the squamous mucosa were performed and gastric fluid sampled after 24-28 hr feed removal. Three days after EE, blood was collected at 1400 hrs on pasture, following 12-hr feed removal (0 min), and at 60 and 120 min after consuming 1 kg of a pelleted concentrate. There were no differences in the number ($P > 0.05$) and severity ($P > 0.05$) of ulcers and prevalence of hyperkeratosis ($P > 0.05$) between CB and NCB. There was no difference ($P = 0.87$) in gastric pH of CB compared to NCB (3.92 vs. 3.78, respectively, SEM = 0.60). There was no effect of CB ($P = 0.56$) on serum gastrin concentration (14.22 vs. 12.16 pg/ml for CB and NCB, respectively, SEM = 2.46) with free access to hay and pasture. Concentrate feeding increased gastrin concentration ($P < 0.01$). Serum gastrin concentration within CB was greater at times 60 and 120 min compared to 0 min ($P < 0.01$). Compared to 0 min, serum gastrin concentration in NCB tended to differ at 60 minutes ($P = 0.07$) and was greater at 120 minutes ($P < 0.05$). Serum gastrin concentration at 60 minutes was greater ($P < 0.05$) in CB compared to NCB. Compared to NCB, there was a trend for greater serum gastrin concentration in CB horses at 120 minutes post-concentrate feeding ($P = 0.06$). The results suggest gastric

mucosal damage is not associated with CB in mature horses maintained on pasture. Greater gastrin response to concentrate feeding in CB may indicate altered gastrointestinal function in CB, which could result in a more acidic gastric environment following the consumption of concentrate feed.

Weaving and crib-biting behavior (WCB) are two of the most recognizable equine stereotypies (repetitive, invariant behaviors with no apparent function), and are viewed as a management and welfare concern. A web-based questionnaire was developed to investigate WCB in Michigan horses. Responses from 293 individuals were received representing a total of 2,181 horses. The percentage of horses exhibiting weaving (W) and CB was 2.7% and 5.2%, respectively. The proportion of respondents attempting to stop CB (81.0%) was greater ($P < 0.01$) compared to W (37.5%). Methods employed to stop or reduce W included increased turn-out (21.4%) and provision of toys (14.3%). Cribbing collars (77.6%), alteration of CB surfaces (55.3%), and increased turn-out (54.1%) were used most frequently to stop or reduce CB. Many owners used a combination of methods. A negative association was identified between hours of daily turn-out and the probability of WCB ($P < 0.01$). Risk of CB was greater for horses with visual contact only (Adjusted odds ratio (OR) = 5.61) and for horses without social contact (Adjusted OR = 6.26) compared to horses allowed turn-out with conspecifics. Contrary to previous studies, a larger daily amount of concentrate was associated with a decrease in the odds of W ($P < 0.05$) and CB ($P < 0.01$). Michigan horse owners expressed concern about WCB and attempted to control WCB. Additional research into the risk factors associated with WCB is needed, as well as careful documentation of the development of these behaviors in order to improve horse management and welfare.

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LIST OF ABBREVIATIONS

CB	Crib-biting
DA	Dopamine
EE	Endoscopic examinations
MES	Michigan Equine Survey
MSU	Michigan State University
NCB	Non crib-biting
OR	Odds ratio
OSR	Office for Survey Research
P	P-value
SST	Serum separator tube
W	Weaving
WCB	Weaving and Crib-biting

INTRODUCTION

Stereotypies are defined as repetitive, relatively invariant patterns of behavior with no apparent goal or function (Mason, 1991). Development and continued performance of stereotypic behavior has been linked to sub-optimal environments (Ödberg, 1987; Cooper and Albentosa, 2005). Specifically, stereotypic behavior can develop within the following contexts: when an animal is unable to execute a behavior pattern that it is highly motivated to perform, such as nesting or feeding behavior; when it cannot escape or avoid a stressful or fearful situation; or when it is kept in confinement or social isolation (Mason, 1991). Stereotypies have been observed in several species kept in captivity (Mason, 1991; Mason and Rushen, 2006). The performance of stereotypic behavior has been used as an indicator of poor welfare (Broom, 1983; Mason and Latham, 2004) although it is often difficult to determine whether the behavior is the result of poor welfare in the past or due to current adverse conditions. Ethologists and welfare scientists have employed a multidisciplinary approach to address questions related to stereotypic behavior including the use of behavioral and physiological measures, as well as application of epidemiological research methods.

Studies conducted in Canada (Luescher et al., 1991) and the United Kingdom (McGreevy et al., 1995a) have reported that greater than 13% of domesticated horses exhibit stereotypies. The primary classifications assigned to stereotypic behavior patterns observed in domestic horses (Houpt and McDonnell, 1993; Mills, 2002) and captive wild horses, e.g. Przewalski horse, (Boyd, 1986) are oral and locomotor. Crib-biting and weaving behavior are two of the most widely recognized equine stereotypies (Kiley-Worthington, 1983). Crib-biting is an example of an oral stereotypic behavior in which

the horse anchors its top incisor teeth on a fixed object (e.g. fence, stall or building structures), pulls backward, contracting the neck muscles, and draws air into the cranial esophagus emitting an audible grunt (McGreevy et al., 1995a,b). Weaving is a locomotor stereotypic behavior pattern characterized by a lateral swaying movement in which the head, neck, forequarters and sometimes hindquarters are engaged (McGreevy et al., 1995c). The average prevalences of crib-biting and weaving behavior in Europe and Canada are 4.1% and 3.3 %, respectively (Nicol, 1999a). In the United States, the reported prevalence of crib-biting behavior is 4.4%. Crib-biting and weaving are recognized as both a management and a welfare concern, and many owners attempt to physically prevent horses from engaging in these behaviors (McGreevy and Nicol, 1998; McBride and Long, 2001). The primary problem with physical prevention, e.g. attempting to stop crib-biting using a cribbing collar or by removing crib-biting surfaces, is that these approaches fail to address the underlying causes of the behavior and may further reduce equine welfare (McBride and Cuddeford, 2001).

Although the underlying cause of crib-biting behavior remains to be elucidated, there is some evidence to suggest a link between crib-biting behavior and gastrointestinal irritation. Nicol (1999b) proposed that the behavior is an adaptive response to gastric acidity and that the act of crib-biting may raise gastric pH as a result of increased flow of alkaline saliva. A study conducted by Moeller et al. (2008) demonstrated that crib-biting behavior stimulates salivation, lending support to this hypothesis. Crib-biting behavior recently has been associated with gastric ulceration in foals, with gastric ulceration and inflammation present in 60% of cribbing foals compared to 20% of non-cribbing foals (Nicol et al., 2002). In addition, crib-biting foals had greater severity of ulceration and

inflammation upon initial endoscopic examination (Nicol et al., 2002). In adult horses, crib-biting has been associated with lower basal and post-feeding gastric pH (Lillie et al., 2004) and long-term treatment with antacids has reduced the frequency of crib-biting (Mills and Macleod, 2002). However, an association between crib-biting behavior and gastric ulceration in mature horses has never been documented.

Few experimental studies have been conducted specifically to address weaving behavior. However, the provision of mirrors in the stable reduced the performance of weaving (McAfee et al., 2002) suggesting that this behavior may be performed in response to social isolation. Stable designs that increased visual horizons, such as open stable doors providing access to views of adjacent horses and surrounding fields also reduced weaving behavior (Cooper et al., 2000). Ninomiya et al. (2007) found that weaving behavior was mainly observed before feeding, and that investigation of bedding was more likely to follow eating. These results suggested that weaving also may be performed in an attempt to cope with frustration associated with meal anticipation.

Survey studies in the UK and Canada have demonstrated an association between various management practices and stereotypic behavior. For example, Waters et al. (2002) found young horses fed concentrate feed post-weaning to be 4 times more likely to develop crib-biting behavior than foals not receiving concentrate. Management factors associated with a *reduced* risk of stereotypic behavior include increasing forage intake, allowing visual contact between stalled horses, and increasing the amount of time spent outside the stable (McGreevy et al., 1995a,c; Redbo et al., 1998). Management factors associated with an *increased risk* of stereotypic behavior include the feeding of

concentrates (Redbo et al., 1998; Waters et al., 2002; Bachmann et al., 2003) and stabling/stalling of foals prior to weaning (Parker et al., 2008)

Certain breeds of horses may be more likely to exhibit stereotypic behavior than others. This was demonstrated by Bachmann et al. (2003) in a survey of stereotypic behavior in Swiss horses in which Warmbloods and Thoroughbreds were at 1.8 and 3.1 times greater risk of performing stereotypic behavior, respectively, compared to other breeds. Vecchiotti and Galanti (1986) also have suggested the involvement of a genetic component in the performance of stereotypic behavior with the finding that certain Thoroughbred lines were more susceptible to developing stereotypic behavior. Stereotypic behavior has never been investigated in horses in Michigan. Specifically, there is a paucity of information regarding the prevalence and owner perceptions of, and risk factors associated with crib-biting and weaving behavior within the Michigan horse population.

The overall goal of this dissertation is to provide a further understanding of crib-biting and weaving behavior in horses. The specific objectives of this research were to: 1) determine prevalence and severity of gastric mucosal damage in mature crib-biting horses, 2) determine the effect of feeding on circulating gastrin concentrations in crib-biting and non crib-biting horses, 3) assess the perceptions of weaving and crib-biting behavior held by Michigan horse owners, and 4) investigate risk factors associated with these behaviors in the Michigan horse population. The first and second objectives are addressed in Chapter 2 using video endoscopy and measurement of serum gastrin concentrations in crib-biting and non crib-biting horses following free-access to pasture/hay and in response to pelleted concentrate feeding. We hypothesized that horses

exhibiting crib-biting behavior would have a higher degree of gastric mucosal damage and greater serum gastrin response to concentrate feeding compared to non crib-biting horses.

The third and fourth objectives are addressed in Chapter 3 utilizing a web-based questionnaire. It was hypothesized that Michigan horse owners would express concern regarding weaving and crib-biting behavior and that the majority of owners attempt to stop or reduce performance of these behaviors. Additionally, the author hypothesized that certain housing and feeding strategies, for example, those which limit a horse's time out of the stable, limit contact with other horses, or limit foraging opportunities, would result in an increased probability of horses exhibiting weaving and/or crib-biting behavior. Some of the specific predictions were that increased turn-out would reduce the probability of a horse being a weaver or crib-biter and that the probability of being a weaver or crib-biter would be increased in horses with no visual or tactile contact with other horses. Furthermore, those horses fed larger amounts of concentrate would be more likely to weave or crib-bite.

The rationale for hypothesizing greater mucosal damage and gastrin response to concentrate feeding in mature crib-biting horses is based on the associations between crib-biting behavior, concentrate feeding, and gastrointestinal irritation identified in the literature. The rationale behind the hypotheses and predictions related to horse owner perceptions and risk factors associated with weaving and crib-biting behavior in Michigan are based on findings of previous survey and epidemiological research. Weaving behavior was included in the Michigan horse behavior survey study for two reasons. First, in comparison with crib-biting behavior, the number of studies dedicated

specifically to weaving remains low and we wanted to add to the body of knowledge regarding this locomotor stereotypy. Secondly, because information about stereotypic behavior has never been collected within the Michigan horse industry, we were interested in learning about more than just one behavior. However, crib-biting behavior is the main focus of the dissertation. Thus, the purpose of Chapter 1 is to provide the reader with a relatively comprehensive review of what is currently known about crib-biting behavior in horses. Chapter 4 provides a summary of the main findings of the dissertation research and implications for the equine industry.

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CHAPTER 1

CRIB-BITING BEHAVIOR IN HORSES: A REVIEW

Abstract

During the past decade, stereotypic behavior in horses, specifically crib-biting behavior, has received considerable attention in the scientific literature. Epidemiological and experimental studies designed to investigate crib-biting behavior have provided valuable insight into the prevalence, underlying mechanisms, and owner perceptions of the behavior. The findings of these studies have demonstrated how the management of horses can influence their behavior and well being. The work of previous authors also has been vital in generating additional research questions and hypotheses related to crib-biting. The findings of several survey and experimental studies are reviewed, with emphasis on research conducted since the late 1990's, in an attempt to provide the reader with a relatively comprehensive look into what is currently known about crib-biting behavior in horses. Knowledge deficiencies and areas for future research are identified.

Keywords: Horse, Behavior, Crib-biting, Welfare, Review

1. Introduction

Stereotypies are defined as repetitive, relatively invariant patterns of behavior with no apparent goal or function (Mason, 1991). Development and continued performance of stereotypic behavior have been linked to sub-optimal environments (Ödberg, 1987; Cooper and Albentosa, 2005). Specifically, stereotypic behavior can develop within the following contexts: when an animal is unable to execute a behavior pattern that it is highly motivated to perform, such as feeding behavior; when it cannot escape or avoid a stressful or fearful situation; or when it is kept in confinement or social isolation (Mason, 1991). It has been suggested that stereotypic behavior may serve as a coping mechanism, functioning to reduce stress or to provide the animal with some form of control over its environment (Mason, 1991; Cooper and Albentosa, 2005). The presence of stereotypies has been used as an indicator of poor welfare (Broom, 1983; Mason and Latham, 2004) although whether the welfare is currently poor or has simply been poor in the past is more difficult to determine. Stereotypies have been observed in several species (Mason, 1991) and in captive ungulates, performance of oral stereotypic behavior is common (Bergeron et al., 2006; Mason and Rushen, 2006). Specific examples include object-licking in giraffes, bar-biting and sham chewing in sows, tongue-rolling in cattle, and crib-biting in horses (Mason and Rushen, 2006).

Horses exhibiting crib-biting behavior anchor their top incisor teeth on a fixed object (e.g. fence, stall or building structures), pull backward, contract the neck muscles, and draw air into the cranial esophagus emitting an audible grunt (McGreevy et al., 1995a,b; Dodman et al., 2005). The behavior is not known to occur in feral, free-ranging horses, but is observed in domestic (Houpt and McDonnell, 1993; Mills, 2000) and

captive wild horses, e.g. Przewalski horse (Boyd, 1986). Performance of crib-biting behavior has been reported to occupy from 15% (Nicol et al., 2002) up to 65% (Bachmann et al., 2003a) of the daily time budget.

It is widely reported in the literature that crib-biting, and other stereotypic behaviors, are viewed by owners as being problematic and undesirable (Kiley-Worthington, 1983; Houpt and McDonnell, 1993; Nicol, 1999a; Mills, 2002). Crib-biting behavior has been linked to unthriftiness (weight loss and poor condition) in horses. This is thought to be a result of increased energy expenditure and/or a decrease in the amount of time spent eating and grazing during performance of the behavior (Houpt and McDonnell, 1993; McGreevy and Nicol, 1998a). The behavior also has been associated with excessive tooth wear (Owen, 1982; Boyd, 1986), which in severe cases may impair the horse's ability to graze or result in dental disease. Two recent studies have demonstrated an association between epiploic foramen entrapment, a specific form of colic, and crib-biting behavior (Archer et al., 2004, 2008). Despite the latter findings however, evidence for direct negative consequences of crib-biting behavior on horse health remains largely anecdotal, requiring further empirical investigation and careful documentation.

The precise etiology of crib-biting behavior has yet to be elucidated, and it is likely that the cause is multifactorial. Several studies have been conducted to investigate the potential biological mechanisms underlying crib-biting behavior. For example, crib-biting has been associated with altered neuroendocrine physiology (Gillham et al., 1994; Lebelt et al., 1998; McBride and Hemmings, 2005) and brain function (Hemmings et al., 2007; Parker et al., 2008a). There is also some evidence to support a role of

gastrointestinal irritation in performance of the behavior (Mills and Macleod, 2002; Nicol et al., 2002; Lillie et al., 2004). The findings of these studies have greatly enhanced our understanding of the behavior, but in some cases, results have been conflicting or insufficient, and warrant further investigation. Application of survey research methodology to questions about crib-biting behavior has provided some insight into the prevalence of and risk factors associated with the behavior. Specific factors found to be associated with crib-biting behavior include time spent out of the stable, forage and concentrate feeding, breed and sex of horse (McGreevy et al., 1995c; Luescher et al., 1998; Redbo et al., 1998; Bachmann et al., 2003b) and method of weaning (Waters et al., 2002; Parker et al., 2008b). Some of the more recent epidemiological studies have also attempted to assess owner awareness and perceptions regarding crib-biting behavior (McBride and Long, 2001; Albright et al., 2009; Wickens, Chapter 3) in an effort to determine the current level of concern with and knowledge about the behavior within the equine community.

1.1 Aim of the review

Within the past decade, equine scientists have conducted a number of studies designed to examine the etiology of crib-biting behavior. The purpose of this paper is to review the existing literature on crib-biting behavior with special attention directed toward research carried out after the publication of equine stereotypic behavior review articles in the mid- to late- 1990s (Winskill et al., 1995; Cooper and Mason, 1998; Nicol, 1999b). Emphasis is placed on our current understanding of the role of neuroendocrine and brain physiology and of gastrointestinal irritation in the performance of the behavior, as well as the contribution of horse characteristics and environmental factors to crib-

biting behavior. Recommendations concerning areas needing additional research are made throughout.

2. Neuroendocrine physiology and brain function in crib-biting horses

The repetitive and persistent nature of stereotypic behavior has led authors in the past to describe such behavior in horses as "obsessive compulsive disorder" or OCD (Luescher et al., 1991; Shuster and Dodman, 1998). However, because obsessions involve recurrent, intrusive thoughts, a capability that horses are not known to possess, the terms "compulsive disorder" (Luescher et al., 1998), and "stereotypic behavior" (Mills and Nankervis, 1999) are preferred. Nonetheless, implication of the serotonergic system in compulsive disorders in both humans and horses represents a commonality between the two species in the underlying pathology of such repetitive or stereotyped behavior patterns. Serotonin reuptake inhibitors have been used to treat compulsive disorders in humans (Bandelow, 2008) and have been reported to reduce stereotypic behavior in horses (McDonnell, 1998). However, Lebelt et al. (1998) expressed uncertainty regarding whether these drugs selectively affect stereotypic behavior or result in changes in behavior by way of a general sedative effect. Lebelt et al. (1998) did find a trend for lower basal serotonin levels in crib-biting compared to non-stereotypic horses, suggesting that the serotonergic system of crib-biters may differ from that of non crib-biting horses. The precise role of serotonin in the development or maintenance of the behavior remains unclear however, and the results obtained by Lebelt et al. (1998) have yet to be confirmed or refuted through additional experimental studies of the serotonergic system in crib-biting horses.

Endogenous opioids have been suggested to facilitate and reinforce stereotypic behavior (Dodman et al., 1987; Gillham et al., 1994; Zanella et al., 1996). In a study conducted by Dodman et al. (1987), infusion of opioid antagonists reduced crib-biting behavior, lending support to this hypothesis. Similarly, McBride and Cuddeford (2001) demonstrated a reduction in crib-biting behavior by administering naloxone, but the authors suggested that a general sedative effect of the opiate antagonist might have influenced performance of the behavior. Measurement of plasma β-endorphin in crib-biting horses has produced conflicting results. Gillham et al. (1994) reported significantly lower baseline concentrations of β-endorphin in crib-biting horses compared to non crib-biting controls, whereas Lebelt et al. (1998) found 3 times higher basal β-endorphin concentrations in crib-biting horses. Pell and McGreevy (1999), however, found no significant difference in plasma β-endorphin concentrations between crib-biting and normal horses. Lebelt et al. (1998) and Nicol (1999) have suggested that peripheral plasma β-endorphin concentrations may not reflect concentrations in the central nervous system that would be responsible for producing behavioral changes. Pell and McGreevy (1999) have proposed that a failure to detect differences in plasma β-endorphin concentrations between crib-biting and normal horses may indicate greater sensitivity of opioid receptors in stereotypic horses.

Crib-biting behavior also has been proposed as a means to alleviate a horse's stress. Heart rate and nociceptive threshold were lowered in horses during periods of crib-biting (Lebelt et al., 1998). McBride and Cuddeford (2001) reported a significant reduction in plasma cortisol concentration following bouts of crib-biting, providing evidence that the act of crib-biting may reduce stress. McGreevy and Nicol (1998b)

found higher mean baseline concentrations of cortisol in crib-biting compared to normal horses, but prevention of the behavior via removal of the crib-biting surface, did not result in a rise in cortisol concentration. Subsequent studies have found no significant differences in plasma (Pell and McGreevy, 1999; Clegg et al., 2008) or salivary (Pell and McGreevy, 1999) cortisol between crib-biting and control horses, suggesting that levels of arousal in stereotypic and normal horses are similar. There is some evidence suggesting crib-biting horses react more strongly to acute stressors (Minero et al., 1999; Bachman et al., 2003a) compared to their non crib-biting counterparts. In addition, Minero et al. (1999) found that heart rate and general activity of crib-biting horses returned more quickly to basal levels following application of the stressor, providing additional support that the behavior may serve as an adaptive response to stress. However, interpretation of the findings obtained from these studies is difficult and remains controversial. Results may be confounded by individual differences in temperament, reactivity and life experiences of the crib-biting and non crib-biting horses enrolled in such studies. An inherent limitation in many of these studies is that measurements of cortisol have been obtained in mature horses with an established history of performing the behavior rather than in horses just developing the behavior. Although McGreevy and Nicol (1998b) observed higher cortisol concentrations in crib-biters, a result that may imply a heightened stress response in the stereotypic horses, the authors suggested that longitudinal studies would be necessary to establish whether development of crib-biting had been successful in reducing already elevated concentrations of stress hormones.

Research aimed at addressing the role of neuroendocrine physiology and brain function in the development and continued performance of stereotypic behavior is further complicated by the interrelationships between the hypothalamus-pituitary-adrenal (HPA) axis and reward systems within the brain. Cabib et al. (1998) found that stress induces significant changes in dopamine (DA) receptor densities within the mesoaccumbens and nigrostriatal systems in mice. In inbred strains of mice, these stress-induced changes in dopamine neurophysiology have been associated with the development of stereotypic behavior (Cabib et al, 1997). More recently, McBride and Hemmings (2005) reported significantly lower DA D1-like receptor sub-types in the caudate nucleus (dorsomedial striatum; DMS) and significantly higher DA D1-like and D2-like receptor sub-types in the nucleus accumbens (ventral striatum) of crib-biting horses. Due to the involvement of basal ganglia and dopamine pathways in instrumental task learning, specifically goal-directed learning and response-outcome processes, Hemmings et al. (2007) and Parker et al. (2008) proposed that basal ganglia dysfunction and alterations in dopamine physiology in crib-biters would be expressed as aberrant or impaired learning task performance. Hemmings et al. (2007) demonstrated that horses exhibiting crib-biting behavior required significantly more unreinforced trials to reach extinction criterion (i.e. stereotypic horses continued to perform button presses without receipt of the food reward), and it was suggested that this perseverative responding might be indicative of basal ganglia dysfunction. In the study by Parker et al. (2008), learning performance within a free-operant instrumental choice paradigm was compared between crib-biting horses and non-stereotypic horses. Crib-biting horses failed to choose a more immediate reinforcer demonstrating difficulty of the crib-biters to effectively learn the response-

outcome contingency. These studies are among the first to examine and provide evidence of a behavioral correlate for neurophysiologic dysregulation in crib-biting horses. Investigating differences in learning ability between crib-biting and non-stereotypic horses, specifically within response-outcome paradigms offers a promising, non-invasive approach to addressing questions pertaining to the role of brain and neuroendocrine physiology in the performance of crib-biting behavior in horses.

3. Gastrointestinal irritation and crib-biting behavior

Free-ranging horses spend a large proportion of their time grazing and foraging. In contrast, domesticated horses, particularly elite performance horses, are often fed high concentrate, relatively low forage diets to meet the increased energy demands associated with their competitive lifestyles. Concentrate and forage rations are often delivered only 2 times per day, thus subjecting horses to longer periods of feed deprivation. Feed deprivation can result in gastric ulceration due to increased exposure of the squamous mucosal lining to gastric acidity (Murray and Eichorn, 1996). Gastrin, a peptide hormone secreted into the blood, is a potent stimulator of gastric acid secretion (Katz, 1991), and in horses, Smyth et al. (1989) observed a greater and more prolonged gastrin response to the feeding of pelleted and sweet feed diets compared to ad libitum hay feeding. Several studies have demonstrated associations between concentrate feeding and crib-biting behavior (Kusunose, 1992: Gillham et al., 1994; Redbo et al., 1998; Waters et al., 2002).

It has been suggested that crib-biting behavior may be an adaptive response to gastric acidity and that the act of crib-biting may raise gastric pH as a result of increased flow of alkaline saliva (Nicol, 1999b). Moeller et al. (2008) demonstrated that salivation is stimulated with crib-biting, which lends support to this theory. Crib-biting behavior has

recently been associated with gastric ulceration in foals, with gastric ulceration and inflammation present in 60% of crib-biting foals compared to 20% of non crib-biting foals (Nicol et al., 2002). In addition, crib-biting foals had greater severity of ulceration and inflammation upon initial endoscopic examination (Nicol et al., 2002). In the same study, the stomach condition of foals consuming a diet containing an antacid improved and there was a trend toward reduced duration of crib-biting in supplemented foals. In mature horses, long-term treatment with antacids has been shown to reduce the frequency of crib-biting (Mills and Macleod, 2002), particularly in the period post-feeding. Crib-biting horses also have been found to have lower basal and post-feeding gastric pH compared to that of non crib-biters (Lillie et al., 2004). In the study conducted by Mills and Macleod (2002), integrity of the gastric mucosa was not examined, thus it is unclear whether the reduction in crib-biting frequency observed in mature horses consuming an antacid diet was due to an increase in gastric pH alone or to an overall improvement in stomach condition. The underlying cause of lower gastric pH in crib-biting horses observed in the study by Lillie et al. (2004) has not been determined. Wickens (Chapter 2) recently conducted a study to examine the integrity and function of gastric mucosa in mature horses with a history of crib-biting behavior, but found no differences in the number or severity of squamous mucosal lesions between crib-biting and normal horses maintained on pasture. However, serum gastrin response to concentrate feeding was found to be higher in crib-biting horses compared to controls, providing some additional evidence that gastrointestinal physiology may be altered in horses exhibiting crib-biting behavior. It was suggested that gastrin-stimulated acid secretion may be enhanced in crib-biting horses due to greater G cell numbers or increased secretory capacity of the existing

G cells, but this idea can only be confirmed through further investigation involving mucosal biopsies and molecular genetic techniques. It would be interesting to discover whether pathways involved in gastric acid secretion are upregulated in crib-biting horses. Additional studies employing continuous recordings of gastric pH in conjunction with repeated blood sampling for determination of basal and post-feeding serum gastrin concentrations in crib-biting and non crib-biting horses may also be helpful in determining whether the gastrointestinal environment of crib-biting horses differs from that of normal horses.

Fermentation of concentrate feeds in the cecum and large intestine is known to reduce hindgut pH in horses (Rowe et al., 1994). In a study conducted by Johnson et al. (1998), increasing the amount of concentrate fed to horses resulted in the appearance of aberrant oral behaviors, such as wood-chewing, and reductions in fecal pH. Accumulation of lactic acid in the hindgut of horses was reduced by the addition of virginiamycin to the diet (Rowe et al., 1994), and supplementation with virginiamycin was shown to increase fecal pH and reduce the performance of abnormal oral behavior in horses receiving concentrate feed (Johnson et al., 1998). However, Moeller et al. (2008) contended that crib-biting was not one of the oral behaviors reported in the study by Johnson et al. (1998). A recent study conducted by Freire et al. (2008) found no effect of virginamycin supplementation on crib-biting behavior. Thus, the authors suggested that established crib-biting behavior in adult horses may not be influenced by hindgut acidosis.

Horses with gastric mucosal injury exhibit bruxism and behavioral signs of colic (Muray 1998), thus appearing that horses are able to detect gastric acidity and mucosal

damage, or at least the pain it likely induces. Pain is known to bring about changes in dopaminergic activity (Wood, 2004), and Hemmings et al. (2007) postulated that visceral discomfort in horses may play an important role in the establishment of oral stereotypy through alteration of basal ganglia programming. This author is aware of one report in which a horse recovering from colic surgery had started to crib-bite. Recovery from colic surgery usually entails periods of feed withdrawal and stall confinement, conditions known to be ulcergenic in horses (Murray and Eichorn, 1996). However, some level of distress and general discomfort would also be associated with the procedure and recovery process. Perhaps in this situation, crib-biting is initiated by the horse in an attempt to reduce gastric acidity through production of alkaline saliva, but the behavior becomes established as a result of pain-induced changes in neuroendocrine physiology. It seems probable that a complex interrelationship between gastrointestinal and brain physiology is involved in the etiology of crib-biting behavior and further research in this area is warranted.

4. Findings of survey and epidemiological research on crib-biting behavior

The prevalence of crib-biting behavior reported in horses in Europe and Canada is 2.4 to 8.3% (Vecchiotti and Galanti, 1986; McGreevy et al., 1995c; Luescher et al., 1998). Albright et al. (2009) reported an overall crib-biting prevalence of 4.4% in U.S. horses, and the results of a recent behavior survey study conducted in Michigan (Wickens, Chapter 3) provide a similar prevalence estimate of crib-biting behavior of 5.2%.

Survey studies in the UK and Canada have demonstrated an association between various management practices and stereotypic behavior. For example, a prospective study

conducted by Waters et al. (2002) found that young Thoroughbred and part-Thoroughbred horses fed concentrate feed post-weaning were 4 times more likely to develop crib-biting behavior than foals not receiving concentrate. Weaning method also has been associated with the performance of stereotypic behavior including crib-biting. In a recent survey of management practices implemented on breeding farms in Europe, North America, and Australia, natural weaning (mare allowed to wean foal) was associated with a decrease in the chance of foals developing abnormal behavior (Parker et al., 2008b). Post-weaning housing was also associated with the performance of abnormal behavior with decreased risk of abnormal behavior in foals kept exclusively on grass (Parker et al., 2008b). In eventing and dressage horses in the UK, increased amounts of time spent outside the stable were associated with a decreased risk of stereotypic behavior (McGreevy et al., 1995c). In addition, Wickens (Chapter 3) found a negative relationship between the daily amount of turn-out and crib-biting behavior. Wickens (Chapter 3) also found that social contact with other horses reduced the probability of crib-biting behavior. Survey studies conducted to investigate stereotypic behavior in race horses in Sweden (Redbo et al., 1998), and in Swiss horses of multiple breed types and uses (Bachmann et al., 2003b) found that regular feeding of concentrates increased the risk of performing stereotypic behavior. Specifically, Redbo et al. (1998) demonstrated a positive relationship between the amount of concentrate and stereotypic behavior, including crib-biting, and a decreased risk of stereotypy with increased amount of roughage.

An experimental study conducted by Visser et al. (2008) to investigate the effect of two different housing conditions on the welfare of young horses exposed to stabling

for the first time, lends empirical support to the associations between housing, social isolation and the performance of stereotypic behavior identified using survey methodology. A total of 36 Dutch Warmblood horses, 2 years of age and naïve to stall housing were enrolled in the study. Upon completion of the 12-week study, 22% of the horses housed individually in 10.5 m^2 boxes were seen exhibiting crib-biting behavior whereas horses pair-housed in boxes (48 m^2) did not begin performing stereotypic behavior (crib-biting, weaving or box walking). Although additional studies of this nature need to consider the welfare implications of purposely subjecting horses to management conditions known or suspected to induce stress and behavioral disturbances, this approach seems valuable in obtaining a better understanding of the circumstances that elicit development of crib-biting behavior. Although the data were not shown, Visser et al. (2008) indicated that after 12 weeks of stabling, performance of stereotypic behavior was still reversible in the majority of the horses exhibiting stereotypic behavior. This finding stresses the importance of identifying behavioral problems early so that appropriate management changes can be made before crib-biting and other stereotypic behaviors become established.

Certain breeds of horses may be more likely to exhibit stereotypic behavior, including crib-biting, than others. This was demonstrated by Bachmann et al. (2003b) in a survey of stereotypic behavior in Swiss horses in which Warmbloods and Thoroughbreds were at 1.8 and 3.1 times greater risk of performing stereotypic behavior, respectively, compared to other breeds. Albright et al. (2009) found that among U.S. horses, Thoroughbreds were 3 times more likely to exhibit crib-biting behavior than Quarter Horses and 5 times more likely than Arabians. Vecchiotti and Galanti (1986) suggested

the involvement of a genetic component in the performance of stereotypic behavior, as evidenced by the finding that one or more relatives in 8 families of Thoroughbreds exhibited crib-biting behavior. Luescher et al. (1998) found a higher prevalence of crib-biting in geldings and stallions compared to mares, and a greater risk of crib-biting among Thoroughbred horses. The particular breed of horse may determine the primary use of the animal, which in turn may affect the manner in which the horse is managed. For example, many Thoroughbreds are used for competitive disciplines such as racing, eventing, show-jumping, and dressage. Race horses in particular may be exposed during the early part of their life to rigorous training regimens, high concentrate/ low forage diets, very limited liberty turnout, and, depending on the track stabling, very limited amounts of social contact. Stallions are typically managed very differently than geldings and mares. For example they are often housed individually to prevent accidental breeding and aggression. Stress or frustration associated with limited opportunities for turn-out or social contact may therefore be associated with the performance of stereotypic behavior in stallions.

Actual accounts of crib-biting behavior in other equid species are rare. For example, this author was not able to find documented cases of crib-biting in captive zebra. Personal communications with individuals working with large numbers of donkeys and mules indicate that occurrence of crib-biting in this species is infrequent, with only one donkey being reported to engage in a portion of the crib-biting sequence, i.e. anchoring its incisor teeth on fence boards (Windsor, 2009; Taylor, 2009). Donkeys, however, generally are not subjected to individual stall confinement and the high concentrate feeding that many horses are exposed to. It is possible that the temperament

and management of donkeys is protective against development of crib-biting. Boyd (1986) documented crib-biting in a zoo-kept female Przewalski's horse, and in a later publication (Boyd, 1991) referred back to this case cautioning that Przewalski's horses kept in small enclosures may begin crib-biting. Wood-chewing and coprophagy were observed in these horses in the small enclosures, but not when the horses were out on pasture (Boyd, 1986).

Interconnections between genetic and environmental factors, specifically interactions between gender and management, or breed and management, almost certainly play a role in the development of crib-biting behavior, and these relationships warrant further consideration in future experimental and epidemiological studies. Nonetheless, there is some evidence for a genetic predisposition in the display of the behavior (Vecchiotti and Galanti, 1986; Albright et al., 2009) and identification of specific genes responsible for crib-biting through pedigree analysis and association mapping should be pursued.

A few of the more recent survey studies have included questions related to owner and farm manager perceptions of stereotypic behavior in horses. British horse owners have demonstrated concern regarding the performance of stereotypic behavior and the majority of owners attempted to physically prevent horses from performing the behavior (McBride and Long, 2001). This included the use of cribbing straps to stop horses from crib-biting. Michigan horse owners and farm managers also expressed concern about crib-biting behavior and 81% of owners indicated that they have tried to stop the behavior (Wickens, Chapter 3). However, perceptions regarding the impact of the behavior on horse performance/learning, horse health, and monetary value of the animal were

different between owners of non-stereotypic horses and those respondents currently owning/managing a crib-biter. In general, respondents presently owning/managing a crib-biting horse were less concerned about the behavior having a negative impact on learning, health, or monetary value. Thus, it appeared that perceptions about stereotypic behavior within the equine community at large may not coincide with those held by individuals having first-hand experience with crib-biting horses.

Despite this discrepancy, many of the respondents currently owning/managing crib-biting horses agreed/strongly agreed that crib-biting has a negative impact on horse health (Wickens, Chapter 3). A small group of owners reported wear of the incisor teeth and some problems with colic in their crib-biting horses, however a causal relationship between the behavior and any specific health problems could not be ascertained. In the Michigan horse behavior survey, many respondents believed that environmental variables were largely responsible for the performance of crib-biting behavior, a finding similar to the perceptions of U.S. horse owners reported by Albright et al. (2009). These results indicate that a large proportion of owners are aware and fairly well informed that management practices can have an impact on the behavior of their horses.

One additional aspect of crib-biting behavior that has received some consideration in recent epidemiological research is the question concerning whether horses learn to copy the behavior by watching or interacting with others. Currently, there is little evidence to support the belief that horses learn to perform stereotypic behavior by observing others. A small percentage of crib-biting horse owners (5%) in the Michigan study (Wickens, Chapter 3) reported that a horse had started to crib-bite after another crib-biting horse had arrived at the farm. The management practices of those farms

differed from one another with respect to primary housing, social contact, and hours of turn-out. Thus, it would be difficult to determine whether horses are in fact copying the behavior or if the behavior is the result of exposure to common management factors, specifically those factors previously demonstrated to be associated with an increased risk for crib-biting behavior. Albright et al. (2009) reported that only 1% of horses surveyed started to crib-bite after the arrival of a crib-biting horse. On the other hand, Nagy et al. (2008) found an increased risk of stereotypic behavior (crib-biting and weaving) in horses exposed to stereotypic neighbors. Subsequent empirical and epidemiological investigation is needed prior to reaching a conclusion about the ability of horses to imitate stereotypic behavior through observation. It has been suggested that familiarity with other horses and dominance hierarchies between horses may be important factors in the ability of horses to learn a particular behavior by observation (Murphy and Arkins, 2007; Ninomiya, 2007) and should therefore be examined in future studies.

Cross-sectional studies are somewhat limited in their ability to determine cause and effect associations between management factors and crib-biting behavior, specifically because many horses included in such studies may already be well established in the behavior. Horses purchased or brought onto the farm already exhibiting crib-biting behavior may have developed the behavior as a result of previous management rather than from exposure to their present environment and management. Nonetheless, cross-sectional studies have been extremely helpful in identifying the prevalence of, and in generating additional hypotheses about, stereotypic behavior. Prospective epidemiological research studies allow researchers to follow the development of behavior in young horses exposed to various management factors, and are the favored approach to

identifying associations between environmental and horse-related variables and the performance of stereotypic behavior. However, the increased cost and time commitment associated with conducting longitudinal studies and the need for large sample sizes represent a definite challenge to researchers. Collaboration among equine scientists and epidemiologists from multiple institutions and regions may facilitate funding opportunities, enhance questionnaire and experimental design, and provide increased accessibility to farm managers/owners and available horses. Meta-analysis of existing studies may also be of value.

5. Motivation to crib-bite and attempts to stop the behavior

Many owners attempt to physically prevent horses from performing crib-biting behavior (McBride and Long, 2001; Wickens, Chapter 3). Specific methods used to stop the behavior, with varying success, include removal of cribbing surfaces and application of repellents or electric wire, cribbing straps and muzzles, aversion therapy (Baker and Kear-Colwell, 1974) and the surgical removal of the paired omohyoideus and sternothyrohyoideus muscles, a procedure known as modified Forssell's technique (Delacalle et al., 2002). The primary problem with these methods is that they fail to address the underlying causes of crib-biting behavior and may further reduce equine welfare (McBride and Cuddeford, 2001), particularly if the behavior serves a function in stress reduction or alleviation of gastrointestinal discomfort. Short-term prevention of crib-biting behavior using a cribbing strap has been shown to increase crib-biting rate upon removal of the device (McGreevy and Nicol, 1998c). It was suggested that this post-inhibitory rebound reflected an increase in internal motivation to crib-bite during the period when the behavior was thwarted. McGreevy and Nicol (1998c) stated that

behaviors that display this pattern of motivation may be considered functional to the horse. Houpt et al. (2005) demonstrated that crib-biting horses will work to gain access to a crib-biting surface and the results suggested that crib-biting horses valued the behavior nearly as much as they valued food.

The use of pharmacological agents in the treatment of crib-biting behavior has to some extent been successful in stopping or reducing the behavior (Dodman et al., 1987; McDonnell, 1998; Rendon et al., 2001) but requires constant infusion/administration, which would increase costs and labor inputs on farms. Moreover, the side effects and toxicity levels of such compounds have not been adequately studied in horses. Previous authors have recommended that management of crib-biting horses should be targeted toward removal of the causal factors as opposed to prevention through physical means. Increasing opportunities for horses to engage in natural foraging and social behavior is probably the best approach in attempting to prevent the development of crib-biting behavior and shows some promise for reducing frequency and duration of the behavior in established crib-biters (Redbo et al., 1998; Parker et al., 2008b; Wickens, Chapter 3).

Conclusion

Experimental and survey research studies conducted within the past 12 to 15 years have provided a wealth of knowledge regarding the potential causal factors involved in crib-biting behavior. This information has been used extensively to help increase the awareness within the equine community on how the routine management of horses can affect their behavior and welfare. These studies have also given professionals engaged in the study of equine behavior a framework from which to generate additional hypotheses and research questions related to the development and continued performance of crib-

biting behavior. Some of the specific areas meriting additional investigation include the use of learning tasks in assessing the role of brain function and further study of the gastrointestinal environment in crib-biting horses, application of genetic techniques to identify specific genes involved in the behavior, the potential interactions between genetics and management, and the role of observational learning in the performance of crib-biting behavior. Ethologists and welfare scientists should continue to seek a multidisciplinary approach to address questions related to crib-biting behavior, including the use of behavioral and physiological measures, as well as application of epidemiological research methods. Furthermore, collaboration among equine scientists is encouraged to facilitate knowledge and resource sharing.

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CHAPTER 2

GASTRIC ULCERATION IN MATURE HORSES WITH HISTORY OF CRIB-BITING

Abstract

Gastrointestinal irritation has been implicated in crib-biting (CB) in horses. Eighteen horses (9 CB and 9 NCB = non crib-biting) were used to determine prevalence and severity of gastric mucosal damage and effect of concentrate feeding on circulating gastrin concentrations in CB and NCB horses. Horses were maintained on Coastal Bermudagrass (*Cynodon dactylon)* pasture with free access to Bermudagrass hay and water and twice daily delivery of a pelleted (10% protein) concentrate diet. Number of crib-bites were recorded from all CB horses in a 24 hr observation period. Endoscopic examinations (EE) of the squamous mucosa were performed and gastric fluid sampled after 24-28 hour feed removal. Following EE, horses were returned to pasture for 72 hours. Blood was collected at 1400 hours on pasture, following 12-hour feed removal (0 minutes), and at 60 and 120 minutes after consuming 1 kg of the pelleted diet. Mean number of crib-bites in 24 hours was 1,558 ± 303 with CB peaking prior to and during the afternoon feeding (1530 hours, $P < 0.05$). There were no differences in the number ($P > 0.05$) or severity ($P > 0.05$) of ulcers or prevalence of hyperkeratosis (Fisher's Exact $P > 0.05$) between CB and NCB. There was no difference ($P = 0.87$) in gastric pH of CB compared to NCB (3.92 vs. 3.78, respectively, SEM = 0.60). There was no effect of CB ($P = 0.56$) on serum gastrin concentration (14.22 vs. 12.16 pg/ml for CB and NCB, respectively, SEM = 2.46) with free access to hay and pasture. Concentrate feeding increased gastrin concentration ($P < 0.01$). Serum gastrin concentration within CB was greater at times 60 and 120 minutes compared to 0 minutes concentration ($P < 0.01$).

Compared to 0 minutes, serum gastrin concentration in NCB tended to differ at 60 minutes ($P = 0.07$) and was greater at 120 minutes ($P < 0.05$). Serum gastrin concentration at 60 minutes was greater ($P < 0.05$) in CB compared to NCB. Compared to NCB, there was a trend for greater serum gastrin concentration in CB horses at 120 minutes post-concentrate feeding ($P = 0.06$). These results suggest gastric mucosal damage is not associated with established CB in mature horses maintained on pasture. The greater gastrin response to concentrate feeding in CB may indicate altered gastrointestinal function in CB, which could result in a more acidic gastric environment following the consumption of concentrate feed. Further research into the gastrointestinal physiology of crib-biting horses is warranted.

Keywords: Horse, Behavior, Crib-biting, Gastric ulcers, Serum gastrin

Introduction

Crib-biting is an oral stereotypic behavior unique to horses. It is characterized as a repetitive behavioral sequence in which the horse anchors its incisor teeth on a fixed object (e.g. fence, stall and building structures), pulls backward, contracts the neck muscles, and draws air into the cranial esophagus emitting an audible grunt (McGreevy et al., 1995, Dodman et al., 2005). The prevalence of CB in horses in the United States is approximately 4.4% (Albright et al., 2009), with similar prevalence rates reported in other countries (Nicol, 1999). Crib-biting is recognized as a welfare and management concern. For instance, the behavior has been reported to be associated with epiploic foramen colic (Archer et al., 2004, 2008) and has been suggested as a coping mechanism to alleviate suffering or stress (Lebelt et al., 1998; McBride and Cuddeford, 2001). Crib-

biting may limit the horse's eligibility for insurance coverage or acceptance into boarding facilities.

Many owners perceive CB as having a negative impact on horse health and attempt to physically prevent horses from performing the behavior (McBride and Long, 2001; Wickens, Chapter 3). Methods employed in an effort to stop the behavior, with varying success, include the removal or alteration of crib-biting surfaces (e.g. application of repellents, installation of electric wire), neck collars (which prevent expansion of the throat needed to crib-bite), and even surgical removal of the muscles (paired omohyoideus and sternothyrohyoideus) involved in the act of crib-biting, a procedure known as the modified Forssell's technique (Delacalle et al., 2002). These approaches may further reduce equine welfare (McBride and Cuddeford, 2001; Mills and Macleod, 2002) and fail to address the underlying causes of CB.

Although the etiology of CB remains to be elucidated, gastrointestinal irritation has been implicated. Nicol and others (2002) demonstrated an association between CB and gastric ulceration in foals. Upon initial endoscopic examination, CB foals had greater severity of ulceration and inflammation of the gastric squamous mucosa compared to normal foals. Consumption of a diet containing an antacid improved stomach condition in the foals and tended to reduce duration of CB. In mature horses, CB has been associated with lower basal and post-feeding gastric pH (Lillie et al., 2004), and long-term treatment with antacids has been shown to reduce the frequency of CB (Mills and Macleod, 2002). The underlying cause of lower gastric pH in CB horses has not been determined. Endoscopic examinations were not performed during the Mills and Macleod study (2002), thus it is unclear whether the reduction in CB frequency observed in mature

horses consuming an antacid diet was due to an increase in gastric pH alone or to an overall improvement in the condition of the gastric mucosa. Nicol (1999) suggested that horses may perform CB in an attempt to reduce gastric acidity through the production of alkaline saliva. A study conducted by Moeller et al. (2008) demonstrated that salivation is stimulated with CB lending support to this hypothesis. Although results of previous research have provided some evidence that gastric acidity may be involved in CB, an association between gastric ulceration and CB in mature horses has never been reported.

Strong causal associations between gastric acidity and mucosal damage have been demonstrated in horses (Murray and Eichorn, 1996; Murray, 1999). Gastric acid secretion is stimulated by the peptide hormone gastrin, which is released into the blood by G cells located in the glandular portion of the stomach (Katz, 1991) in response to gastric distension, protein, and increased luminal pH (Wolfe and Soll, 1988). Gastrin concentration in horses has been shown to increase following feeding (Brown et al., 1987; Young and Smyth., 1988; Wilson et al., 2007), with greater and more prolonged gastrin secretion occurring in response to pelleted and sweet feed diets (Smyth et al., 1989) compared to ad libitum feeding of Coastal Bermudagrass hay. Several studies have demonstrated a positive relationship between concentrate feeding and crib-biting behavior (Kusunose, 1992: Gillham et al., 1994; Redbo et al., 1998; Waters et al., 2002). Specifically, Kusunose (1992) and Gillham (1994) observed an increase in crib-biting frequency in the period following concentrate feeding. The studies conducted by Redbo et al. (1998) and Waters et al. (2002), found concentrate feeding to be associated with an increased risk of crib-biting behavior.

The proximal portion of the equine stomach is covered by stratified squamous mucosa. The distal portion is covered by glandular mucosa containing glands that secrete hydrochloric acid, pepsin, bicarbonate, and mucus. The two regions are separated by a cuticular ridge known as the margo plicatus (Figure 2-1). In mature horses, gastric ulcers primarily occur in the squamous mucosa adjacent to the margo plicatus (Murray and Eichorn, 1996; Murray, 1997; Murray, 1998) Andrews and Nadeau, 1999, Dionne et al., 2003). The squamous mucosa is susceptible to ulceration because it lacks intrinsic protective factors, (mucus and bicarbonate), found in the glandular region of the stomach, and the area adjacent to the margo plicatus is frequently exposed to high acidity (Murray and Eichorn 1996; Murray, 1997; Murray, 1999). Damage to the gastric mucosa has been associated with bruxism and behavioral signs of colic (Murray, 1998), thus it appears horses are able to detect mucosal injury.

The aim of this study was to investigate the relationship between CB and the integrity and function of the gastric mucosa in mature horses. We hypothesized that horses exhibiting CB would have a higher degree of gastric mucosal damage and higher serum gastrin response to concentrate feeding compared to non crib-biting horses. The specific objectives were to determine: 1) prevalence and severity of gastric mucosal damage in mature CB horses, and 2) effect of feeding on circulating gastrin concentrations in CB and non crib-biting horses.

Materials and Methods

Animals and diet

Eighteen mature horses, 9 with history of crib-biting (CB) and 9 controls (NCB) were used in this study. Horses were housed at the Auburn University Horse Unit in

Auburn, Alabama and were part of the existing university teaching and research herd. The study was conducted in December 2007. Crib-biting and NCB horses were matched as closely as possible based on sex, age, and breed. Characteristics of each group are presented in Table 2-1. All horses were maintained on Coastal Bermudagrass (*Cynodon dactylon*) pasture with free access to Bermudagrass hay (8% crude protein on an as-fed basis) and water. Crib-biting and NCB horses were kept in separate pastures. Twice daily (0730 and 1530 hours), horses received 2 kg of a 10% crude protein, 9% crude fiber commercial pelleted diet (Nutrena® Life Design® Compete, Minneapolis, MN). The main ingredients of the pelleted diet are presented in Table 2-2. Horses were routinely dewormed every 8 to 12 weeks. Each horse's body condition was assessed using a scale of 1-9, with 1 designating poor condition (extremely emaciated) and 9 designating a horse in extremely fat condition (Henneke et al., 1983). All experimental procedures were carried out under Auburn University Institutional Animal Care and Use Committee approval.

Behavioral observations

Crib-biting horses were observed on pasture at the beginning of the study for frequency and duration of crib-biting behavior. Human observers recorded the number of crib-bites and duration of cribbing bouts during a 24-hour observation period (0600 to 0600 hours the following day). CB was not exhibited by any of the control horses during the study.

Endoscopic examination, blood collection, and gastric pH measurement

Forty-eight hours following behavioral observations, horses were placed in box stalls. Feed was withheld 24 to 28 hours and water was removed 12 hours prior to

endoscopy to allow for adequate emptying of the stomach. Ingestion of bedding was prevented by removing shavings from the stalls. On the morning of the endoscopic examinations, horses were loaded onto trailers and transported 0.25 miles (402.3 meters) to the Auburn University Large Animal Teaching Hospital. A complete blood count (CBC) and blood gas profile were obtained from each horse prior to endoscopic examination. Briefly, for the blood gas profile, 1 ml of blood was drawn from the jugular vein via a heparinized syringe and placed on ice until analysis. A second blood sample (3 ml) was collected into a vaccutainer tube containing EDTA for CBC analysis. The CBC and blood gas analyses were performed immediately following blood collection by the Auburn University College of Veterinary Medicine Pathobiology Diagnostic Services. Body weights were determined using a livestock scale. Horses were sedated using a combination of butorphanol (0.02 mg/kg, IV) and detomadine (0.01 mg/kg, IV) and confined in treatment stocks. A nose twitch was applied for further restraint. A nasogastric tube was passed through the nasal passages into the esophagus, and a 3 meter video endoscope (Fujinon EV-40-45-LP5-30, Wayne, NJ) was inserted through the lumen of the nasogastric tube into the esophagus and into the stomach. Insufflation with room air was used to facilitate visualization of the gastric mucosa. Video records (approximately 10 minute clips) of the squamous mucosa of the saccus cecus, non-glandular fundus, and along the margo plicatus were obtained for ulcer scoring.

During the examination, 10 to 20 ml of gastric fluid was aspirated from the glandular fundus region of the stomach through the channel of the endoscope using a 60 ml syringe. One sample per horse was transferred to a specimen cup for determination of pH using a digital pH meter (Omega PHH-26, Omega Engineering, Inc., Stamford, CT).

Endoscopic examinations were performed between 0830-1200 hours over a 2-day period. Horses were divided into 2 groups (n = 9 in each group) for endoscopic examination. On day 1, endoscopic examinations were performed on 5 CB and 4 NCB horses. On day 2, endoscopic examinations were performed on 4 CB and 5 NCB horses. The order in which CB and NCB horses underwent endoscopy was randomized on both days. Immediately following endoscopy, each horse was returned to an outpatient stall until all horses had been examined. Horses were transported back to the Auburn University Horse Unit and returned to their home pasture 1 to 3 hours following endoscopy. No adverse effects as a result of the procedure were observed.

Ulcer Scoring

Video records from each horse were viewed by 2 observers (experienced veterinarians) blinded to the horses' behavioral classification. Condition of the gastric mucosa was assessed using an accepted gastric ulcer scoring system (MacAllister et al., 1997). This system assigns both a lesion number and a lesion severity score. The non-glandular lesion number score ranges from 0 to 4 and is defined as follows: 0 (no lesions), 1 (1-2 localized lesions), 2 (3-5 localized lesions), 3 (6-10 lesions), and 4 [>10 lesions or diffuse (or very large) lesions]. The non-glandular lesion severity score ranges from 0 to 5, and is defined as: 0 (no lesions), 1 (appears superficial), 2 [deeper structures involved (lesion has greater depth than number 1)], 3 [multiple lesions and variable severity (1, 2, or 4)], 4 [same as number 2 and has active (hyperemic or darkened lesion crater] appearance, and 5 (deep structures involved, having an active appearance with active hemorrhage or adherent blood clot). Thus, a total of 4 scores were obtained for each horse. The observers also noted the presence of hyperkeratosis; i.e. the

keratinization or thickening of the mucosa, indicative of exposure to high acidity (Murray, 1992; 1997).

Serum gastrin protocol

Three days following endoscopic examination, horses were brought into unbedded box stalls at 1345 hours following continuous access to pasture, hay and water. At 1400 hours, 10 ml of blood was drawn from each horse via jugular venipuncture, collected into SST vaccutainer tubes and allowed to clot on ice. Blood samples were centrifuged (IEC Centra CL2, Thermo Electron Company, Milford, MA) at 1560 x g for 20 minutes and serum was removed and stored at -20° C until analysis. The initial sample was collected to determine gastrin concentration in horses allowed free access to forage (pasture and hay). Horses were fed 1.5 kg of Bermudagrass hay at 1645 hours and 1 kg of the pelleted concentrate diet at 1830 hours. Hay and concentrate were consumed by all horses by 1845. Water was provided in 5 gallon buckets. The next morning, three additional blood samples (10 ml each) were collected and serum harvested using the same protocol described above. The first sample was drawn at 0645 following 12-hour feed removal to obtain basal metabolite values (0 minutes). Horses then were fed 1 kg of the pelleted diet and allowed to eat for 15 minutes. All horses consumed the ration within the allotted time period, and the second and third blood samples were collected from each horse 60 and 120 minutes post-feeding.

Gastrin assay

Serum gastrin concentrations were measured using a commercially available double antibody radioimmunoassay designed for human use (Siemens Medical Solutions Diagnostics, Los Angeles, CA). The method had been validated previously for use in

horses (Young and Smyth, 1988), but a validation with samples obtained from the crib-biting and non crib-biting horses from the current study was conducted to assess the agreement between the linear portion of the standard curve of the assay and the linear portion of the equine serum gastrin samples. Equine serum gastrin concentrations reported in previous studies (Brown et al., 1987; Smyth et al., 1989) have included several values below 30 pg/ml. Therefore, the lowest standard included in the assay (25 pg/ml), was diluted using the 0 pg/ml calibrator solution to prepare a 12.5 pg/ml and a 6.25 pg/ml standard. All samples were run in duplicate and were assayed on the same day.

Statistical analysis

Ulcer score and hyperkeratosis data were analyzed using SPSS (version16.0, SPSS Inc., Chicago, IL). Ulcer number and severity scores were analyzed by Mann-Whitney tests, and presence of hyperkeratosis was analyzed by chi-square tests of independence. A Kendall correlation was used to evaluate agreement among scores obtained from the 2 observers (CORR procedure of SAS, Version 9.1, SAS Institute Inc., Cary, NC).

Behavioral, hemoglobin, RBC count, blood gas, gastric pH, body condition and initial serum gastrin data (samples collected following free-access to hay and pasture) were submitted to ANOVA using the GLM procedure of SAS (Version 9.1, SAS Institute Inc., Cary, NC). The statistical model for analysis of number of crib-bites and duration of crib-biting included effects of horse and time. Horse was treated as a random effect. The 24-hour observation period was divided into 12, 2-hour time intervals to assess diurnal crib-biting patterns. Multiple comparisons between time intervals were generated using

Tukey-Kramer adjustments. The model for hemoglobin, RBC count, blood gas, body condition, gastric pH and initial serum gastrin concentration included the effect of cribbing. Blood chemistry and gastric pH data also were subjected to tests for homogeneity of variance and normality.

Serum gastrin data collected at 0, 60, and 120 minutes post-feeding, were analyzed using the GLIMMIX procedure of SAS for repeated measures applying Kenward-Roger's adjusted degrees of freedom to determine cribbing differences within time (GLIMMIX 2006, SAS Institute Inc., Cary, NC). The model for serum gastrin was cribbing, horse nested within cribbing, time, and time by cribbing. Horse within cribbing was a random effect which was the error term used to test the effect of cribbing. Cribbing effect within a time was tested with the slicediff option in SAS GLIMMIX.

Kendall correlations between 24-hour crib-biting frequency, ulcer number and severity scores, presence of hyperkeratosis, gastric pH, and serum gastrin concentrations were analyzed using the CORR procedure of SAS. Kendall correlations also were examined between body condition score and ulcer number and severity in both groups of horses.

Results

Behavior

Diurnal crib-biting frequency is shown in Figure 2-2. The mean number of crib-bites in 24 hours was 1,558 ± 303. Crib-biting frequency peaked prior to and during the afternoon feeding (1530 hours, $P < 0.05$). Duration of crib-biting during the 24-hour observation period is shown in Figure 2-3. The mean duration of crib-biting in 24 hours was 237.3 ±54.4 min. Thus, study horses spent approximately 16 to 17% of the day

engaged in crib-biting behavior. The duration of crib-biting behavior followed a similar diurnal pattern as crib-biting frequency with a peak in bout length occurring during consumption of the afternoon pelleted meal ($P < 0.05$). No significant correlations were found between 24-hour crib-biting frequency, ulcer number and severity scores, presence of hyperkeratosis, gastric pH, and serum gastrin concentrations.

Condition of gastric mucosa

Ulcer number and severity scores of CB and NCB horses reported by the 2 observers are presented in Table 2-3. Based on the scores reported by observer 1, there were no differences in ulcer number (1.0 ± 0.50 vs. 0.7 ± 0.37, Mann-Whitney $U = 35.5$, $P = 0.61$) or severity (0.7 ± 0.29 vs. 0.6 ± 0.29, Mann-Whitney $U = 37.0$, $P = 0.72$) between CB and NCB. There were also no differences in ulcer number (0.6 ± 0.44 vs. 0.4 ± 0.44, Mann-Whitney $U = 36.5$, $P = 0.59$) or severity (0.6 ± 0.44 vs. 0.3 ± 0.33, Mann-Whitney $U = 36.0$, $P = 0.54$) between CB and NCB, based on the scores reported by observer 2. Presence of hyperkeratosis in CB and NCB horses is presented in Table 2-4. There was no difference in presence of hyperkeratosis between CB and NCB as assessed by either observer 1 (Fisher's Exact $P = 1.00$) or observer 2 (Fisher's Exact $P = 0.34$). Prevalence of ulcers observed in this study was 38.9% and 16.7% based on the assessment of observers 1 and 2, respectively. Agreement among the 2 observers for ulcer number (Kendall Correlation Coefficient = 0.63, $P < 0.05$) and ulcer severity score (Kendall Correlation Coefficient = 0.64, $P < 0.05$) was moderate. There was less agreement among the two observers regarding presence of hyperkeratosis (Kendall Correlation Coefficient = 0.44, $P = 0.07$). Mean body condition score of CB (6.19 ± 0.22)

was higher ($P < 0.01$) compared to NCB (5.12 ± 0.22). No significant correlation was found between body condition and ulcer number or severity scores in CB or NCB horses.

Blood chemistry and gastric pH

Blood chemistry and gastric pH results for CB and NCB are presented in Table 2-5. Red blood cell count, hemoglobin, and hematocrit were higher ($P < 0.05$) in CB compared to NCB. There was no difference in blood pH between CB and NCB ($P = 0.52$). Venous pO_2 and oxygen saturation tended to be higher in CB ($P < 0.10$, and $P = 0.11$, respectively) compared to NCB. Gastric pH following 24-28 hours of feed removal was not different between CB and NCB ($P = 0.87$). Gastric pH data did not meet the assumptions of normality (Shapiro-Wilk = 0.89, $P < 0.05$) and were log transformed. Log transformation confirmed that gastric pH was not different between CB and NCB ($P = 0.81$).

Serum gastrin concentration

Results of the validation using serum samples from CB and NCB horses confirmed that gastrin concentrations measured by the radioimmunoassay were on the linear portion of the standard curve. When horses were allowed free access to hay and pasture (Figure 2-4), there was no effect of CB ($P = 0.56$) on serum gastrin concentration. Serum gastrin response to concentrate feeding in CB and NCB is shown in Figure 2-5. Consumption of a pelleted concentrate meal increased gastrin concentration ($P < 0.01$). The time by cribbing interaction was not found to be significant ($P = 0.18$). Serum gastrin concentration within CB was greater at times 60 and 120 minutes compared to pre-feeding (0 minutes) concentration ($P < 0.01$). Compared to 0 minutes, serum gastrin concentration in NCB tended to differ at 60 minutes ($P = 0.07$) and was greater at 120

minutes ($P < 0.05$). Serum gastrin concentration at 60 minutes was greater ($P < 0.05$) in CB compared to NCB. Compared to NCB, serum gastrin concentration tended to be greater in CB horses at 120 minutes post-concentrate feeding ($P = 0.06$).

Discussion

Previous studies of crib-biting behavior in adult horses have demonstrated an increase in crib-biting frequency shortly after the consumption of a concentrated meal (Kusunose, 1992; Gillham et al., 1994). Thus, in the current study, an increase in crib-biting frequency was expected following consumption of the pelleted diet during the morning and afternoon feeding. The number of crib-bites increased during the observation period in which horses received the afternoon concentrate meal, as did the amount of time spent crib-biting, however, a peak in crib-biting frequency or duration was not observed during the morning concentrate feeding. Performance of crib-biting may have been interrupted during the morning delivery of the pelleted diet due to a general increase in activity associated with the arrival of the feeding crew. In addition, crib-biting behavior in the current study was observed in horses maintained on pasture with ad libitum access to hay. This differs from methods employed in earlier studies (Kusunose, 1992; Gillham et al., 1994) in which horses were stabled and were not given continuous access to forage. Kusunose (1992) showed crib-biting frequency to be low around the time of roughage meal delivery, and Redbo et al., (1998) found the risk of stereotypic behavior, including crib-biting, to be reduced when the amount of roughage is increased. Deviations in the diurnal crib-biting pattern between studies also may be due to differences in behavioral observation techniques. Behavioral data in the current study were recorded by human observers as opposed to use of video surveillance in the study

conducted by Kusunose (1992). Video surveillance would have eliminated any confounding effects of human presence on diurnal crib-biting patterns, however, project horses were accustomed to human observers, thus human influence on crib-biting behavior should have been minimal. Furthermore, the large pasture where crib-biting horses were kept was not conducive to the use of video surveillance equipment, and the authors felt it was important to assess crib-biting behavior in the environment in which the horses were normally housed, minimizing confounding effects of stall confinement on behavior.

The prevalence of non-glandular gastric ulcers in adult horses ranges from 11% (Chameroy et al., 2006) to 93% (Murray et al., 1996) with prevalence and severity of lesions found to be greatest among racing Thoroughbreds (Hammond et al., 1986; Murray et al., 1996). Based on the evidence implicating gastrointestinal irritation as a motivating factor for crib-biting in mature horses (Mills and Macleod, 2002; Lillie et al., 2004; Moeller et al., 2008) and the association between gastric acidity and mucosal damage (Murray and Eichorn, 1996; Murray, 1999), prevalence and severity of gastric ulceration was expected to be greater in horses exhibiting crib-biting behavior. Prevalence of ulcers observed in the current study was relatively low, particularly as assessed by observer 2. Lesion severity was mild, as only 1 horse received an ulcer severity score greater than 3. The manner in which both crib-biting and non crib-biting horses were routinely managed may have influenced the severity of ulceration observed in this study. All of the horses enrolled in the study at the Auburn University Horse Unit were maintained on pasture with free access to hay, factors shown to be protective against gastric acidity (Murray and Schusser, 1993) and development of gastric ulcers

(Murray and Eichorn, 1996; Pagan, 1997). Horses used in this study were not subjected to intensive training regimens, or extended periods of stall confinement, factors that have been considered to be ulcerogenic in horses (Hammond et al., 1986; Murray and Eichorn, 1996). Agreement between observers in the number and severity of ulcers using the scoring system of MacAllister et al. (1997) was moderate. MacAllister et al. (1997) reported consistency in the way observers scored severity of non-glandular lesions, but found significant variability between observers in the number of lesions identified in the squamous mucosa. Thus, some level of discrepancy in scores assessed using the MacAllister scoring system was expected. The level of agreement between observers with regards to presence of hyperkeratosis was low, however very few studies have assessed the presence or absence of hyperkeratosis, and therefore have not analyzed the extent to which multiple observers' diagnoses of hyperkeratosis coincide. The degree to which the mucosa appears hyperkeratotic (yellow and thickened) may be highly subjective and could vary widely between observers. Nonetheless, ulcer number and severity scores, and presence of hyperkeratosis in the squamous mucosa as reported by either observer were not supportive of a link between gastric ulceration and crib-biting in mature horses, at least in this population of pastured horses.

Although a small portion of the glandular mucosa adjacent to the margo plicatus was visible in a majority of the horses, insufficient insufflation and presence of gastric fluid may have precluded accurate assessment of ulceration in the glandular mucosa. Thus, the prevalence of ulcers may have been underestimated. Improvements in endoscopic examination equipment have enhanced the ability of clinicians to visualize the equine stomach in its entirety (Murray et al., 2001; Murray, 2002), but many authors

still report difficulties in viewing the glandular portion of the stomach (Andrews et al., 2002; Chameroy et al., 2006; Dukti et al., 2006). Perhaps the challenge lies in extending the time and effort required to allow adequate visualization of the stomach in a clinical setting for the purposes of definitively diagnosing and treating gastric ulcers in individual horses, to multiple horses enrolled in research studies. Murray et al. (2001) reported ulcer prevalences in the glandular fundus and pylorus of horses of 8% and 58%, respectively. However, in other studies where endoscopic views of the glandular mucosa have been obtained, occurrence of ulcers in the glandular region was less frequent (McClure et al., 1999; Andrews et al., 2002; Dionne et al., 2003). Whereas ulcers in the glandular mucosa are suspected to result from impairments in mucosal defense mechanisms (Murray 1992; Murray 1997; Murray et al., 2001), ulceration in the squamous mucosa is suggested to result primarily from exposure to high acidity (Murray, 1997; Murray et al., 2001). Compared to non crib-biting horses, gastric pH of crib-biting horses has been shown to be lower in both the fasted and fed state (Lillie et al., 2004). Exposure to an acidic environment more likely would affect the proximal portion of the stomach, particularly the region adjacent to the margo plicatus, thus it was within the scope of this study to assess and compare the condition of the squamous mucosa of crib-biting and non-crib-biting horses.

Previous research has demonstrated an association between gastric ulceration and poor body condition in horses (Murray et al., 1989; Dionne et al., 2003). Specifically, prevalence and severity of ulceration were greater in horses presenting clinical signs including poor condition and decreased appetite (Murray et al., 1989). No relationship between body condition and ulcer number or severity was found in the current study.

However, ulcers in both the crib-biting and control horses were considered to be mild (mean number and severity scores in both groups were ≤ 1), and therefore did not have a negative impact on body condition. Although crib-biting horses received a higher mean body condition score (BCS), a mean BCS of 5 in controls indicated the majority of non crib-biting horses were also in good condition.

Horses with gastric ulcers have been shown to have lower RBC count and hemoglobin compared to horses without ulcers (McClure et al., 1999). McClure and others (1999) suggested the lower RBC count and hemoglobin may be the result of chronic ulceration, although it was noted by the authors that mean RBC in both groups was within the reference range (6 to 12 x 10^6 cells/μl). According to Murray (1998), lesions in the squamous mucosa can be deep enough to cause bleeding, however, this bleeding typically does not result in anemia. None of the horses in the current study received an ulcer severity score of 5, characterizing lesions with active hemorrhage, and mean RBC count and hemoglobin were within normal range. There is some evidence suggesting crib-biting horses react more strongly to acute stressors (Minero et al., 1999; Bachman et al., 2003) compared to their non crib-biting counterparts. Psychological factors such as stress or excitement during transport can cause splenic contraction in horses resulting in release of red blood cells into circulation producing elevated RBC count and hemoglobin (Fazio and Ferlazzo, 2003). Cortisol concentration and heart rate were not measured which prevented quantification of a heightened stress response in crib-biting horses during study procedures. However, if crib-biting horses did experience greater arousal and anxiety during transportation or blood sampling, it may explain the higher RBC count and hemoglobin observed in this study. Water was withheld from all

horses 12 hours prior to endoscopy, thus losses in plasma volume and subsequent elevation in RBC count and hemoglobin would have been expected to occur in both groups. Therefore, release of RBC via splenic contraction is more likely to have contributed to the differences observed between crib-biting horses and controls. Higher RBC, hemoglobin, and hematocrit can increase oxygen carrying capacity, which would explain the tendency toward greater venous pO2 and oxygen saturation observed in the crib-biting horses.

Due to the importance of mucosal blood flow in removing waste products from the gastric mucosa (Murray, 1999), it was thought a decrease in venous blood pH might be indicative of increased permeability of damaged gastric mucosa to hydrogen ions. Mean venous blood pH of both crib-biting and non crib-biting horses was within normal range. To the authors' knowledge, no studies have found a decrease in venous blood pH in subjects with gastric ulcers. Perhaps a relationship between gastric ulceration and blood pH would have been demonstrated had prevalence and severity of ulcers been greater in this sample of horses. Although it is probable that venous blood pH values that deviate from normal may be more reflective of systemic acid-base status rather than being useful in pinpointing a local acidotic condition within the stomach. Gastric pH of crib-biting horses following 24 to 28 hours of feed removal (3.92) was similar to 15-hour fasting pH (3.36) observed in the study by Lillie and others (2004). Fasting gastric pH of non crib-biting horses in the present study (3.78) was lower compared to mean gastric pH (5.50) of non crib-biting horses measured previously (Lillie et al., 2004). Therefore, unlike the findings of Lillie et al. (2004), differences in fasting gastric pH between crib-biting and non crib-biting horses were not observed. Too much emphasis should not be

placed on the fasting pH measurements obtained in either study as in both research settings, only one gastric fluid sample was obtained. The pH of gastric fluid sampled from horses during endoscopy was highly variable, with gastric pH in crib-biting and non crib-biting horses ranging from 1.80 to 6.24 and from 1.47 to 6.40, respectively. In studies where pH electrodes have been used to continually monitor gastric pH in horses, intermittent periods of alkalinization with pH readings 6.0 and greater have been observed (Murray and Schusser, 1993; Baker and Gerring, 1993). The periods of alkalinization became more frequent and values more variable, the longer horses were withheld from feed. Reflux of more basic duodenal contents (pH 6.0 to 7.0) into the stomach is reported to be a common occurrence in horses (Merritt, 1999) and is the most probable cause of spontaneous increases in gastric pH. Therefore, repeated sampling as was used in the study conducted by Lillie et al. (2004) to measure post-feeding gastric pH would be preferred because it would reduce variation and provide a more accurate representation of the gastric acidity in each horse.

Basal and post-feeding serum gastrin concentrations were similar to values obtained in other studies (Brown et al., 1987; Young et al., 1988; Smyth et al., 1989; Furr et al., 1993). Gastrin concentrations in crib-biting and control horses following ad libitum access to hay and pasture were also in agreement with values reported by Smyth et al. (1989) in horses fed Coastal Bermudagrass hay. Although gastric pH and serum gastrin concentration data were not measured simultaneously, the author speculates that the greater gastrin response to concentrate feeding in crib-biting horses could lead to a larger increase in gastric acid secretion. Indeed, infusion of synthetic horse gastrin has been shown to increase gastric acid secretion and reduce the pH of gastric fluid in horses

(Sandin et al., 1999). Gastrin stimulated acid secretion may be enhanced in crib-biting horses due to greater G cell numbers or increased secretory capacity of the existing G cells, but further studies involving mucosal biopsies and employing molecular genetic techniques would be needed to confirm this idea. In the study conducted by Lillie et al. (2004), horses were fed a commercial sweet feed and given access to Bermudagrass hay during gastric fluid sampling. Hay consumption stimulates increased saliva production due to the longer period of mastication required to ingest forage (Meyer et al., 1985) and bicarbonate in saliva aids in buffering the gastrointestinal tract. Indeed, Lillie and others (2004) found that gastric pH increased with feeding in both crib-biting and non crib-biting horses (4.21 and 5.62, respectively), but gastric pH of the crib-biting horses remained lower than controls ($P < 0.03$). Thus, the response of gastric mucosa of crib-biting horses to the concentrate portion of the diet may have been responsible for the lower pH. Gastrin concentrations in crib-biting and non crib-biting horses consuming pasture and hay for 6 hours were not different, indicating that gastrin response to forage was similar in both groups. A heightened gastrin response to concentrate feeding could result in crib-biting horses having a more acidic gastrointestinal environment, an effect that is most likely attenuated when horses have ready access to forage. Higher gastrin concentrations did not result in greater mucosal damage in crib-biting horses, but as mentioned previously, management of study horses was protective against development of gastric ulcers. Moeller et al. (2008) suggested that the alkalinity of equine saliva, if produced in large enough amounts, could have a significant buffering effect. It was thought that total 24-hour crib-biting frequency would be negatively correlated with gastric pH and positively correlated with mucosal damage and serum gastrin

concentration as horses attempted to alleviate the acidic gastric environment through increased saliva production. However, no associations between 24-hour crib-biting frequency, gastric pH, gastric ulcer number and severity, hyperkeratosis, or serum gastrin concentrations were found.

It has been suggested by Cooper et al. (1996) that with time, stereotypies can become emancipated from the original causal factors. Crib-biting horses used in this study were donated to the Auburn University equine program, thus a thorough history on each horse was not available. However, the majority of horses included in the study had been known to crib-bite for at least 2 years. Therefore, crib-biting behavior can be considered to be established in this group of horses. The fact that horses housed on pasture continue to crib-bite, may be reflective of past gastrointestinal irritation rather than being the result of an existing condition. Altered gastrointestinal function, specifically an increased gastrin response to concentrate feeding, could be a key factor in the development or onset of crib-biting behavior in horses. Particularly vulnerable would be horses undergoing drastic changes in management earlier in life, such as exposure to high concentrate:low roughage diets, increased stall confinement, and enrollment into strenuous training regimens.

Conclusion

The results of this study suggest that gastric mucosal damage is not associated with established crib-biting in mature horses maintained on pasture. Thus, owners of crib-biting horses who provide their animals with adequate foraging opportunities should not suspect gastric ulcers as being the primary cause of the behavior. However, the greater gastrin response to feeding in crib-biting horses is of interest as this finding may indicate

altered gastrointestinal function in crib-biting horses that could result in a more acidic gastric environment following consumption of concentrated meals. An increase in gastric acidity may be more problematic for horses receiving low forage diets in light of the evidence that increased roughage and provision of an antacid diet are effective in reducing crib-biting behavior even in established crib-biters. Longitudinal studies of the gastrointestinal environment including measurement of gastrointestinal hormones in a large population of horses exposed to various management practices are needed to further elucidate the role of gastrointestinal irritation in crib-biting behavior.

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Table 2-1 Characteristics of study horses

Group	Sex	Age	Breed*
Crib-biting (N = 9)	8 geldings, 1 mare	7-20 years	TB, QH, TBxQH Cross
Non crib-biting (N = 9)	8 geldings, 1 mare	9-18 years	TB, Warmblood

* TB = Thoroughbred, QH = Quarter Horse.

Table 2-2 Main ingredients of commercial pelleted diet*

Wheat middlings
Ground corn
Rice bran
Soybean hulls
Cane molasses
Corn oil
Glycerin
Calcium carbonate
Salt
Dehydrated alfalfa meal
Grain products
Dehulled soybean meal
Yeast culture
Vitamin A, D, and E supplement
Vitamin B 12, Riboflavin, Folic Acid, and Biotin supplement
Thiamine
L-lysine
DL-methionine

* Nutrena® Life Design® Compete, Minneapolis, MN. Ingredients are listed in the order in which they appear on the feed tag.

Table 2-3 Ulcer number and severity scores by behavior*

	Ulcer Number Score					Ulcer Severity Score					
	0	1	2	3	4	0	1	2	3	4	5
Observer 1											
Crib-biting (n = 9)[a]	5	2	0	1	1	5	2	2	0	0	0
Non crib-biting (n = 9)[a]	6	1	1	1	0	6	1	2	0	0	0
Observer 2											
Crib-biting (n = 9)[b]	7	1	0	0	1	7	1	0	0	1	0
Non crib-biting (n = 9)[b]	8	0	0	0	1	8	0	0	1	0	0

* Number of horses with ulcer number and severity scores of 0 to 4 and 0 to 5, respectively.

[a] Ulcer number and severity did not differ (P = 0.61, P = 0.72, respectively) between crib-biting and non crib-biting horses.

[b] Ulcer number and severity did not differ (P = 0.59, P = 0.54, respectively) between crib-biting and non crib-biting horses.

Table 2-4 Presence of hyperkeratosis by behavior*

	Hyperkeratosis Present	
	Yes	No
Observer 1		
Crib-biting (n = 9)	1[a]	8
Non crib-biting (n = 9)	1[a]	8
Observer 2		
Crib-biting (n = 9)	5[b]	4
Non crib-biting (n = 9)	2[b]	7

* Number of horses with evidence of hyperkeratosis.

[a] Presence of hyperkeratosis was not different between crib-biting and non crib-biting horses (P = 1.00).

[b] Presence of hyperkeratosis was not different between crib-biting and non crib-biting horses (P = 0.34).

Table 2-5 Blood chemistry and gastric pH values by behavior

	Behavior			
	CB (n = 9)	NCB (n = 9)		
Item	Mean	Mean	SEM	P-Value
RBC (x 10^6/uL)[§]	9.34[a]	7.92[b]	0.380	0.018
HGB (g/dL)[¶]	16.27[a]	13.70[b]	0.671	0.016
Hematocrit (%)[*]	40.53[a]	34.61[b]	1.600	0.019
Venous pO_2 (mmHg)[**]	36.52[a]	33.98[c]	1.023	0.099
Venous Oxygen Saturation (%)[†]	70.07[a]	65.34[c]	1.976	0.110
Venous Blood pH[‡]	7.43[a]	7.44[a]	0.005	0.517
Gastric pH	3.92[a]	3.78[a]	0.287	0.739

[a,b] Least squares mean estimates within a row with unlike superscripts differ at $P < 0.05$.

[a,c] Least squares mean estimates within a row with unlike superscripts tend to differ at $P \leq 0.1$.

[§] Normal range = 6 to 12 x 10^6/μL.

[¶] Normal range = 10 to 18 g/dL.

[*] Normal range = 32 to 48%.

[**] Normal range = 17.9 to 42.2 mmHg.

[†] Normal range = 60 to 80%.

[‡] Normal range = 7.38 to 7.46.

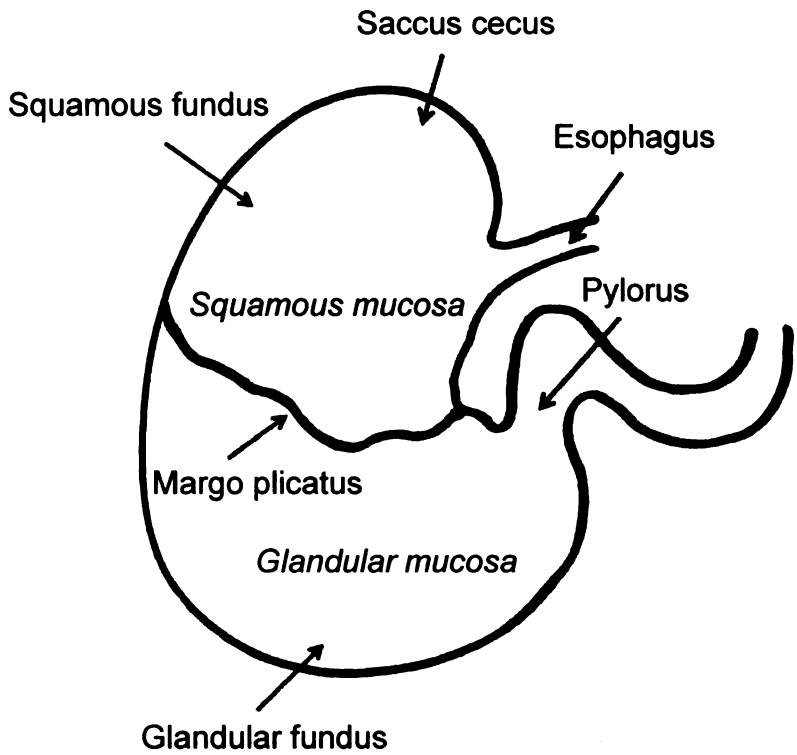

Figure 2-1 Schematic representation of equine stomach anatomy.

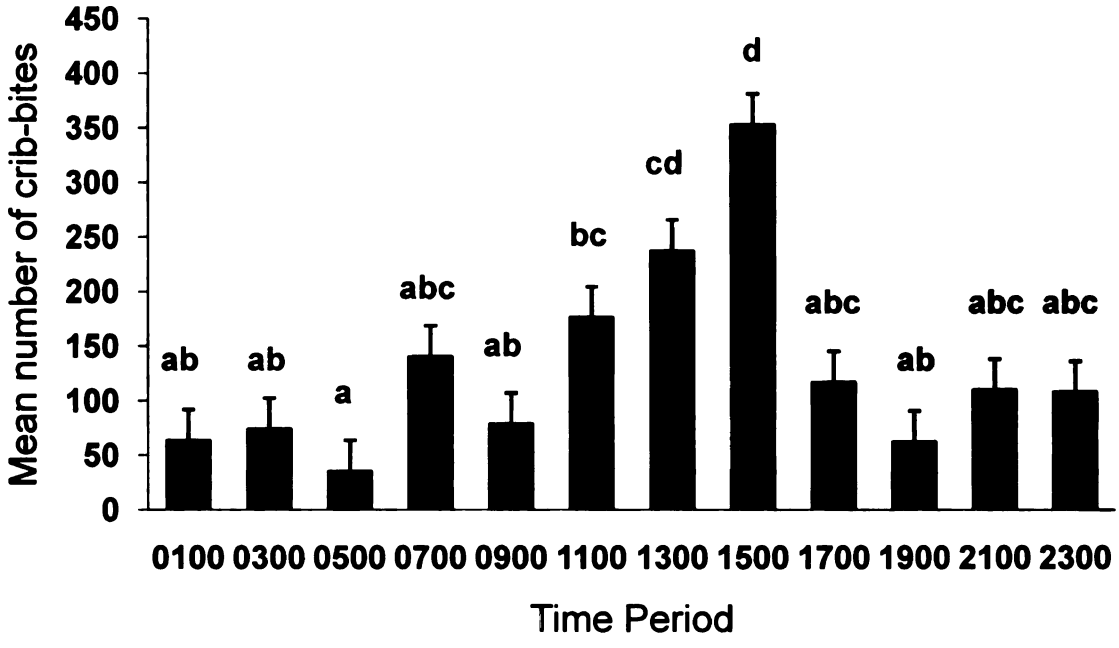

Figure 2-2 Mean crib-biting frequency of CB horses observed for 24 hours on pasture. Each bar represents a 2 hour time period with the midpoint of each time period shown along the x-axis. The pelleted diet (2 kg) was fed at 0730 and 1530 hours. Least squares mean estimates ±S.E.M. are shown. Superscripts denote significant differences at $P < 0.05$.

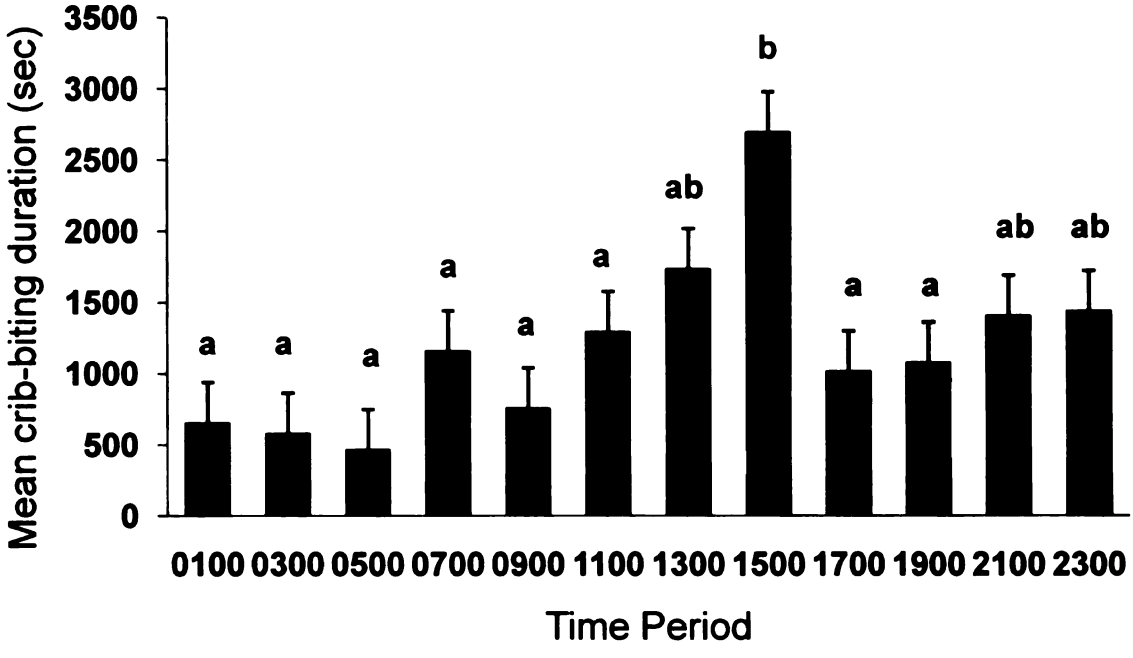

Figure 2-3 Mean crib-biting duration of CB horses observed for 24 hours on pasture. Each bar represents a 2 hour time period with the midpoint of each time period shown along the x-axis. The pelleted diet (2 kg) was fed at 0730 and 1530 hours. Least squares means estimates ±S.E.M. are shown. Superscripts denote significant differences at $P < 0.05$.

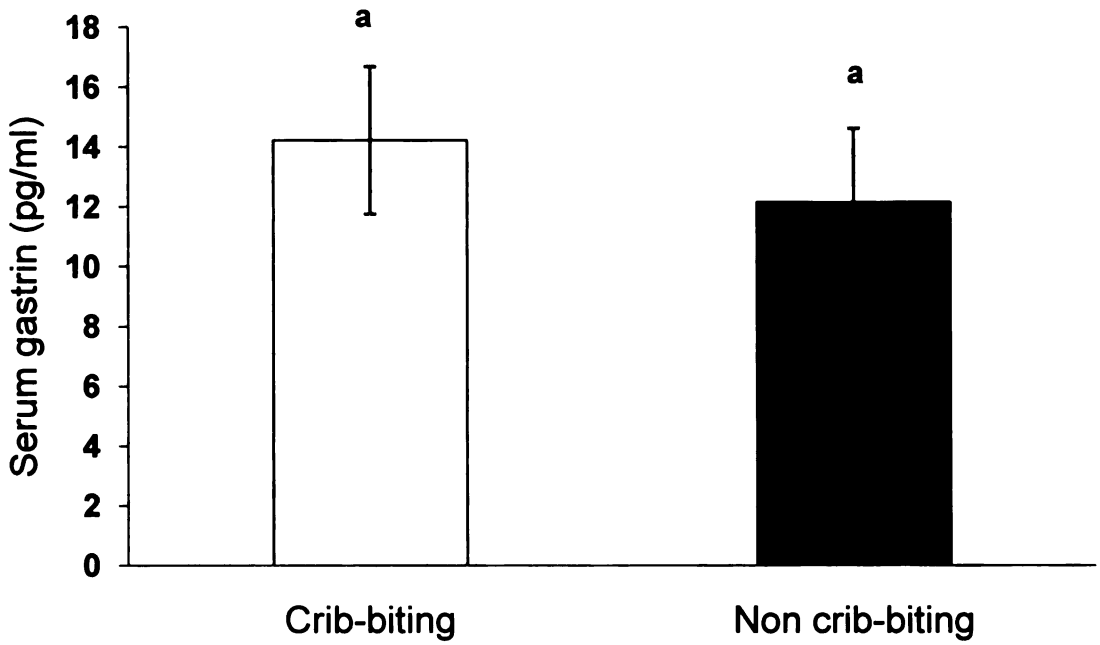

Figure 2-4 Serum gastrin concentrations in CB and NCB horses following free access to Bermudagrass hay and pasture. Least squares mean estimates ±S.E.M. are shown. Common superscripts indicate no effect of CB on serum gastrin concentration (P = 0.56).

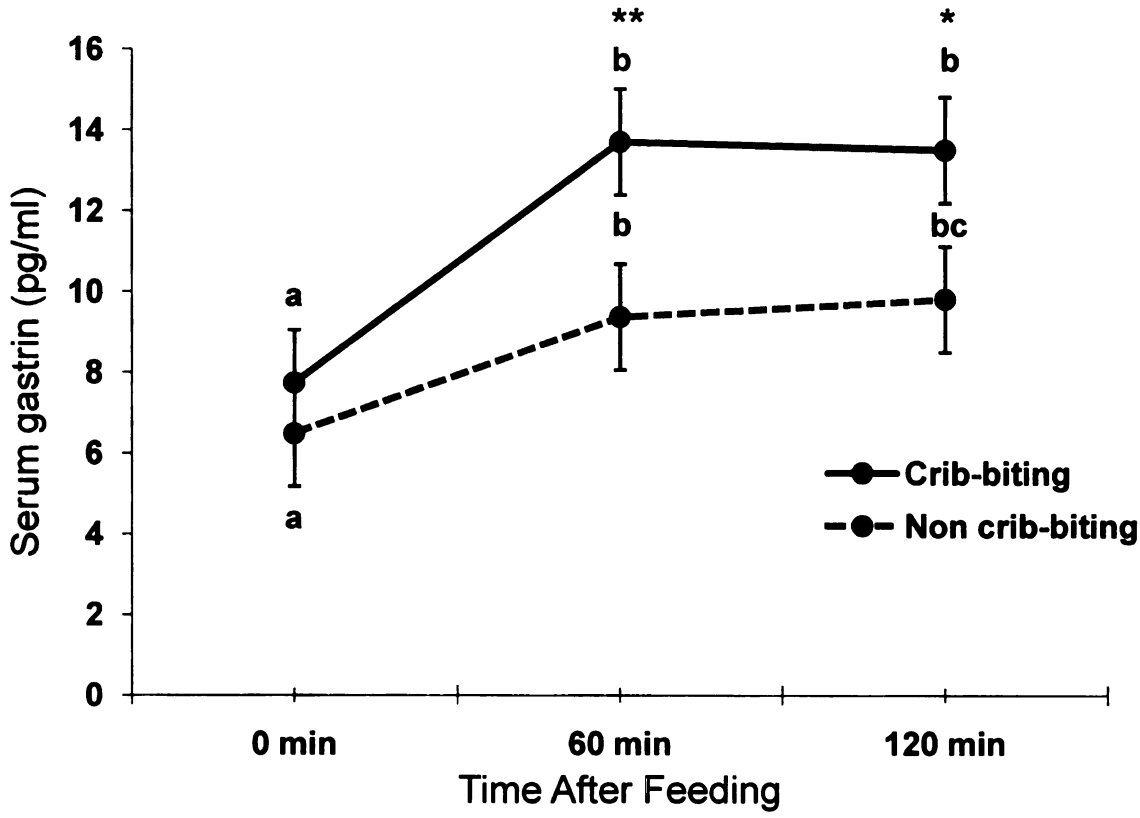

Figure 2-5 Serum gastrin concentrations in CB and NCB horses following 12-hour feed removal, 60 and 120 minutes after consuming 1 kg of the pelleted diet. Least squares mean estimates ±S.E.M. are shown. [a,b] Times 60 and 120 minutes compared to 0 minutes within CB differ at $P < 0.01$. [a,b,c] Within NCB, compared to 0 minutes, time 60 minutes tended to differ at $P = 0.07$ and 120 minutes differs at $P < 0.05$. **CB differs from NCB at time 60 minutes at $P < 0.05$. *CB tended to differ from NCB at time 120 minutes at $P = 0.06$.

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CHAPTER 3

INVESTIGATING WEAVING AND CRIB-BITING BEHAVIOR IN THE MICHIGAN HORSE POPULATION VIA WEB-BASED SURVEY METHODOLOGY

Abstract

The manner in which horses are managed greatly influences their behavior and well-being. The performance of stereotypic behavior in horses is suggested to be indicative of either current or past sub-optimal welfare. Survey research conducted in Europe and Canada has provided insight into the prevalence of and risk factors associated with weaving and crib-biting behavior (WCB). Owner perceptions about WCB also have been investigated in some of these studies. Currently, information regarding WCB in Michigan's horse population is unavailable. The objectives of this study were: (1) determine whether Michigan horse owners are concerned about WCB and (2) investigate risk factors associated with WCB. A web-based questionnaire was developed to investigate WCB, and participants included members of 6 Michigan-based equine associations, recipients of 2 Michigan equine periodicals, and visitors to Michigan State University's (MSU) Youth Equine Extension website. Complete responses from 293 individuals were received representing a total of 2,181 horses. The percentage of horses exhibiting weaving and crib-biting was 2.7% and 5.2%, respectively. Compared to respondents with weaving and crib-biting horses, a greater percentage of owners with non-affected horses agreed/strongly agreed that WCB hinders learning ability ($P < 0.01$), has a negative impact on horse health ($P < 0.01$ for weaving, and $P < 0.05$ for crib-biting), and reduces the horse's monetary value ($P < 0.01$). The proportion of respondents attempting to stop crib-biting behavior (81.0%) was greater ($P < 0.01$) compared to

weaving behavior (37.5%). Methods employed most frequently to stop or reduce weaving behavior included increased turn-out (21.4%) and provision of toys (14.3%). Cribbing collars/straps (77.6%), alteration of crib-biting surfaces (55.3%), and increased turn-out (54.1%) were the methods used most frequently to stop or reduce crib-biting. Many owners used a combination of methods. Stepwise logistic regression analysis identified associations between the probability of weaving and crib-biting and farm management factors. A negative association was identified between hours of daily turn-out and the probability of WCB ($P < 0.01$). Compared to horses allowed turn-out with conspecifics, the risk of crib-biting was greater for horses with visual contact only (Adjusted odds ratio (OR) = 5.61) and for horses without social contact (Adjusted OR = 6.26). In contrast to previous studies, a larger daily amount of concentrate was associated with a decrease in the odds of weaving (2.3 or more kg/day vs. less than 0.5 kg, $P < 0.05$) and crib-biting (0.5 to 1.8 kg and 2.3 or more kg/day vs. less than 0.5 kg, $P < 0.01$). The results of this study demonstrate that Michigan horse owners express concern about WCB and that attempts are often made to control these behaviors. Additional research into the risk factors associated with WCB is needed, as well as careful documentation of the development of these behaviors.

Keywords: Horse, Behavior, Weaving, Crib-biting, Survey, Management factors

Introduction

Weaving and crib-biting behavior are two of the most widely recognized stereotypic behaviors in horses. Weaving behavior is a locomotor stereotypy in which the horse engages the forequarters, neck and head in a lateral swaying motion, repeatedly shifting its weight from the left to right front foot (McGreevy et al., 1995a). Horses exhibiting crib-biting behavior anchor their top incisor teeth on a fixed object, pull back,

arch the neck, and draw air into the cranial esophagus emitting an audible grunt (McGreevy et al., 1995a; Dodman et al., 2005). Few experimental studies have been conducted specifically to address weaving behavior. However, the provision of mirrors in the stable reduced the performance of weaving (McAfee et al., 2002) suggesting that this behavior may be performed in response to social isolation. Stable designs that increased visual horizons, such as open stable doors providing access to views of adjacent horses and surrounding fields, also reduced weaving behavior (Cooper et al., 2000). Ninomiya et al. (2007) found that weaving behavior was observed mainly before feeding, and that investigation of bedding was more likely to follow eating. These results suggest that weaving also may be performed in an attempt to cope with frustration associated with meal anticipation. Several studies have been conducted to investigate the potential biological mechanisms underlying crib-biting behavior. Crib-biting has been associated with gastrointestinal irritation (Mills and Macleod, 2002; Nicol et al., 2002), and with altered brain function (Hemmings et al., 2007; Parker et al., 2008) and neuroendocrine physiology (Gillham et al., 1994; Lebelt et al., 1998; McBride and Hemmings, 2005). However, the etiology of these behaviors has yet to be completely elucidated.

Application of epidemiological research methods to questions about equine stereotypic behavior has provided some insight into the prevalence of and risk factors associated with weaving and crib-biting behavior. A summary of 5 cross-sectional surveys conducted in Europe and Canada demonstrated average prevalence of weaving and crib-biting behavior of 3.3% and 4.1%, respectively (Nicol, 1999a). A similar prevalence of crib-biting behavior (4.4%) has recently been reported in horses in the United States (Albright et al., 2009). Some of the management factors found to be

associated with weaving and crib-biting behavior include time spent out of the stable, extent of social contact, forage and concentrate feeding, and breed and sex of horse (McGreevy et al., 1995a,b; Luescher et al., 1998; Redbo et al., 1998; Bachmann et al., 2003). Based on previous studies, Thoroughbreds (Luescher et al., 1998; Redbo et al., 1998; Albright et al., 2009) and Warmbloods (Bachmann et al., 2003) have been identified as the breeds at greatest risk of displaying stereotypic behaviors, and there is some evidence to suggest a genetic predisposition for stereotypic behavior (Vecchiotti and Galanti, 1986).

It is widely reported in the literature that weaving and crib-biting behavior may endanger horse health and that these behaviors are viewed by owners as being problematic and undesirable (Kiley-Worthington, 1983; Houpt and McDonnell, 1993; Nicol, 1999; Mills, 2002). Owner perceptions of stereotypic behavior have been investigated to some extent using survey research methodology. McBride and Long (2001) reported that the majority of horse owners in the United Kingdom (UK) attempted to stop horses from performing stereotypic behavior and that a large proportion of owners were concerned about the impact of the behavior on horse health and monetary value. Many owners believe that horses learn to perform stereotypic behavior by observing others, i.e. that these behaviors are copied (McGreevy et al., 1995b; Albright et al., 2009). The recent survey study conducted by Albright et al. (2009) also provided information on what horse owners in the United States (U.S.) perceive to be the predominant contributing factor to crib-biting behavior. The majority of respondents indicated the horse's environment was the primary cause.

Survey research studies have been conducted in the state of Michigan to determine the economic impact of the equine industry, providing valuable information about the number of horses, breed inventories, geographic distribution of horses, as well as equine operation demographics (Michigan Equine Survey, 2007). However, stereotypic behavior has never been investigated in the Michigan horse population. The objectives of this study were to assess the perceptions of weaving and crib-biting behavior held by Michigan horse owners and to investigate risk factors associated with these behaviors in the Michigan horse population. It was hypothesized that Michigan horse owners would express concern regarding weaving and crib-biting behavior and that the majority of owners attempt to stop or reduce the performance of these behaviors. Additionally, the authors hypothesized that certain housing and feeding strategies, for example those which limit a horse's time out of the stable, limit contact with other horses, or limit foraging opportunities, would result in an increased probability of horses exhibiting weaving and/or crib-biting behavior. Some of the specific predictions were that increased turn-out would reduce the probability of a horse being a weaver or crib-biter, and that the probability of being a weaver or crib-biter would be increased in horses with no visual or tactile contact with other horses. Furthermore, that those horses fed larger amounts of concentrate would be more likely to weave or crib-bite.

Materials and Methods

Horse behavior questionnaire

In collaboration with Michigan State University's (MSU) Office for Survey Research (OSR), a comprehensive online survey instrument was constructed and administered to Michigan horse owners to collect information about weaving and crib-biting behavior. The questionnaire consisted of a combination of multiple choice, Likert

scale, and open-ended question types (Table 3-1). Questions were focused on stable and management information (type of operation, number of horses, housing, feeding, exercise), and horse behavior (familiarity and level of concern with weaving and crib-biting behavior, type of behavior observed on each farm and number of horses exhibiting the behavior, demographics on weaving and crib-biting horses, and methods used in an attempt to reduce or stop the behavior). Previous survey research studies conducted in Canada and the United Kingdom to investigate stereotypic equine behavior served as a starting point for question generation (McGreevy et al., 1995a,b; Luescher et al., 1998; McBride and Long, 2001; Waters et al., 2002). Prior to the beginning of the study, the survey was pilot tested on a small group (n = 12) of equine owning faculty, staff, and graduate students within MSU's Department of Animal Science for the purpose of assessing questionnaire content, readability, and functionality of the online format. Comments obtained from the pilot group were used to modify the questionnaire. A copy of the final questionnaire is included in Appendix A.

Sampling frame and subject recruitment

The sampling frame for this study consisted of self-selected recipients of the MSU Equine Newsletter and Saddle-Up magazine in addition to web site recruitment of owners, managers, and barn employees belonging to Michigan-based equine organizations. Participating organizations included the Michigan Horse Council, Arabian Horse Association of Michigan, Michigan Quarter Horse Association, Central Michigan Horsemen's Association, Wolverine Morgan Horse Association, and the Michigan Horse Show Association. The sampling frame was further supplemented by providing a link to the survey on the MSU Youth Equine Extension site. The sampling frame was

constructed in this manner in an effort to collect information across a wide variety of horse breeds/types and riding disciplines and was created in consultation with OSR staff.

Subscribers to the MSU Equine Newsletter and Saddle-Up magazine were informed of the survey study through a brief project description posted in both publications explaining the purpose of the study and directing readers to a web link from which they could access the electronic survey. The contact information for the project leader also was provided in case interested persons without computer access wanted to request a paper copy of the questionnaire. The various horse organizations were contacted in July and August 2006 by phone or email and asked to provide a link to the online questionnaire on their organization's home page and/or to post a project announcement in their fall newsletters. Subjects were encouraged to participate even if they did not currently own or manage a weaving or crib-biting horse. This allowed assessment of potential risk factors based on management information collected for non-stereotypic as well as stereotypic horses. Data collection was initiated in October 2006 and concluded at the end of February, 2007. In March 2008, a subset of respondents from the online survey, who had indicated their willingness to participate in future research, was contacted either by post or email to request a follow-up telephone interview. The purpose of conducting a follow-up interview was to collect horse characteristics (breed, sex, and age) of the non-stereotypic horses on the respondents' farms as well as additional information about the history of their weaving and crib-biting horse(s). All survey research procedures were approved by MSU's Committee for Research Involving Human Subjects.

Data collection

Data were collected and stored electronically at MSU through the OSR server using 128 bit encryption software. Data from the server were downloaded to one specific login/password protected personal computer. The project manager at OSR was responsible for uploading and downloading data and was the only person with access to the sample files and the software used for collecting data. The software program allowed data to be uploaded into a database compatible with SPSS (Statistical Package for the Social Sciences, SPSS Inc., Chicago, IL) statistical software to facilitate later data analysis. The online format allowed for inclusion of a detailed battery of questions while minimizing the time commitment required of respondents. To the author's knowledge, this is one of the first studies to utilize a web-based survey instrument to collect information about stereotypic behavior in horses.

Statistical Analysis

Farm management, owner perception, and horse behavior data were analyzed using SPSS (Version 16.0; SPSS Inc., Chicago, IL). Data are presented as frequency counts. Where Bernoulli proportions were conducted (Lindgren, 1976), question responses were first ranked from highest percentage of respondents to lowest, and then the proportion for each situation was compared with that of the next highest proportion on the list using pairwise Z-test statistics. In addition, univariate and multivariate logistic regression models were fitted separately to the probability of a horse being a weaver and to the probability of a horse being a crib-biter using SAS statistical software (Version 9.1, SAS Institute Inc., Cary, NC). In each case, explanatory variables of interest considered for model inclusion were the categorical variables: primary housing, type of turn out,

social contact, kilograms of concentrate fed per day, amount of controlled exercise per week, and number of times per day horses had access to forage (Table 3-2), as well as the continuous variables: hours of turn out and number of times per day horses were fed concentrate. Selection of these variables as potential risk factors for weaving and crib-biting behavior was based on their known or suspected associations presented in the literature (McGreevy et al., 1995a,b; Luescher et al., 1998; Waters et al., 2002). A stepwise model selection procedure was implemented for each response variable to determine a final model of best fit, which was then used for analysis. Criteria for inclusion and stay of factors/covariates in the model were p-values of 0.10 and 0.15, respectively. Results are presented as estimated odds ratios (OR) and 95% confidence intervals. The odds of an event occurring is defined as the probability that the event will occur to the probability that it will not. The odds ratio is the ratio of the odds of stereotypic behavior (e.g. odds of a horse being a weaver) in the exposed group (e.g. no visual or tactile contact with other horses) to the odds of stereotypic behavior in the unexposed group (e.g. turned out with other horses). An odds ratio greater than 1.0 indicates an increase in risk while an odds ratio less than 1.0 indicates decreased risk.

Questions related to the daily amount of forage fed to horses as well as type of forage offered, type of stall bedding used, and type of concentrate feed offered were included in the online questionnaire. However, these variables were excluded from the statistical analysis due to extreme category problems (i.e. under representation of each behavior type across levels of the categorical variable) or because of difficulties in collecting detailed information. For example, when asked to report the amount of forage fed to horses on average each day, some owners provided the actual amount in pounds

per day while many others indicated amount in terms of flakes of hay per day. There was also overlap among the types of grain fed to horses in approximately 50% of the cases, e.g. several owners reported feeding more than one type of grain.

Comparison of sample data with 2007 Michigan Equine Survey results

The 2007 Michigan Equine Survey (MES) project constituted a state-wide census of horse operations based on a comprehensive list sampling frame and enumeration. Comparisons were made between sample demographics from the current study and results of the MES (where possible based on question wording and category choices) to assess the degree to which participating farms/owners and their horses were representative of the larger Michigan equine population.

Results

A total of 293 useable responses were received, representing a total of 2,181 horses. This included 290 responses to the online questionnaire and 3 paper copies of the survey instrument which were included in the analysis. The percentages of horses exhibiting weaving and crib-biting behavior were 2.7% (n=58) and 5.2% (n=113), respectively. The median number of horses per facility was 4 (range 1-100 horses/farm). There were 191 farms without any stereotypic behavior observed in their horses, 17 farms with both non stereotypic horses and weavers, 60 farms with both non-stereotypic horses and crib-biters, and 25 farms indicating that non-stereotypic, weaving and crib-biting horses were owned/managed. Respondents were not asked detailed questions as to whether a particular horse performed both weaving and crib-biting behavior, thus it was difficult to determine with certainty if horses exhibited more than one stereotypic

behavior. However, careful examination of individual horse information suggested that a small subset of horses (n=9) probably exhibited both behaviors.

A comparison of farm/respondent demographics between this study and the 2007 Michigan Equine Survey (MES) is presented in Tables 3-3 and 3-4. The percentage of operations with 3-9 head of horses was similar between the two studies as was the distribution of operations by primary housing. Wording of our questionnaire was developed prior to the development of the MES. Thus, responses to the two survey instruments are not completely parallel. Based on the recent MES data, 76% of farms surveyed were private residence/backyard operations with the majority of horses (37.1%) being used for recreation/pleasure. In the current study, the majority of farms (37.9%) also indicated pleasure/backyard as type of operation.

Owner perceptions about weaving and crib-biting behavior

Of those respondents owning or managing weaving horses on their farm (n=42 respondents; 58 horses represented), 57.1% believed environmental factors were the primary cause of the behavior, 2.4% considered genetics to be the primary cause, and 40.5% believed that a combination of genetic and environmental factors contributed to the behavior. A similar trend was found within respondents owning or managing crib-biting horses (n=84 respondents; 112 horses represented) with 54.8%, 2.4%, and 42.9% believing environment, genetics, or a combination of genetics and environment, respectively, predominantly contribute to the behavior. The level of concern with stereotypic behavior, specifically perceptions about the impact of weaving and crib-biting behavior on the horse's learning ability, health, and monetary value, differed depending on whether the respondent currently owned or managed an affected horse (Figures 3-1

and 3-2). Compared to respondents with weaving and crib-biting horses, a greater percentage of responders with non-affected horses agreed/strongly agreed that weaving and crib-biting behavior hinder learning ability ($P < 0.01$), have a negative impact on horse health ($P < 0.01$ for weaving, and $P < 0.05$ for crib-biting), and reduce the horse's monetary value ($P < 0.01$). The apparent triggers to weaving and crib-biting behavior based on the observations of the respondents are shown in Figure 3-3. The factors reported to initiate bouts of weaving and crib-biting behavior appear to differ. Horses are observed to begin weaving before feeding (54.8%), before turn-out (35.7%), or when the horse is separated from other horses (38.1%). The majority of farms reporting on crib-biting behavior indicated that crib-biting starts after feeding (45.9%), but that the behavior also occurs before feeding (38.8%), and as a result of separation from other horses (20.0%). Of the respondents owning or managing weaving and crib-biting horses, a small percentage indicated that a horse had started to weave (2.5%) or crib-bite (5.0%) after another weaving or crib-biting horse had arrived at their farm.

Respondents indicated that they receive equine behavior information from a variety of sources including the Internet, equine magazines, equine association and/or extension newsletters, equine seminars/workshops, their veterinarian, and personal contacts (e.g. fellow horse owner). The most frequently marked resources included equine magazines (70.3%), personal contacts (62.8%), veterinarian (49.8%) and the internet (44.4%). Equine newsletters and seminars/workshops were utilized less frequently (28.7% and 25.6%, respectively).

Attempts at stopping or reducing weaving and crib-biting behavior

Although many respondents attempt to stop horses from performing weaving and crib-biting behavior (Figure 3-4), the proportion of respondents attempting to stop crib-biting behavior (81.0%) was greater ($P < 0.01$) compared to weaving behavior (37.5%). The methods employed by owners/farm managers in an attempt to stop or reduce weaving and crib-biting behavior are shown in Figures 3-5 and 3-6, respectively. Methods most frequently used to stop or reduce weaving behavior included increased turn-out (21.4%) and provision of toys (14.3%). The methods used most frequently to stop or reduce crib-biting behavior included fitting horses with cribbing collars/straps (77.6%), alteration of crib-biting surfaces by, for example, electrifying fences and/or applying distasteful substances to barn and pasture fixings (55.3%), followed by increased turn-out (54.1%). Many farms utilized a combination of methods. The percentage of respondents reporting that attempts to stop weaving and crib-biting behavior were successful was only 26.7% and 27.9%, respectively. Attempts to reduce weaving and crib-biting behavior were more successful (66.7% and 49.3%, respectively) than attempts to completely extinguish the behavior. Consistent use of a cribbing collar was reported as the only means of effectively stopping a horse from performing crib-biting behavior (n=11). The method reported as being successful in stopping weaving behavior was keeping horses turned-out rather than confined to a stall (n=3). Increased turn-out, often in combination with increased social contact (n=8) and providing horses with a consistent routine (n=2) were the methods respondents reported as being effective in reducing weaving behavior. Methods reported by respondents as being effective in

reducing crib-biting behavior included increased turn-out (n=14), increased forage (n=5), and removal/alteration of crib-biting surfaces (n=10).

Characteristics of weaving and crib-biting horses

Sex distribution of weaving and crib-biting horses is presented in Table 3-5. Information about sex of horse was reported for 56 weaving and 106 crib-biting horses. Of the 56 weaving horses, 25 (44.6%) were geldings, and 30 (53.6%) were mares. One weaving horse was a stallion (1.8%). Of the 106 crib-biting horses, 73 (68.9%) were geldings and 33 (31.1%) were mares. Breed distribution of weaving and crib-biting horses is presented in Table 3-6. Breed data were reported for 56 weaving and 107 crib-biting horses. Large percentages of weaving horses were Quarter Horses (35.7%) and Thoroughbreds (21.4%). Many of the horses exhibiting crib-biting behavior were also Quarter Horses (47.7%) and Thoroughbreds (14.0%). No draft horses were reported as exhibiting either behavior. The majority of both weaving (71.9%) and crib-biting (60.7%) horses were aged 6-17 years. Data related to age distribution of horses were not included in the MES (2007) survey, but data collected on weaving and crib-biting horses were in good agreement with age demographics reported in the 2005 U.S. Department of Agriculture Equine Health and Management survey (56.7% of horses were 5-19 years of age). The sex, breed, and age of non-stereotypic horses were not queried in the web-based survey.

Associations between farm management factors and weaving behavior

At the univariate level (Table 3-7), an association was identified between primary method of housing and the probability of weaving (P = 0.041). Horses housed equally between stalls and pasture were 2 times more likely to display weaving behavior (OR =

2.10) compared to horses housed completely on pasture. An association also was found between hours of turn out and the probability of weaving (Maximum Likelihood Estimate = - 0.0319, P = 0.053). An increase in 1 hour of turn-out was associated with a 0.97 change (i.e. with a 3% decrease) in the odds of a horse being a weaver. Factors remaining in the final multivariate logistic regression model (Table 3-8) included kilograms of concentrate fed per day (P = 0.043) and hours of turn-out (Maximum Likelihood Estimate = -0.0619, P = 0.003). The odds of being a weaver decreased by 75% in horses that received 2.3 or more kilograms of concentrate per day (Adjusted OR = 0.25) compared to horses that received less than 0.5 kilogram of concentrate per day. An increase in 1 hour of turn-out was associated with a 0.94 change (i.e. with a 6% decrease) in the odds of a horse being a weaver.

Associations between farm management factors and crib-biting behavior

At the univariate level (Table 3-7), associations were identified between primary housing (P = 0.066), type of turn-out (P = 0.037), social contact (P < 0.001) and the probability of crib-biting. Horses housed primarily in stalls were 1.8 times more likely to display crib-biting behavior (OR = 1.83) compared to those housed on pasture. Horses turned out in an indoor arena were 7.2 times more likely to display crib-biting behavior (OR = 7.24) than horses receiving pasture turn-out. Compared to being turned out with other horses, horses allowed visual contact only and horses with no visual or tactile contact with other horses were 5.5 (OR = 5.48) and 6.6 (OR = 6.64) times more likely to display crib-biting behavior, respectively. An association was also found between hours of turn out and the probability of crib-biting (Maximum Likelihood Estimate = - 0.0310, P = 0.009). An increase in 1 hour of turn-out was associated with a 0.97 change (i.e. with

a 3% decrease) in the odds of a horse being a crib-biter. Factors remaining in the final multivariate logistic regression model (Table 3-8) included social contact ($P < 0.001$), kilograms of concentrate fed per day ($P = 0.001$) and hours of turn-out (Maximum Likelihood Estimate = -0.0425, $P = 0.006$). Compared to being turned out with other horses, horses allowed visual contact only and horses with no visual or tactile contact with other horses were 5.6 (Adjusted OR = 5.61) and 6.3 (Adjusted OR = 6.26) times more likely to display crib-biting behavior, respectively. The odds of a horse being a crib-biter were decreased by 44% in horses that received 0.5-1.8 kilograms of concentrate per day (Adjusted OR = 0.56) compared to horses that received less than 0.5 kilogram of concentrate per day. The odds of being a crib-biter were decreased by 82% in horses that received 2.3 or more kilograms of concentrate per day (Adjusted OR = 0.18) compared to horses that received less than 0.5 kilogram of concentrate per day. An increase in 1 hour of turn-out was associated with a 0.96 change (i.e. with a 4% decrease) in the odds of a horse being a crib-biter.

Follow-up interviews

Requests for a follow-up telephone interview were sent via post or email to 124 respondents. These participants had indicated in their responses to the web-based questionnaire that they had an interest in participating in additional research. A total of 38 individuals provided their telephone number (30.6% response rate). However, repeated attempts to contact 12 farms were unsuccessful, thus interviews were conducted with only 26 respondents. Therefore, the actual response rate was 21.8% representing a total of 149 horses, 4 of which were weavers and 13 of which were crib-biters. A time lapse of approximately 13 months passed between completion of data collection using the online

questionnaire and the follow-up interviews. Follow-up interviews were conducted for the purpose of collecting sex, breed, and age of stereotypic and non-stereotypic horses on respondents' farms simultaneously and to ask about the history/early life of weaving and crib-biting horses. Unfortunately, due to the small sample size, associations between stereotypic behavior and individual horse characteristics could not be examined. One owner did report that a newly acquired yearling Percheron draft horse stallion had started to crib-bite. The horse suffered a leg injury shortly after weaning and had been confined to a stall with limited exercise in the form of hand-walking and round pen turn-out. Qualitative assessment of responses to questions pertaining to the history/early life of weaving and crib-biting horses and behavior management strategies revealed several interesting themes and are presented in Table 3-9.

Discussion

This study is the first to investigate stereotypic behaviors in Michigan horses. The percentages of horses in Michigan exhibiting weaving and crib-biting behavior were similar to the prevalence reported previously in other countries (Nicol, 1999). Specifically, the percentages observed were almost identical to the approximately 2.6% and 5.3% of Canadian horses reported to exhibit weaving and crib-biting behavior. The findings are also in good agreement with the 4.4% prevalence of crib-biting recently reported for U.S. horses (Albright et al., 2009). Although the sampling frame for this study consisted of self-selected respondents, it would appear based on comparisons with demographic data from the 2007 MEMS survey, that the sample was fairly representative of the Michigan equine population with respect to number of horses per operation, type of operation and primary use of horses, and manner in which horses were primarily

housed. Calculating a precise response rate for the web-based survey was not possible due to the passive style of recruitment used to invite subjects to participate (Vate-U-Lan, 2006). Passive invitation methods, e.g. posting a link to the questionnaire on an association web page, do not allow the researcher to determine the contact rate. Knowing the total membership or readership of the various participating Michigan-based equine organizations and publications would not necessarily provide an accurate assessment of the number of people who viewed the survey advertisement, and as a result would greatly underestimate the response rate.

In the study conducted by McBride and Long (2001), British horse owners demonstrated concern regarding the performance of stereotypic behavior and attempts often were made to physically prevent horses from performing the behavior. This included the use of anti-weave bars and cribbing straps to stop horses from weaving and crib-biting, respectively. Michigan horse owners and farm managers also expressed concern about weaving and crib-biting behavior, but perceptions regarding the impact of these behaviors on horse performance/learning, horse health, and monetary value of the animal were different between owners of non-stereotypic horses and those respondents currently owning/managing a weaver or crib-biter. Overall, respondents presently owning/managing weaving and crib-biting horses were less concerned about the behaviors having a negative impact on learning, health, or monetary value. Thus, perceptions about stereotypic behavior within the equine community at large may not coincide with those held by individuals having first-hand experience with weaving and crib-biting horses, particularly if a horse exhibiting stereotypic behavior has been a beloved companion, performs well, and/or has not encountered any major health

problems. For example, a relatively low percentage of respondents with weaving and crib-biting horses indicated that they are concerned the behavior hinders learning or performance, thus it would not appear that these behaviors substantially interfere with training or with the overall usefulness of the horse. However, in light of recent research providing some evidence that learning ability is impaired in stereotypic horses (Hausberger et al., 2007; Parker et al., 2008), this is an area that warrants further investigation. Additional inquiry into the experiences and observations of horse owners may provide valuable insight into how weavers and crib-biters respond to various training and handling procedures compared to their non-stereotypic counterparts.

Concern with weaving and crib-biting behavior having a negative impact on horse health was lower among respondents with these behaviors on their farms compared to respondents with only non-stereotypic horses, but it should be noted that the respondents currently owning/managing crib-biting horses still expressed a high level of concern with the behavior from a horse health standpoint. Indeed, qualitative assessment of responses obtained from owners of crib-biting horses revealed that crib-biting had resulted in at least some wear of the incisor teeth and that some crib-biting horses had experienced repeated bouts of colic. It is not possible to ascertain from the qualitative interview data, given the small sample size and lack of information about colic in non-stereotypic horses, whether a true link between crib-biting and colic exists, but an association between crib-biting behavior and epiploic foramen entrapment, a specific type of colic, has been demonstrated (Archer et al., 2004, 2008). Crib-biting behavior also has been associated with gastric ulceration in foals (Nicol et al., 2002), and with lower basal and post-feeding gastric pH in mature crib-biting horses (Lillie et al., 2004). In light of the work conducted

by Mills and Macleod (2002) demonstrating a reduction in crib-biting frequency in adult horses receiving an antacid product, it was interesting to learn that some Michigan horse owners had administered ulcer treatments to their crib-biting horses. The success of these products in reducing crib-biting frequency, as reported by owners, varied. In fact, only one owner indicated that the ulcer treatment appeared to result in a decrease in the horse's crib-biting behavior, and this effect would need to be validated through an on-farm visit. The relatively high percentage of respondents perceiving some ill effect of crib-biting behavior on horse health may partially explain why more respondents with crib-biting horses attempt to stop the behavior compared to those respondents owning/managing horses exhibiting weaving behavior. The possibility also exists that the behavioral sequence of crib-biting represents a greater nuisance to horse owners/barn managers (i.e. it is more aesthetically displeasing) or that there are simply more available devices for physically preventing crib-biting behavior (e.g. collars, muzzles, electric wire, and distasteful paints) compared to weaving behavior. The two groups compared using Bernoulli proportions (owners with weaving horses and owners with crib-biting horses) are neither independent nor entirely dependent. There would have been some degree of overlap between the two groups as 25 respondents indicated having both weaving and crib-biting horses on their farms and a very small percentage of horses exhibited both behaviors. In general, the majority of respondents believed that environmental variables were largely responsible for the performance of stereotypic behavior, similar to the perceptions of U.S. horse owners reported by Albright et al. (2009). This finding indicates that Michigan owners and farm managers are aware and fairly well informed

that management practices do have a direct impact on the behavior of the horses under their care.

The majority of weaving and crib-biting horses in Michigan were aged 6-17 years, therefore the stereotypic behavior exhibited by these horses was likely well established. This would explain why the efforts of respondents to completely stop the behaviors were largely unsuccessful. The use of cribbing collars and the removal or alteration of cribbing surfaces by owners and managers in the current study could be classified as a reactive solution to the performance of stereotypic behavior, while turnout represents a more proactive management strategy aimed at minimizing or eliminating causal factors. Increasing the amount of turn-out, social contact, and forage were reported as being effective in reducing performance of the behaviors.

Situations or daily events reported as triggering bouts of stereotypic behavior seemed to agree with factors identified in experimental behavior studies. In studies conducted by Ninomiya et al. (2007) and Clegg et al. (2008), weaving behavior was mainly observed prior to feed delivery. Clegg et al. (2008) also observed an increase in the frequency of weaving in the hour preceding turn-out. Overall it appears from these studies that weaving behavior is closely related to periods of high activity and frustration associated with anticipation of an event, specifically feeding. Bouts of crib-biting were reported as beginning after feeding which also coincides with results from previous studies demonstrating increased frequency of crib-biting following consumption of concentrate feed (Kusunose, 1992; Gillham et al., 1994; McGreevy et al., 1995c; Clegg et al., 2008).

To date, there is very little evidence to support the belief that horses learn to perform stereotypic behavior by observing others. The percentage of Michigan respondents indicating that a horse had learned to weave or crib-bite after another weaving or crib-biting horse had arrived at the farm was low, and on these farms, management practices differed with regards to primary housing, social contact, and hours of turn-out. Thus, it is difficult to distinguish whether horses are in fact copying the behaviors or if the behavior is the result of exposure to common management factors, specifically those factors previously demonstrated to be associated with an increased risk for stereotypic behavior. In the study of crib-biting behavior in U.S. horses, only 1% of horses started to crib-bite after the arrival of a crib-biting horse (Albright et al., 2009). In contrast however, Nagy et al. (2008) recently demonstrated an increased risk of stereotypic behavior in horses exposed to stereotypic neighbors. Again, this is an area that requires further empirical and epidemiological investigation before coming to a conclusion about the ability of horses to learn a stereotypic behavior through observation.

Without information about the sex and breed of non-stereotypic horses, statistical analysis of associations between horse characteristics and weaving and crib-biting behavior were not possible. However, in looking at the percentages of weaving and crib-biting horses that fall into each sex and breed category in relation to the percentages reported in the MES, it appears that there is a relationship between horse characteristics and the performance of stereotypic behavior. For example, based on these preliminary findings related to weaving and crib-biting behavior in Michigan horses, it would appear there is a gender-based factor involved. Specifically, mares appear to be more at risk for locomotor stereotypy, e.g. weaving, while geldings appear to be at greater risk for oral

stereotypy, e.g. crib-biting. Breed of horse also appeared to be an important factor. Thoroughbreds and Quarter Horses appeared to be at higher risk for stereotypic behavior in general compared to other breeds. It is not known whether these apparent differences reflect a genetic predisposition to stereotypic behavior or a gender by management or breed by management interaction of some kind, and additional investigation would be required in order to validate these findings. Compared to geldings, Luescher et al. (1998) found a higher prevalence of weaving in mares, and a greater risk of both weaving and crib-biting among Thoroughbred horses. The study conducted by Luescher et al. (1998) also demonstrated a higher prevalence of weaving and crib-biting in stallions when compared with the other sexes. The management of stallions is typically quite different from geldings and mares. Stallions often are housed individually to prevent accidental breeding and aggression, thus stallions may be more prone to developing stereotypic behavior as a result of stress or frustration associated with limited social contact and/or turn-out. None of the crib-biting horses and only 1.8% of weaving horses in the current study were stallions. Approximately 5% of respondents to the Michigan horse behavior survey reported breeding as the type of their operation. This is similar to the 4.6% of operations in the MES survey reporting breeding as the primary activity of their operation. It is likely that current stallion numbers in Michigan in general are much lower than the number of geldings and mares and that very few of the farms participating in the behavior survey presently owned or managed a stallion. The particular breed of horse also may determine the primary use of the animal, which in turn may ultimately affect the manner in which the horse is managed. For example, many Thoroughbreds and Quarter Horses are used for competitive sports including racing, eventing, or physically

demanding western events such as barrel racing and cutting. Race horses in particular may be exposed during the early part of their life to rigorous training regimens, high concentrate/comparatively low forage diets, very limited liberty turnout, and, depending on the track stabling, very limited amounts of social contact. Thus interconnections almost certainly exist between genetic and environmental factors and these relationships warrant further consideration in future experimental and epidemiological studies.

Several studies have demonstrated associations between management factors and stereotypic behavior in horses. The risk of performing stereotypic behavior was decreased in Thoroughbred horses fed 6.8 kilograms or greater of forage per day and offered forage more than 3 times daily (McGreevy et al., 1995a). Stall designs that minimized social contact between horses and use of bedding other than straw increased the risk of stereotypic behavior (McGreevy et al., 1995a). It should be noted however, that in the study conducted by McGreevy et al. (1995a), it appeared that results were reported only for weaving, woodchewing, or abnormal behaviors as a whole. The authors indicated that crib-biting behavior was included in the study, but the number of horses exhibiting crib-biting behavior in the yards sampled was not clearly stated, and specific relationships between management factors and crib-biting were not identified. However, a general note included in the authors' discussion indicated that yards offering less forage per day had a higher prevalence of oral-based stereotypies (i.e. crib-biting). Wood-chewing behavior is often included in epidemiological studies, although this behavior may be more appropriately classified as an aberrant or redirected oral behavior as opposed to a true stereotypic behavior pattern as it is more variable in form and more nearly resembles normal ingestive behavior. Nonetheless, there is some evidence to suggest that wood-

chewing may be a precursor to crib-biting. Waters et al. (2002) documented that in foals which developed crib-biting behavior, 74% had been wood-chewers. Therefore the associations between various management factors and wood-chewing behavior are of interest to investigators. In eventing and dressage horses in the UK, a greater amount of time spent out of the stable was associated with a decreased risk of stereotypic behavior (McGreevy et al., 1995b). Survey studies conducted to investigate stereotypic behavior in race horses in Sweden (Redbo et al., 1998), and in Swiss horses of multiple breed types and uses (Bachmann et al., 2003) found that regular feeding of concentrates increased the risk of performing stereotypic behavior. Specifically, Redbo et al. (1998) reported a positive relationship between the amount of concentrate and stereotypic behavior. In the current study, the negative relationship identified between weaving and crib-biting and hours of turn-out in both the univariate and multivariate regression models is in good agreement with the previous finding that increased amount of time spent outside the stable reduces the risk of stereotypic behavior (McGreevy et al., 1995b). In light of previous studies demonstrating a role of social isolation in the performance of weaving behavior (McGreevy et al., 1995a; Cooper et al., 2000; McAfee et al., 2002), it was expected that the probability of a horse being a weaver would decrease in horses allowed social contact with others, but no such association was demonstrated in the present study. However, because visual contact with other horses alone has been shown to reduce the frequency of weaving (Cooper et al., 2000), and all of the respondents reporting on weaving horses indicated that horses were provided with at least visual contact with others, the social contact factor did not contribute to the risk of weaving. It is interesting that the risk of weaving was greater for horses housed equally between stalls and pasture

compared to those housed primarily on pasture. Perhaps horses housed in this manner experience greater arousal or frustration in anticipation of scheduled turn-out times or are more sensitive to stall confinement after having been left out for a longer period of time during the day, as opposed to horses accustomed to living primarily in stalls. Although increased turn-out in general appears to be protective against both forms of stereotypic behavior, a minimum threshold level of turn-out required to prevent weaving and crib-biting behavior from developing in horses remains to be determined.

Other individual level factors associated with crib-biting behavior included primary housing, type of turn-out, and social contact. Horses primarily housed in stalls and those receiving turn-out in an indoor arena only, were at greater risk of performing crib-biting behavior. This finding is not surprising since these practices would greatly limit the horse's opportunity to engage in natural foraging behavior and social contact. The extent or quality of social contact appeared to be an important factor as those horses without social contact or visual contact only were at an increased risk for crib-biting compared to horses being turned out with other horses or allowed both visual and tactile contact. The magnitude and direction of the association between social contact and crib-biting behavior was similar in the final model after adjusting for potential confounders.

The direction of the relationship between the amount of concentrate and stereotypic behavior was surprising to these authors, especially for the risk of crib-biting behavior. The authors had expected to see an increased risk of crib-biting behavior in horses fed larger amounts of concentrate per day rather than a reduced risk. Associations between increased concentrate feeding and increased crib-biting behavior have been documented in several studies (Kusunose, 1992; Gillham et al., 1994; Waters et al.,

2002). Gillham et al. (1994) and Kusunose (1992) observed an increase in crib-biting frequency shortly after the consumption of concentrate meals, and in the prospective study conducted by Waters et al. (2002) foals receiving concentrate feed after weaning were 4 times more likely to develop crib-biting behavior than those receiving only forage. Data on the amount of concentrate fed to horses in the current study was not collected on a continuous scale. Limiting owners to the selection of only a few categories may have hindered the ability to detect a similar association between this variable and stereotypic behavior found in previous studies. For most horses, it only takes a short amount of time to complete a small grain meal. Thus, it is possible that horses receiving less than 0.5 kilogram of concentrate per day experience some frustration associated with feeding and as a result, redirect their thwarted feeding motivation toward aberrant oral or locomotor behavior. The type of concentrate offered also may affect the association between grain feeding and stereotypic behavior. For example, consumption of highly palatable sweet feed was shown to increase crib-biting frequency (Gillham et al., 1994). Many of the Michigan horse owners and barn managers reported feeding a variety of ingredients and the protein, carbohydrate and fiber content of the diets was not queried. Therefore, in this study, it is unknown how the type of concentrate, and perhaps more specifically, how the nutrient composition of the diet may influence the risk of stereotypic behavior.

In light of the unexpected nature of the results regarding the relationship between greater amounts of concentrate fed and apparently lower rate of stereotypic behaviors in horses, a post-hoc analysis was used to investigate this association further. The author looked at the effect of an interaction between daily amount of concentrate and the number of times horses were fed grain per day on the predicted probability of stereotypic

behaviors. This analysis confirmed the original finding that greater daily amounts of concentrate were associated with an increase in the probability of a horse being a weaver or crib-biter. More specific questions about the diet of horses should be included in epidemiologic research studies in an effort to further elucidate the role of concentrate feeding in the development and continued performance of stereotypic behavior.

Finally, an association between the number of times per day horses had access to forage and the risk of stereotypic behavior was also suspected in this study. It would seem that offering forage more frequently throughout the day would potentially increase the total amount of time horses spend eating, resulting in less time engaged in stereotypic behavior. However, it is likely in light of the findings of McGreevey et al. (1995a), that the total daily amount of forage is the more important factor in minimizing the risk of stereotypic behavior. The role of gut fill and satiety mechanisms in the development and continued performance of stereotypic behavior, specifically the oral stereotypy of crib-biting, remains to be determined. Clustering (i.e. the non-independence of horses housed within the same farm) was not accounted for in this study. Thus it is possible that by not fitting a random effect of farm, some of the associations identified between the probability of weaving and crib-biting and the various management factors may have been influenced by differences in management of horses between farms. However, even if clustering of horses is considered in the statistical model, it may still fail to account for "sub-clusters" within farms. For example, within a given farm, horses exhibiting stereotypic behavior may be managed differently from non-stereotypic horses, just as management strategies implemented for horses of a particular sex or age group may vary within a farm.

Conclusion

The results of the current study demonstrate that weaving and crib-biting occur in Michigan horses with the same frequency reported in other countries, and that owners are concerned about these behaviors. Although some of the associations identified between management factors and weaving and crib-biting behavior were in good agreement with those reported previously, some of the relationships investigated produced conflicting results and warrant further investigation. Reports by owners/barn managers that increased turn-out and social contact and/or increased amounts of forage are effective in reducing weaving and crib-biting behavior concur with previous studies in which housing and feeding strategies have greatly influenced the performance of stereotypic behavior. Management strategies that provide horses with increased opportunities to engage in natural behaviors should be employed as the first means of moderating stereotypic behavior, as they are aimed at removing the causal factors of the stereotypic behavior rather than at physical prevention that may result in reduced welfare. These practices would be especially crucial to implement on farms raising young horses in order to prevent the development of stereotypic behavior or for those owners with horses just starting to engage in weaving or crib-biting behavior so as to prevent the behaviors from becoming established. Many owners in Michigan look to veterinarians for information about stereotypic behavior, highlighting the importance of providing veterinary professionals with current, science-based information about performance of stereotypic behavior in horses. Continued research into the etiology of weaving and crib-biting behavior is needed. Acquiring a better understanding of the interactions between horse characteristics and management factors in the development of stereotypic behavior, and

the impact of these behaviors on the learning ability and health of affected horses will be essential in making sound recommendations to horse owners and farm managers on how best to care for their horses.

Acknowledgments

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Table 3-1 Examples of question types used

Question type	Question asked	Response choices
Multiple choice	How are horses primarily housed during the majority of the year (≥ 9 months)?	1.) Mainly in stalls 2.) Mainly on pasture 3.) Nearly equal time between stalls and pasture
Likert	I am concerned with cribbing behavior because it negatively impacts the health of the horse	Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, Strongly Disagree
Open ended	What techniques or management changes have been successful in *reducing* crib-biting behavior?	Survey participants were provided a text box in which to type their responses

Table 3-2 Levels of the explanatory variables (housing and management factors)

Variable	Description				
Primary housing	Stalls	Pasture	Equal between stalls and pasture		
Type of turn out	Pasture	Grass paddock	Dry lot	Indoor arena	
Social contact	Turned out with other horses	Visual contact only	Visual and tactile contact*	No visual or tactile contact	
Kilograms concentrate (kg/day)	Less than 0.5 kg	0.5-1.8 kg	2.3 or more kg		
Controlled exercise† (times/week)	Less than 1 time	1-3 times	4-6 times	7 times	
Access to forage (times/day)	1 time	2 times	3 times	4 times	Free choice

* Horses can touch over fence line, stall door, between bars on stall.

† Horse is ridden, driven, lunged.

Table 3-3 Percentage of operations by number of horses

Number of Horses	Sample (n=293)	MES 2007[†] (n=35,000)
1-2 head	33.1	44.0
3-9 head	47.7	47.4
10-29 head	13.4	7.6
30+ head	5.3	1.0

[†] Michigan Equine Survey (MES).

Table 3-4 Percentage of operations by housing category

Housing category	Sample (n=293)	MES 2007 (n=35,000)
Primarily stalls	11.9	9.7
Primarily pasture	42.0	38.7
Equally between stalls and pasture[†]	46.1	51.6

[†] Michigan Equine Survey (MES) labeled this category as Partially Stalled. Equine operations in this category were described as providing horses with 4 or more hours of turnout daily.

Table 3-5 Sex distribution of weaving and crib-biting horses (percentage of horses in each category) in the present study

Sex	Weaving (n=56)	Crib-biting (n=106)
Geldings	44.6	68.9
Mares	53.6	31.1
Stallions	1.8	0.0

Table 3-6 Breed distribution of weaving and crib-biting horses compared to general Michigan horse population (number of horses in each breed category)*

Breed	Weaving		Crib-biting		MES 2007†	
Arabian	8	(14.3)	4	(3.7)	12,500	(8.3)
Half-Arabian	2	(3.6)	0	(0.0)	3,400	(2.3)
Draft	0	(0.0)	0	(0.0)	13,900	(9.3)
Morgan	1	(1.8)	8	(7.5)	4,000	(2.7)
Pony	2	(3.6)	3	(2.8)	9,300	(6.2)
Quarter Horse	20	(35.7)	51	(47.7)	41,000	(27.4)
Saddlebred	1	(1.8)	1	(0.9)	1,800	(1.2)
Standardbred	2	(3.6)	2	(1.9)	12,000	(8.0)
Thoroughbred	12	(21.4)	15	(14.0)	7,100	(4.7)
Warmblood	0	(0.0)	2	(1.9)	3,800	(2.5)
Other	8	(14.3)	15	(14.0)	37,300	(24.9)
Grade	0	(0.0)	6	(5.6)	3,700	(2.5)
Total	56		107		149,800	

* Percentage of horses shown in parentheses.

† Michigan Equine Survey (MES).

Table 3-7 The univariate relationships between farm management factors and the risk of performing weaving and crib-biting behavior as estimated based on logistic regression*

	Weaving			Crib-biting		
Variable	P-value	Odds ratio	95% CI	P-value	Odds ratio	95% CI
Primary housing	0.041			0.066		
Stalls		1.19	0.48-2.95		1.83	1.06-3.17
Pasture		1.00			1.00	
Equal		2.10	1.14-3.86		1.51	0.97-2.34
Type of turn out	0.666			0.037		
Pasture		1.00			1.00	
Grass paddock		0.70	0.31-1.56		1.03	0.61-1.75
Dry lot		1.028	0.46-2.31		1.18	0.66-2.13
Indoor arena†		-	-		7.24	1.88-27.82
Social contact	0.966			< 0.001		
Turn-out w/other horses		1.00			1.00	
Visual		0.94	0.22-3.93		5.48	3.03-9.91
Visual and tactile		0.90	0.40-2.01		0.94	0.50-1.74
No visual or tactile†		-	-		6.64	2.12-20.82
Kilograms concentrate	0.413			0.106		
Less than 0.5 kg/day		1.00			1.00	
0.5-1.8 kg/day		1.20	0.56-2.16		0.85	0.54-1.35
2.3 or more kg/day		0.63	0.24-1.65		0.49	0.25-0.96
Controlled exercise	0.845			0.201		
Less than 1/week		0.78	0.36-1.71		0.55	0.30-1.00

Table 3-7 Continued

1-3 times/week		1.00			1.00	
4-6 times/week		1.08	0.58-2.01		0.93	0.60-1.46
7 times/week		0.83	0.35-1.95		0.69	0.37-1.30
Access to forage	0.148			0.489		
Once/day		3.11	0.39-24.95		1.57	0.20-12.41
Twice/day		1.00			1.00	
3 times/day		1.31	0.70-2.44		1.16	0.73-1.86
4 times/day		1.16	0.40-3.38		0.89	0.38-2.13
Ad libitum		0.52	0.25-1.08		0.72	0.45-1.17
Hours of turn out daily	0.053	0.97	0.94-1.00	0.009	0.97	0.95-0.99
Times fed grain daily	0.455	1.15	0.80-1.66	0.763	1.04	0.80-1.35

* Individual level factors considered significant at $P < 0.10$.

† Category included no weaving horses and was excluded from the analysis.

Table 3-8 The multivariate relationships between farm management factors and the risk of performing weaving and crib-biting behavior as estimated based on logistic regression*

	Weaving (n = 272)			Crib-biting (n = 285)		
Variable	P-value	Odds ratio	95% CI	P-value	Odds ratio	95% CI
Social contact	n.s.			< 0.001		
Turn-out w/other horses		-	-		1.00	
Visual		-	-		5.61	2.80-11.23
Visual and tactile		-	-		1.17	0.60-2.29
No visual or tactile		-	-		6.26	1.86-21.11
Kilograms concentrate	0.043			0.001		
Less than 0.5 kg/day		1.00			1.00	
0.5-1.8 kg/day		0.72	0.35-1.51		0.56	0.33-0.94
2.3 or more kg/day		0.25	0.08-0.78		0.18	0.08-0.42
Hours of turn out daily	0.003	0.94	0.90-0.98	0.006	0.96	0.93-0.99

* Odds ratios adjusted for other factors (i.e. adjusted odds ratios).

Table 3-9 Content themes from the qualitative assessment of owner responses to questions related to horse history (e.g. early environment) and management strategies

Theme area	Crib-biting (n=10)	Weaving (n=4)
Horse history:		
Horse was already performing behavior when purchased/acquired*	8	3
Horse began performing behavior at respondent's Farm*	3	1
Horse began performing behavior at less than 2 years of age	3	n/a
Horse began performing behavior at greater than 2 years of age	1	1
Ex-race horse, or started in race training	3	2
Intensive showing career, or started in show training	3	2
At least one relative (sire, dam, sibling) performs the behavior	2	n/a
Performs behavior most during or after grain meal	5	n/a
Horse has experienced bouts of colic	4	n/a

Table 3-9 Continued

Horse is mild mannered, easy to work with	3	1
Hard to keep weight on horse	n/a	1
Horse has some wear of incisor teeth	5	n/a
Management strategies:		
Tried crib-biting collars, but now just let horse crib-bite	6	n/a
Tried ulcer treatments, but did not observe a reduction in the behavior	3	n/a
Tried ulcer treatment and saw a reduction in the behavior	1	n/a

* One owner had a horse that was already crib-biting when purchased and another horse that began crib-biting at the owner's farm at less than 2 years of age.

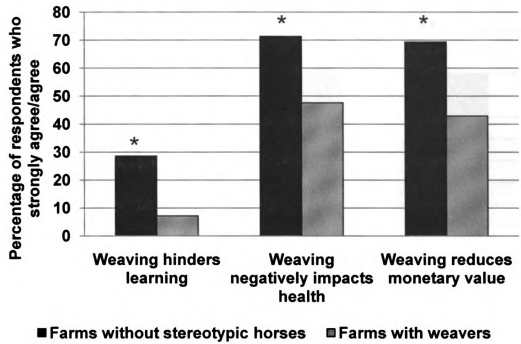

Figure 3-1 The percentage of respondents agreeing with three separate statements about weaving behavior. The percentage of strongly agree/agree responses for each respondent category were ranked from highest to lowest and treated as Bernoulli proportions (Lindgren, 1976). The Bernoulli proportion was compared for each situation to that of the next highest proportion using pairwise *Z*-test statistics. * Denotes a significant difference between farms without weaving horses and farms with weaving horses in each of the three cases at $P < 0.01$.

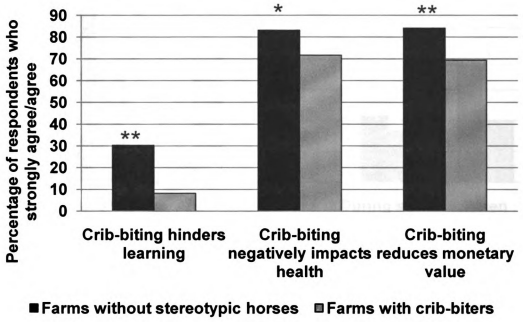

Figure 3-2 The percentage of respondents agreeing with three separate statements about crib-biting behavior. The percentage of strongly agree/agree responses for each respondent category were ranked from highest to lowest and treated as Bernoulli proportions (Lindgren, 1976). The Bernoulli proportion was compared for each situation to that of the next highest proportion using pairwise *Z*-test statistics. * Denotes a significant difference between farms without crib-biting horses and farms with crib-biting horses in each of the three cases at $P < 0.05$, ** $P < 0.01$.

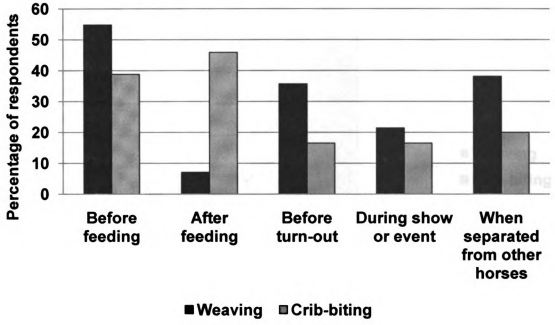

Figure 3-3 Apparent triggers to weaving and crib-biting as reported by owners. Several respondents indicated more than one trigger.

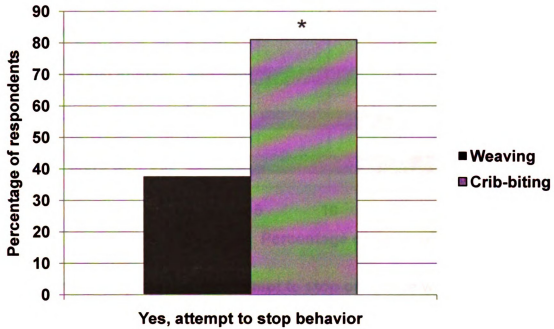

Figure 3-4 Percentage of respondents attempting to stop horses from performing weaving and crib-biting behavior. The percentage of yes responses for each respondent category were ranked from highest to lowest and treated as Bernoulli proportions (Lindgren, 1976). The Bernoulli proportion was compared for each situation to that of the next highest proportion using pairwise *Z*-test statistics. * Denotes a significant difference at $P < 0.01$.

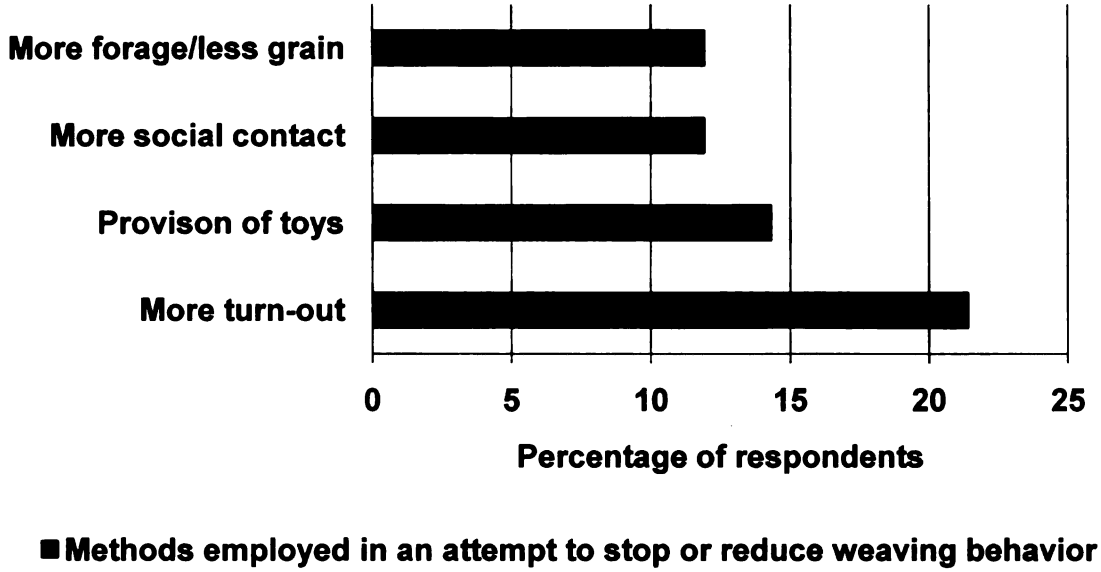

Figure 3-5 Methods employed by farms in an attempt to stop or reduce weaving behavior. Many respondents used a combination of methods.

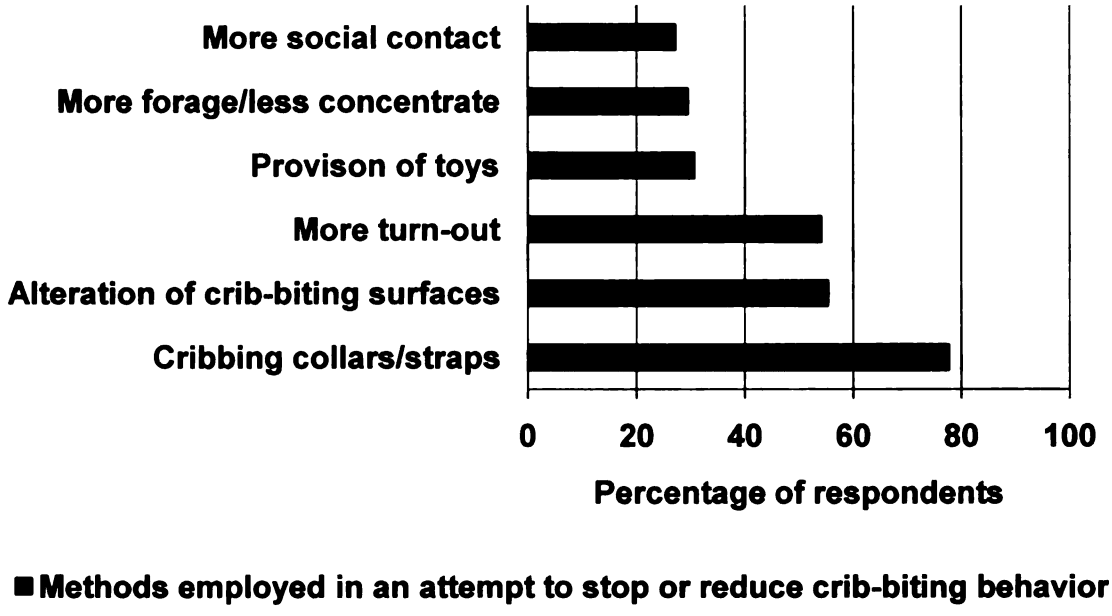

Figure 3-6 Methods employed by farms in an attempt to stop or reduce crib-biting behavior. Many respondents used a combination of methods.

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CHAPTER 4

SUMMARY AND CONCLUSIONS

The overall goal of this dissertation was to provide further insight into the factors associated with the performance of specific stereotypic behaviors in horses. The aim of the first study was to investigate the relationship between crib-biting and the integrity and function of the gastric mucosa in mature horses. We hypothesized that horses exhibiting crib-biting would have a higher degree of gastric mucosal damage and greater serum gastrin response to concentrate feeding compared to non crib-biting horses. The number and severity of gastric ulcers did not differ between crib-biting and non crib-biting horses. However, serum gastrin response to concentrate feeding was greater in crib-biting compared to non crib-biting horses. The results of this study suggest that gastric mucosal damage is not associated with established crib-biting in mature horses maintained on pasture. Owners of crib-biting horses who provide their animals with adequate foraging opportunities should not suspect gastric ulcers as being the primary cause of the behavior. However, the increased gastrin response to concentrate feeding in crib-biting horses is of interest as this finding may indicate altered gastrointestinal function in crib-biting horses that could result in a more acidic gastric environment following consumption of concentrated meals. An increase in gastric acidity may be particularly problematic for horses receiving low forage diets in light of the evidence that increased roughage and provision of an antacid diet are effective in reducing crib-biting behavior even in established crib-biters. Longitudinal studies of the gastrointestinal environment including measurement of gastrointestinal hormones in a large population of horses exposed to

various management practices are needed to further elucidate the role of gastrointestinal irritation in crib-biting behavior.

The aim of the second study was to investigate weaving and crib-biting behavior in the Michigan horse population. It was hypothesized that Michigan horse owners would express concern regarding weaving and crib-biting behavior and that the majority of owners attempt to stop or reduce the performance of these behaviors. Additionally, the author hypothesized that certain housing and feeding strategies, for example those which limit a horse's time out of the stable, limit contact with other horses, or limit foraging opportunities, would result in an increased probability of horses exhibiting weaving and/or crib-biting behavior. Some of the specific predictions were that increased turn-out would reduce the probability of a horse being a weaver or crib-biter, and that the probability of being a weaver or crib-biter would be increased in horses with no visual or tactile contact with other horses. Furthermore, that those horses fed larger amounts of concentrate would be more likely to weave or crib-bite.

This study was the first to examine stereotypic behavior in the Michigan horse population and also among the first to utilize an online questionnaire. The percentages of horses exhibiting weaving and crib-biting behavior were 2.7% and 5.2%, respectively. These results were similar to prevalences reported previously in other countries, and more recently reported for U.S. horses. Michigan horse owners and farm managers expressed concern about weaving and crib-biting behavior, but perceptions regarding the impact of these behaviors on horse performance/learning, horse health, and monetary value of the animal were different between owners of non-stereotypic horses and those respondents currently owning/managing a weaver or crib-biter. Overall, respondents

presently owning/managing weaving and crib-biting horses were less concerned about the behaviors having a negative impact on learning, health, or monetary value. Thus, perceptions about stereotypic behavior within the equine community at large may not coincide with those held by individuals having first-hand experience with weaving and crib-biting horses. A relatively low percentage of respondents with weaving and crib-biting horses indicated that they are concerned the behavior hinders learning or performance, thus it would not appear that these behaviors substantially interfere with training or with the overall usefulness of the horse. However, additional inquiry into the experiences and observations of horse owners may provide valuable insight into how weavers and crib-biters respond to various training and handling procedures compared to their non-stereotypic counterparts.

Information regarding the sex and breed of non-stereotypic horses was not collected in the online questionnaire, thus statistical analysis of associations between horse characteristics and weaving and crib-biting behavior were not conducted. However, in comparing weaving and crib-biting horse demographics with sex and breed distribution data reported in the 2007 Michigan Equine Survey, it appeared that there was a relationship between horse characteristics and the performance of stereotypic behavior. In general, based on the sample data, a gender-based factor appeared to be involved. Mares appeared to be more at risk for locomotor stereotypy, e.g. weaving, while geldings appeared to be at greater risk for oral stereotypy, e.g. crib-biting. Breed of horse also appeared to be an important factor. Thoroughbreds and Quarter Horses appeared to be at higher risk for stereotypic behavior in general compared to other breeds. It is not known whether these apparent differences reflect a genetic predisposition to stereotypic behavior

or a gender by management or breed by management interaction of some kind, and additional experimental and epidemiological research is needed in order to validate and further elucidate these potential relationships.

A negative relationship between weaving and crib-biting and hours of daily turn-out was identified in this study. Specifically, a one hour increase in turn-out was associated with a decrease in the probability of a horse being a weaver or crib-biter. An association was also identified between crib-biting behavior and extent of social contact. Horses without social contact or those allowed visual contact only were at an increased risk for crib-biting compared to horses being turned out with other horses.

In contrast to previous findings, larger daily amounts of concentrate were associated with a decrease in the probability of a horse being a weaver or crib-biter. Data regarding the amount of concentrate fed to horses was not collected on a continuous scale. Limiting owners to the selection of only a few categories may have hindered our ability to detect a similar association between this variable and stereotypic behavior found in previous studies. The type of concentrate offered also may affect the association between grain feeding and stereotypic behavior. Many of the Michigan horse owners and barn managers reported feeding a variety of ingredients and the protein, carbohydrate and fiber content of the diets was not queried. Therefore, in this study, it is unknown how the type of concentrate, and perhaps more specifically, how the nutrient composition of the diet may influence the risk of stereotypic behavior. More specific questions about the diet of horses should be included in epidemiologic research studies in an effort to further elucidate the role of concentrate feeding in the development and continued performance of stereotypic behavior.

The majority of respondents believed that environmental variables were largely responsible for the performance of stereotypic behavior, indicating that Michigan owners and farm managers are aware that farm management practices have a direct impact on the behavior of the horses under their care. Methods reported by owners/barn managers as being effective in reducing weaving and crib-biting behavior included increased turn-out and social contact and/or increased amounts of forage. Management strategies that provide horses with increased opportunities to engage in natural behaviors should be employed as the first means of moderating stereotypic behavior, as they are aimed at removing the causal factors of the stereotypic behavior rather than at physical prevention that may result in reduced welfare. These practices would be especially crucial to implement on farms raising young horses in order to prevent the development of stereotypic behavior or for those owners with horses just starting to engage in weaving or crib-biting behavior so as to prevent the behaviors from becoming established. Many owners in Michigan look to veterinarians for information about stereotypic behavior, highlighting the importance of providing veterinary professionals with current, science-based information about performance of stereotypic behavior in horses.

Acquiring a better understanding of the interactions between equine physiology and management factors in the development of stereotypic behavior, and the impact of these behaviors on the health of affected horses, will be essential in making sound recommendations to horse owners and farm managers on how best to care for their horses. Thus, continued research into the etiology of weaving and crib-biting behavior is warranted.

Appendix A

Michigan Horse Behavior Questionnaire in Microsoft Word Format

Equine Behaviors: A Study of the Michigan Horse Population

The purpose of this research is to learn more about certain behaviors, weaving and cribbing, that may occur in the Michigan horse population. Little is known about the prevalence of these behaviors and there is still much to learn about the underlying causes of these behaviors and about how best to treat and/or prevent them. **The only way to do this is to gather information from horse owners, managers, and trainers whose animals do not exhibit these behaviors as well as those whose animals do exhibit weaving and cribbing.**

The results of this research will be used to educate owners, managers, and trainers about these behaviors and provide them with information to assist them in managing these stereotypic behaviors in the Michigan horse population.

This research is completely voluntary and anonymous. It should take 15 minutes or less to complete depending on your answers. You can skip any question that you do not want to answer. You can also end your participation at any time.

If you have any questions about this research, you need clarification or assistance in answering the questions, or would like a paper copy of the questionnaire, please contact Carissa Wickens at 517.353.2260 or by email at forebac5@msu.edu . If you have technical difficulties with this survey, please contact Karen Clark at the Office for Survey Research at MSU at 517.353.1764 or by email at clarkk@msu.edu .

I indicate my voluntary consent to participate in this research study.

☐ Yes ☐ No

Part I: Stable and Management Information

1.Which of the following *best* describes the type of stable or farm you own, manage, or keep your horse(s) at?

☐ Breeding
☐ Training
☐ Boarding and/or riding lessons
☐ Race (e.g., flat, harness)
☐ Performance (e.g., dressage, eventing, endurance, competitive trail riding, western pleasure, English pleasure)

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☐ Pleasure, "backyard" (leisure, trail riding, etc)

☐ Other _____

2. What is the total number of horses that you own or manage?

_____ horses

3. For the majority of the year, that is, for at least nine months, is your horse/are the horses *primarily* housed . . . **If horses are primarily housed on pasture, you may skip questions 4-7.**

☐ In stalls

☐ In a pasture

☐ Equal between stalls and pasture

4. What type of bedding do you use *most often*?

☐ Wood shavings

☐ Sawdust

☐ Straw

☐ Paper

☐ Pellet

☐ Other_____

If you selected "other", please specify:

5. How many hours of turn-out is given on a typical day?

hours per day (please answer in whole numbers) _____

5a. Does the amount of turn-out vary from season to season, for example, do you do this more in the summer than the winter?

☐ Yes ☐ No

b. Please describe the changes in turn-out from season to season.

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6. In general, what type of turn out is provided *most often*?

☐ Pasture

☐ Small grass lot or paddock

☐ Dry lot

☐ Indoor arena

7. On average, how many hours per day is your horse/are the horses allowed to graze, that is, given access to grass during the grazing season?

_____ hours per day (please answer in whole numbers)

8. How often does your horse/do the horses receive controlled exercise (riding, driving, lunging)?

☐ Less than once a week

☐ 1 -3 times per week

☐ 4 - 6 times per week

☐ Daily

9. Which of the following statements *best* describes your horse's/the horses' social contact?

☐ Horse or horses are turned out with another horse or group of horses

☐ Allowed visual contact with other horses (e.g., over stall door, through windows in stall)

☐ Allowed visual and tactile contact with other horses (e.g., horses can touch over fence line or stall)

☐ Horses do not have social contact with others (e.g., horses are separated by stalls with solid walls, or are housed separately with no visual or tactile contact)

10. How many times per day is your horse/are the horses fed concentrate (grain)?

_____ times per day (please answer in whole numbers)

11. Does the amount of grain fed vary from season to season, for example, do you feed your horse(s) more grain in the winter than the summer?

☐ Yes ☐ No

12. Please describe the feeding changes you make from season to season.

13. What type of concentrate or grain do you feed? *(Please select all that apply)*

☐Oats
☐Corn
☐Soybean meal
☐Corn and oat mixture
☐Commercial sweet feed
☐Commercial pelleted feed
☐Other _____

14. On a typical day, how much concentrate does your horse/a horse at your barn or stable receive?

☐Less than one pound
☐1 - 2 pounds
☐3 - 4 pounds
☐5 - 6 pounds
☐7 or more pounds

15. On a typical day, about how many times a day is your horse/are the horses given access to forage, such as hay?

☐Zero
☐One
☐Two
☐Three
☐Four
☐Ad libitum (free access)

16. What type of forage is *usually* fed?

☐Grass hay
☐Legume hay (e.g, alfalfa, clover)
☐Mix of grass and legume hay
☐Haylage
☐Hay cubes
☐Pasture
☐Other

If you selected "other", please specify:

17. Please describe how often and how much forage is fed to your horse/horses on a typical day.

Part II: Equine Behaviors

This next set of questions focuses on two stereotypic behaviors, weaving and cribbing.

Weaving is defined as swaying back and forth in the stall or paddock and shifting weight between left and right front feet. The neck and head may also be heavily engaged in the swaying motion.

Cribbing or crib-biting is the grasping of a fixed object with the incisor teeth, arching the neck, pulling back, and emitting a grunting sound. Cribbing is *not* wood chewing. When a horse exhibits cribbing or crib-biting, wood is *not* eaten and wood *does not* disappear.

1. How familiar are you with ***weaving*** behavior in general?

☐Very Familiar
☐Somewhat Familiar
☐Not Familiar At All

2. Do you think that *weaving* is . . .

☐Predominantly a genetic disorder
☐Predominately environmental (horse's surroundings and management)
☐Combination of genetics and environment

3. What do you believe to be the underlying cause or causes of why horses develop *weaving* behavior?

4. Please indicate to what extent you agree or disagree with each of the following statements about *weaving* behavior.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't know
Weaving hinders a horse's ability to learn, train, or perform effectively at tasks or during events.					

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Weaving behavior negatively impacts the health of a horse					
Having weaving behavior reduces the monetary value of the horse.					

5. How familiar are you with ***cribbing*** behavior in general?

☐Very Familiar
☐Somewhat Familiar
☐Not Familiar At All

6. Do you think that *cribbing* is . . .

☐Predominantly a genetic disorder
☐Predominately environmental (horse's surroundings and management)
☐Combination of genetics and environment

7. What do you believe to be the underlying cause or causes of why horses develop *cribbing* behavior?

8. Please indicate to what extent you agree or disagree with each of the following statements about *cribbing* behaviors.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't know
Cribbing behavior negatively impacts the health of a horse.					
Having cribbing behavior reduces the monetary value of the horse.					
Cribbing hinders a horse's ability to learn, train, or perform effectively at tasks or during events.					

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9. Does your horse(s) or any of the horses you are familiar with exhibit weaving, cribbing, or both of these behaviors?

Weaving is defined as swaying back and forth in the stall or paddock, shifting weight between left and right front feet. The neck and head may also be heavily engaged in the swaying motion.

Cribbing or crib-biting is the grasping of a fixed object with the incisor teeth, arching the neck, pulling back, and emitting a grunting sound. Cribbing is *not* wood chewing. When a horse exhibits cribbing or crib-biting, wood is not eaten and wood does not disappear.

☐Weaving only
☐Cribbing Only
☐Both weaving and cribbing (e.g, either one horse that does both behaviors or horse(s) that cribs and another that weaves)
☐No, neither behavior

If you selected "No, neither behavior", you may skip to Part III: Source of Information.

This section focuses on *weaving* behavior.

W1. How many of your horses exhibit weaving behavior?

_____ horses

In order to better understand weaving behavior, we would like to gather some background information on your horse or each of the horses (up to five) that you own or manage that exhibit this behavior.

1st Horse or Only Horse (If reporting on multiple horses, please answer questions 1-10 for each horse, up to five horses, on a separate sheet of paper. Be sure to label as horse 2, 3, etc.)

---

1. What is your relationship to the horse (e.g. owner/co-owner, leaser, trainer)?

_____

2. What is the breed of the horse? _____

3. Is the horse a . . .

☐Gelding
☐Mare
☐Stallion

4. What is the age of the horse? _____

5. What is the primary discipline this horse is used for? (e.g. Dressage, Racing, Leisure/trail riding)

_____

5a. On average, in how many events per year does this horse participate (e.g, shows, competitions)?

Number of events _____

6. Are you familiar with this horse's first year of life? **If you selected "No" you may skip questions 7-10.**

☐Yes
☐No

7. Which, if any, of the following relatives of this horse exhibit weaving? *(Please select all that apply)*

	Yes	No	Not sure
A sibling			
Sire			
Dam			

8. At what age was the horse weaned?

☐Weaned at less than 4 months of age
☐Between 4 and 6 months of age
☐Weaned at more than 6 months of age
☐Don't know

9. Was the horse. . .

☐Abruptly weaned, foal moved to own stall

☐Abruptly weaned, the foal left with companions (other foals), mare removed

☐Gradually weaned, time mare and foal spent apart was gradually increased

☐Don't know

☐Other

10. To the best of your knowledge, did the horse experience any of the following?

	Yes	No	Don't know
A major illness as a foal?			
Had an injury or experienced a traumatic event as a foal?			
Was exposed to regular human contact (e.g., imprinted to a human handler at birth, groomed and worked with on a regular basis)?			
Received a high concentrate diet/prepped for showing or sale?			
Received mainly pasture or lots of turn out?			

If you have more than one horse that exhibits *weaving* behavior, when answering the following questions, please think about the horse that displays this behavior most often or the horse that you are most familiar with who displays this behavior.

Please indicate which horse (the 1st, 2nd, 3rd, etc) that you will be referring to for the following set of questions.

W2. Did the horse start to weave after another horse that weaves arrived at your farm or stable?

☐Yes
☐No

W3. Have any horses brought into direct contact with the weaving horse started to weave?

☐Yes
☐No

W4. On average, how many hours per day do you spend directly watching or interacting with the horse?

☐Less than one hour
☐1 - 2 hours
☐3 - 4 hours
☐5 - 6 hours
☐7 - 8 hours
☐9 - 10 hours
☐More than 11 hours

W5. When you are observing the horse, how often does the horse exhibit weaving behavior when the horse is *not* being handled or restrained?

☐All of most of the time
☐Some of the time
☐Rarely

W6. When does the horse begin weaving or what appears to trigger the weaving behavior in the horse? *(Please select all that apply)*

☐Before feeding
☐After feeding
☐Before riding or exercise
☐After riding or exercise
☐Before turnout
☐During stall cleaning
☐At a show or event
☐When the horse is separated
☐Other

If you selected "other", please specify:

W7. Have you ever tried to stop the weaving behavior?

☐Yes
☐No

W8. Which of the following techniques have you tried? *(Please select all that apply)*

☐Anti-weave bars
☐Electric wire in stable or pasture
☐Surgery (e.g., myectomy, neurectomy)
☐Other

If you selected "other", please specify:

W9. Which of the following management changes have you made? *(Please select all that apply)*

☐Increased turn out or grazing opportunities
☐Increased exercise
☐Increased social contact
☐Provided toys
☐Increased forage in diet and decreased concentrate
☐Other

If you selected "other", please specify:

W10. Have any of these techniques or management changes been successful in *stopping* the weaving behavior?

☐Yes
☐No
☐Not Sure

W11. What techniques or management changes have been successful in *stopping* the weaving behavior?

W12. Have any of these techniques or management changes been successful in *reducing* the weaving behavior?

☐Yes
☐No
☐Not Sure

W13. What techniques or management changes have been successful in *reducing* weaving behavior?

W14. Have your efforts to prevent or reduce weaving behavior led to the horse performing other noticeable behavior(s)?

☐Yes
☐No
☐Not Sure

W15. What types of behaviors have you noticed?

W16. On average, how much money do you spend each year on training aids, devices, or informational resources related to weaving behavior? These costs could be for items such as anti-weave bars, horse toys, etc.

$ _____

This section focuses on *cribbing* behavior.

C1. How many of your horses exhibit cribbing behavior?

_____ horses

In order to better understand cribbing behavior, we would like to gather some background information on your horse or each of the horses (up to five) that you own or manage that exhibit this behavior.

1st Horse or Only Horse (If reporting on multiple horses, please answer questions 1-10 for each horse, up to five horses, on a separate sheet of paper. Be sure to label as horse 2, 3, etc.)

---

1. What is your relationship to the horse (e.g. owner/co-owner, leasor, trainer)?

_____

2. What is the breed of the horse? _____

3. Is the horse a . . .

☐Gelding
☐Mare
☐Stallion

4. What is the age of the horse? _____

5. What is the primary discipline this horse is used for? (e.g. Dressage, Racing, Leisure/trail riding)

5a. On average, in how many events per year does this horse participate (e.g, shows, competitions)?

Number of events _____

6. Are you familiar with this horse's first year of life? **If you selected "No" you may skip questions 7-10.**

☐Yes
☐No

7. Which, if any, of the following relatives of this horse exhibit cribbing? *(Please select all that apply)*

	Yes	No	Not sure
A sibling			
Sire			
Dam			

8. At what age was the horse weaned?

☐Weaned at less than 4 months of age
☐Between 4 and 6 months of age
☐Weaned at more than 6 months of age
☐Don't know

9. Was the horse. . .

☐Abruptly weaned, foal moved to own stall

☐Abruptly weaned, the foal left with companions (other foals), mare removed

☐Gradually weaned, time mare and foal spent apart was gradually increased

☐Don't know

☐Other

10. To the best of your knowledge, did the horse experience any of the following?

	Yes	No	Don't know
A major illness as a foal?			
Had an injury or experienced a traumatic event as a foal?			
Was exposed to regular human contact (e.g., imprinted to a human handler at birth, groomed and worked with on a regular basis)?			
Received a high concentrate diet/prepped for showing or sale?			
Received mainly pasture or lots of turn out?			

If you have more than one horse that exhibits *cribbing* behavior, when answering the following questions, please think about the horse that displays this behavior most often or the horse that you are most familiar with who displays this behavior.

Please indicate which horse (the 1st, 2nd, 3rd, etc) that you will be referring to for the following set of questions.

C2. Did the horse start to crib after another horse that cribs arrived at your farm or stable?

☐Yes
☐No

C3. Have any horses brought into direct contact with the cribbing horse started to crib?

☐Yes
☐No

C4. On average, how many hours per day do you spend directly watching or interacting with the horse?

☐Less than one hour
☐1 - 2 hours
☐3 - 4 hours
☐5 - 6 hours
☐7 - 8 hours
☐9 - 10 hours
☐More than 11 hours

C5. When you are observing the horse, how often does the horse exhibit cribbing behavior when the horse is *not* wearing a device designed to stop or prevent the behavior?

☐All of most of the time
☐Some of the time
☐Rarely

C6. When does the horse begin cribbing or what appears to trigger the cribbing behavior in the horse? *(Please select all that apply)*

☐Before feeding
☐After feeding
☐Before riding or exercise
☐After riding or exercise
☐Before turnout
☐During stall cleaning
☐At a show or event
☐When the horse is separated
☐Other

If you selected "other", please specify:

C7. Have you ever tried to stop the cribbing behavior?

☐Yes
☐No

C8. Which of the following techniques have you tried? *(Please select all that apply)*

☐Cribbing collars/straps
☐Electric wire in stable or pasture
☐Surgery (e.g., myectomy, neurectomy)
☐Removal of cribbing surfaces or use of distasteful paints/wood coatings
☐Other

If you selected "other", please specify:

C9. Which of the following management changes have you made? *(Please select all that apply)*

☐Increased turn out or grazing opportunities
☐Increased exercise
☐Increased social contact
☐Provided toys
☐Increased forage in diet and decreased concentrate
☐Other

If you selected "other", please specify:

C10. Have any of these techniques or management changes been successful in *stopping* the cribbing behavior?

☐Yes
☐No
☐Not Sure

C11. What techniques or management changes have been successful in *stopping* the cribbing behavior?

C12. Have any of these techniques or management changes been successful in *reducing* the cribbing behavior?

☐Yes
☐No
☐Not Sure

C13. What techniques or management changes have been successful in *reducing* cribbing behavior?

C14. Have your efforts to prevent or reduce cribbing behavior led to the horse performing other noticeable behavior(s)?

☐Yes
☐No
☐Not Sure

C15. What types of behaviors have you noticed?

C16. On average, how much money do you spend each year on training aids, devices, or informational resources related to cribbing behavior? These costs could be for items such as cribbing collars, removing cribbing surfaces, horse toys, etc.

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Part III: Source of Information

1. From which of the following do you get information about horse behavior *in general*?

☐Computer via Worldwide Web sites and the internet
☐Horse magazines (e.g. Equus, Horse Illustrated, etc.)
☐Horse newsletters (e.g. horse association and/or horse extension newsletters)
☐Oral presentations /programs (e.g. workshops, seminars, conferences)
☐Radio or television programs
☐Veterinarian
☐Other horse owners/family/friends
☐Other

If you selected "other", please specify:

2. From which of the following do you get information about stereotypic horse behaviors such as weaving and cribbing?

☐Computer via Worldwide Web sites and the internet
☐Horse magazines (e.g. Equus, Horse Illustrated, etc.)
☐Horse newsletters (e.g. horse association and/or horse extension newsletters)
☐Oral presentations /programs (e.g. workshops, seminars, conferences)
☐Radio or television programs
☐Veterinarian
☐Other horse owners/family/friends
☐Other

If you selected "other", please specify:

3. Please feel free to make additional comments about these or other stereotypic behaviors.

4. If you would like results of this study, please provide the following information:

Name:

Stable or Farm Name:

Address:

City:

State:

Zip Code:

5. If you would be interested in participating in further research studies involving stereotypic horse behavior (such as additional surveys or on-site visits to observe your horse(s), please check the box below.

☐ Yes, I am interested in participating in further research studies involving stereotypic horse behavior.

Thank you for your assistance!