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EQUINE BEHAVIOR: A NUTRITIONAL LINK?

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Abstract

Common management practices of confining the horse and feeding it a few large meals daily have been shown to cause digestive irritation. Interestingly, horses typically managed in this manner, such as race and show horses, generally exhibit the highest incidence of behavioral problems. Excessive excitability in horses traditionally has been blamed on high-carbohydrate diets, although this claim has not been shown experimentally. Increasing the amount of fat relative to soluble carbohydrates as the primary source of energy in the diet may reduce reactivity of horses on high-energy diets. Commercial supplements containing amino acids, B-vitamins, and herbal ingredients are marketed as calming agents for horses, although little scientific evidence validating the effectiveness of these substances exists. Undesirable locomotor behaviors, such as weaving and stall walking, may be related more to confinement frustration then to nutritional issues; however, providing additional forage often ameliorates these problems by giving the horse a distracting and competing activity. Increased forage consumption also reduces, but does not eliminate, wood chewing in horses. Crib-biting behavior in the horse seems to be linked to nutritional physiology and management. Although cribbing stimulates saliva flow, cribbing horses have less saliva and a more acidic gastric environment than non-cribbers. Antacid therapy has been shown to raise gastric pH in adult cribbing horses, although it had no effect on cribbing frequency. Managers should closely monitor horses for undesirable behaviors and should naturalize horse management by reducing soluble carbohydrates in the diet and increasing forage consumption, exercise, and socialization opportunities.

You Are What You Eat

Nutritional influences on developmental behavior, learning abilities, and aberrant behavior have been examined intensely in rats and humans and in livestock species such as sows and hens. Because horses are the livestock species in which behavior and learning ability have the most direct impact on the animal's usefulness and monetary value, it is puzzling that very little research has been conducted on relationships among nutrition, feeding management, and behavior in horses.

The saying "you are what you eat" may be more truthful than originally intended. Retardation of cognitive development and decreased cognitive functioning have been reported in humans suffering from dietary iron, iodine, zinc, and/or vitamin B12 deficiencies (Sandstead, 2000; Black, 2003), and iron deficiencies in children may lead to irreversible behavioral changes (Pinero et al., 2001). Iron excess also has been associated with neurological diseases such as Alzheimer's disease and Parkinson's disease (Pinero et al., 2001).

Recent research offers evidence that diet can affect childhood behavior problems such as hyperactivity, sleep disorders, and irritability, and dietary intervention can result in a significant change in behavior (Breakey, 1997). Conners and Blouin (1982/83) reported that attention and motor behaviors in children appear quite sensitive to subtle nutritional effects, such as skipping breakfast or ingesting simple sugars. Pollitt et al. (1982/83) reported skipping breakfast had adverse effects on children's late morning problem-solving abilities, supporting observations that timing and nutrient content of meals have an effect on behavior.

Irritability and aggressive behaviors in humans have been associated with iron deficiencies, thiamin deficiencies, and depletion of the amino acid tryptophan (Werbach, 1992; Smith et al., 1997). These links between irritable behavior and dietary deficiencies may be related to the role these dietary substances have on production of neurotransmitters such as dopamine and serotonin.

Human depression also has been linked to several dietary problems. Relationships between depression and low levels of dietary folate have been well-documented in humans (Ortega et al., 1994; Alpert and Fava, 1997), and low folate levels may reduce effectiveness of antidepressant treatments (Alpert and Fava, 1997). The links between low folate levels and depression also may be caused by the role of folates in neurotransmitter production and neuron structure. Low tryptophan levels often are linked to depression (Smith et al., 1997), and higher levels traditionally have been linked with feelings of well-being and sleepiness. Low selenium levels also have been linked to human depression, anxiety, and tiredness (Benton and Cook, 1991).

Studies in human nutrition indicate that links between nutrition and behavior exist; however, horses and humans are nutritionally and behaviorally diverse. Horses are herbivores physiologically adapted to continuous food ingestion while humans are omnivores adapted to larger, infrequent meals. Unfortunately, horses often are fed according to human schedules rather than according to their physiological makeup, which may initiate behavioral problems in the horse.

Common Equine Management Practices: A Recipe for Gastric Irritation

The majority of performance horses in the United States are maintained in stalls and fed two meals daily. These meals often contain a large soluble carbohydrate component and a low fiber component that allow the horse to consume the food rapidly, leaving

a long time period with no food available. Along with allowing soluble carbohydrate to reach the hindgut where its rapid fermentation may lead to colic and laminitis, this feeding regimen reduces intestinal bulk needed to maintain normal intestinal function and position and leaves the horse unsatiated (Pagan, 1998). High-carbohydrate, low-fiber meals also reduce fill in the horse's stomach, which may lead to gastric irritation and ulcers. However, all-forage diets often do not provide enough energy and other nutrients to high-performance horses, so the deleterious effects of a low-forage diet must be weighed against the horse's need for more nutrients than typically are provided by forage.

Horses have relatively small, single-compartment stomachs with limited storage space. Although food passes through the stomach rapidly, the stomach is rarely empty under normal grazing conditions because of the horse's almost constant feed intake. The continuous fill in the stomach forms a protective mat of consumed forage particles between the cardiac (upper) and pyloric (lower) portions of the stomach. This mat of forage particles protects the squamous epithelium in the cardiac portion, which lacks protective mucus, from acidic gastric contents in the pyloric region (Merritt, 2003). Without this protective mat, exercise and normal activity could result in gastric fluid contacting the cardiac portion of the stomach initiating irritation and ulceration (Merritt, 2003).

Bicarbonates in saliva buffer the gastric acid and pepsin produced by the pyloric portion of the stomach and coat and protect the squamous epithelium in the cardiac region. If inadequate saliva is produced by the horse, the pyloric region becomes more acidic and the cardiac region is left unprotected from any contact with gastric acid. While gastric acid in the horse is secreted continuously with or without the presence of food (Murray, 1998), horses salivate only when chewing (Alexander and Hickson, 1970). Feeding forages to horses increases the amount of chewing time and consequently the amount of saliva produced (Murray and Schusser, 1989), and forage meals do not stimulate as much gastric acid production as grain meals (Smyth et al., 1988).

Behavior Problems and Equine Nutrition

Certainly not all equine behavior problems are related to nutrition or feeding management, and it is often difficult to separate effects of nutrition and other potential causative factors. For example, feeding forage to a horse provides nutrients and has some profound effects on digestive physiology, as discussed above. It also provides an activity (eating) that may displace other activities (e.g., playing or sleeping) and may distract the horse from other stimuli in the environment (e.g., flies or humans). Additionally, just as with humans, there are large variations in equine behavior and learning abilities, both within and between horses. Because horses are relatively expensive laboratory animals, it often is difficult to maintain enough horses on a research project to obtain meaningful results because of these wide behavioral

variations. Although some conclusions can be extrapolated from related species, eventually research has to be aimed at the target species to obtain meaningful results. All of these factors make it difficult to obtain conclusive links between behavior and nutrition in the horse.

All horse owners have empirical evidence that diets high in energy tend to make horses excitable and inattentive to the handler. However, research investigating effects of different levels of dietary carbohydrates on spontaneous activity in a stall and reactivity to various startling stimuli could not conclusively show that high carbohydrate levels caused any increase in horse activity or excitability (Ralston and McKenzie, 1992). Holland et al. (1996) reported that adding 10 percent fat to a typical hay/grain diet decreased reactivity of horses to various startling stimuli and reduced responses to pressure as compared to horses without added fat in the diet. This indicates that dietary fat may have a calming effect on horses and/or suggests that excitability in the horse may be more related to the source of energy in the diet than the amount of energy. However, these studies, as well as the average horse owner, have trouble accurately measuring reactivity and ruling out extraneous factors such as inconsistent exercise and changing environmental conditions that might affect reactivity.

A number of commercial supplements are marketed as calming agents for horses. These substances generally contain amino acids (especially tryptophan), B-vitamins, various minerals, and herbal ingredients. Although many horse owners routinely administer these products to horses before stressful situations, there is little scientific research validating the usefulness of these products. Bagshaw et al. (1994) reported that small doses of tryptophan (0.05 and 0.1 mg/kg) actually increased heart rates and activity in both non-stressed and stressed horses 2-4 hours after administration. Additionally they reported no differences in blood concentrations of serotonin, dopamine, or tryptophan among the treatments.

Relationships between nutritional status and learning abilities have been investigated in a number of species. In general, learning tasks which do not require that the animal make a choice (classical conditioning) reflect no differences between malnourished and normal animals (Barnes et al., 1968). In contrast, discrimination tasks in which the animal must learn to eliminate non-reinforced or non-relevant responses often are inhibited by malnutrition (Morris, 1974). Additionally, malnourished animals may be more emotional than normal animals in novel or stressful situations (Barnes et al., 1970). Timing of the nutritional deprivation probably has a large effect on behavior with malnutrition during the prenatal and neonatal periods having the most consequence. With mature horses, malnutrition does not seem to adversely affect learning performance of a simple discrimination task (black vs. white feed bucket with bucket position as a non-relevant stimulus). However, fat horses did make more errors than horses in a moderate or thin condition probably because they were less motivated to work for the feed reward (McCall, 1989).

Lack of fiber in the diet has been implicated in behavioral problems such as wood chewing and tail chewing in the horse. Willard et al. (1977) reported that horses fed a total concentrate diet had a significantly lower cecal pH and spent significantly more

time chewing wood than when on a hay diet. However, horses maintained on pasture still exhibit these behaviors, and Gill et al. (1998) reported no difference in frequency of wood chewing behavior in stalled horses given limited vs. ad lib hay. Although wood chewing can be destructive to facilities, it may be a normal behavior in horses. It seems to increase in cold, wet weather (Jackson et al., 1984) and may have evolved as a mechanism for horses to maintain body heat through activity or to maintain saliva flow without as much exposure to the elements as foraging for grasses.

Nutrition or feeding management may be linked to some stereotypic behaviors in horses. Generally stereotypic behaviors are considered "abnormal" behaviors and are often termed "vices." Stereotypic behaviors are repetitive, relatively invariant and apparently functionless behaviors (Odberg, 1978). Categories of stereotyped behaviors in the horse usually are based on the manifested performance of the behavior. Activities such as pawing, stall kicking, weaving (exaggerated shifting of the horse's weight between the forelegs), head tossing (moving the head in a vertical or vertical to horizontal plane often with considerable force), and stall walking (traversing a set area in a specific pattern) are classified as locomotor stereotypies, while lip flapping (moving the lips apart and together with an audible sound) and cribbing (pressing the upper incisors against a solid object, rocking backward with its body while emitting an audible grunt) are examples of oral stereotypies. Self mutilation, in which the horse bites or otherwise damages its own body, generally is considered a separate class of stereotypy. This classification does not address the source or a solution to these behaviors.

Although little research has been performed on locomotor stereotypies in horses, many seem to be a result of boredom, frustration, and learning. Weaving and stall walking may be forms of barrier frustration in which the animal is anxious because of confinement. Adding extra windows (Cooper et al., 2000) or mirrors (McAfee et al., 2002) to the stall to provide the horse with more visual stimuli significantly reduces weaving and head tossing. Turning the horse out on pasture usually will decrease, if not eliminate, these behaviors. Also, stall kicking and pawing probably are not influenced greatly by nutritional status of the horse although feed may play a role in the development of these behaviors. When the horse kicks the stall prior to feeding time, the owner hastily provides feed to quiet the horse, inadvertently rewarding it for the kicking behavior. Although not tested through research, providing ad lib forage may give the horse a competing activity and provide gut fill, making it less anxious around feeding time and reducing the expression of locomotor stereotypies.

In contrast, some oral stereotypies may be related to digestive physiology, pathological conditions, and feeding management. In other species, oral stereotypies usually occur after feeding and in animals with restricted food intake (Lawrence and Terlouw, 1993). Similar results are reported in horses. Cribbing frequency increases around mealtimes (Kusunose, 1992; Gilham et al., 1994), and crib-biting behavior is increased when adult horses are fed a low-forage and/or high-concentrate diet (McGreevy et al., 1995), sweetened grain rations (Gillham et al., 1994), or on an irregular basis (McClure et al., 1992). Nicol et al. (2002) reported that foals consuming

large amounts of high-concentrate feeds are four times more likely to develop cribbing behavior, and cribbing foals had a higher incidence of stomach irritation and ulceration than non-cribbing foals. Additionally, prevention of both cribbing and hay consumption significantly reduced the rate of passage of feed through the digestive tract compared to non-cribbing horses in which hay consumption was prevented (McGreevy and Nicol, 1998).

Horses on low-forage diets may fail to produce enough saliva to buffer stomach contents. Nicol (1999) proposed that cribbing may be an attempt to increase saliva flow to relieve gastric irritation. If this is the case, cribbing horses may be caught in a vicious cycle in which they begin cribbing in an attempt to relieve gastric irritation, but the cribbing habit itself reduces forage consumption when horses are provided with ad lib hay or pasture. Garcia (2004) and O'Reilly (personal communication) report that horses on pasture crib-bite an average of 1762 crib-bites over a 15-hour (daylight) observation period. These results are very similar to those reported by Fulmer et al. (1998a) for horses housed in stalls. Bachman et al. (2003) reported that stalled cribbers may spend up to 65% of their time performing the behavior.

Moeller (2000) examined saliva production during a 5-minute period in cribbing and non-cribbing horses and reported that saliva weight and saliva pH of cribbing and non-cribbing horses did not differ significantly. However, the initial saliva sample weight was significantly lower in cribbing horses indicating that they may produce less saliva than non-cribbing horses. Saliva weights in non-cribbing horses significantly decreased over the 5-minute period, probably due to a drying effect of the sampling procedure, while horses that cribbed during the 5-minute period showed no significant decrease in saliva weight over the sampling period. These results indicate that cribbing horses may replenish saliva faster than normal horses. This was confirmed in a successive study in which horses prevented from cribbing during the 5-minute sampling period showed a similar significant drying effect due to the sampling procedure as the non-cribbing horses in the first study (McCall et al., 2001). Therefore, cribbing does stimulate saliva production and may be an attempt to relieve gastric irritation, although the behavior probably does not produce enough saliva to buffer the horse's stomach or flush the digestive tract.

Equine stomach pH varies according to gastric fill, hydration, and region of the stomach sampled. Gastric pH ranges from 1-2 in the pyloric region to 6-7 in the cardiac region (Merritt, 2003). Although food stimulates gastric acid production, its overall effect usually is to increase stomach pH because of the buffering action of saliva and the feed itself (Murray, 1998). Lillie (2004) compared gastric pH in cribbing and non-cribbing horses and reported cribbing horses had a significantly lower gastric pH, both after an overnight fast and after food consumption, than non-cribbers. When cribbing was prevented for two weeks, gastric pH of the cribbing horses increased to a level comparable to that of the non-cribbing horses in the initial phase of the study. Garcia (2004) reported that cribbing horses treated with antacid (Neigh-Lox, Kentucky Performance Products, Versailles, KY) for 30 days increased gastric pH by a mean of 0.875 ± 0.41 units, but their cribbing behavior was not reduced by this

treatment. Trends in the cribbing behavior of these horses indicated that a longer treatment time might be necessary to affect cribbing behavior. Similarly, O'Reilly (personal communication) reported no effect of supplemental calcium carbonate on cribbing behavior of horses on pasture. Acidic conditions in the hindgut also have been implicated in crib-biting and other oral behaviors in horses (Willard et al., 1977; Johnson et al., 1998), although O'Reilly (personal communication) reported that fecal pH of cribbing horses maintained on pasture was within normal ranges.

Tryptophan supplements have been used by horse owners in an attempt to reduce cribbing behavior. O'Reilly (personal communication) reported administration of 3 g tryptophan daily for a 3-week period had no effect on cribbing behavior of horses. The use of tryptophan to reduce cribbing is based on the assumption that cribbing behavior is motivated by psychological stress and anxiety in the horse and increasing tryptophan in the diet would allow more conversion of tryptophan to serotonin, a neurotransmitter involved in feelings of calm, sleepiness, and well-being. Recent evidence suggests that cribbing horses may be more stress-sensitive and less flexible than non-cribbing horses, but that cribbing frequency was significantly reduced when horses were subjected to mildly stressful situations (Bachman et al., 2003).

Reducing Stereotypic Behaviors

At the present time, researchers have not identified the cause of stereotypic behaviors or definitive methods of reducing or preventing these behaviors. However, based on the research that has been performed, there are some commonsense management practices that might prevent the behaviors from developing or reduce their frequency in horses. Because it has been reported that many cribbing horses develop the behavior around weaning age (Badnell-Waters et al., 2003), owners and managers should closely observe weanlings for any signs of cribbing behavior. If foals are spending a large amount of time in oral activities other than eating, managers may want to adjust the diet by reducing the amount of soluble carbohydrates in the diet, changing the form of the concentrate ration from a sweet feed to a pellet, and increasing the amount of forage the foal is consuming. Treatment of cribbing foals with antacid may be advantageous (Nicol et al., 2002). These strategies, as well as substituting fat for a portion of the carbohydrate ration, also might work to reduce cribbing frequency in adult horses.

Although exercise has not been shown to be a factor that influences cribbing (Fulmer et al., 1998b), it does reduce wood chewing (Krzak et al., 1991) and may reduce expression of locomotor stereotypies. Moving horses from stall to pasture is recommended to reduce locomotor stereotypies. If pasture is not an option, increasing daily exercise, feeding numerous small meals throughout the day, placing flakes of hay in each corner of the stall to mimic grazing activity, providing toys, and using a foodball to deliver concentrate rations (Winskill et al., 1996) help increase activity in the stalled horse and keep it occupied.

Stalled horses should have visual contact with other horses to reduce development of stereotypic behavior (McGreevey et al., 1995) and promote normal feeding behaviors (Sweeting et al., 1985). If visual contact is not available, distractions such as mirrors may help reduce stereotypic behaviors (McAfee et al., 2002). Managers should observe horses closely for signs of anxiety or stereotypic behaviors when any changes in housing or in neighbors are implemented. Solutions as simple as moving a horse to another stall may greatly influence behavior.

It probably is easier to prevent undesirable behavior in horses than to stop these behaviors once they become habits. Vigilant managers who can identify initial signs of anxiety and stereotypies in horses and who are willing to individualize the care of these horses are the primary protection against horses developing them. "Naturalizing" the nutrition, housing, and care of the horse to mimic free-ranging conditions as much as possible is the best option for reducing and preventing undesirable behaviors in the horse at the present time.

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