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Teaching Basic Equine Nutrition

Part 2: Equine Digestive Anatomy and Physiology

Introduction

A sound nutritional program is important to ensure that horses are happy, healthy, and perform to their best. When teaching an audience about equine nutrition, it is best to start with the digestive anatomy and physiology because it directly relates to what, how, and when a horse is fed. This publication provides educators with information about the anatomy and function of the digestive system along with specific points to make when teaching about sound feeding management practices. This lecture is best when used with the model equine digestive tract discussed in the first part of this publication series, "Teaching Basic Equine Nutrition, Part I: Making the Equine Digestive Tract Model." Remember that the level of information in this publication may need to be changed depending on the learning level of the audience.

Overview of Digestive Anatomy

Horses evolved over millions of years into today's grazing animal, which eats primarily forages. Forages for horses, like pasture and hay, contain water, protein, fat, structural carbohydrates (i.e., fiber), nonstructural carbohydrates (i.e., sugar and starch), vitamins, and minerals. The horse's gastrointestinal tract is well suited to digest long fibers in forages slowly over several days. It was only in the last few thousand years that cereal grain-based concentrates high in non-structural carbohydrates were added to the diet to help meet the energy demands of the equine athlete. The digestive system of the horse can be divided into the foregut consisting of the mouth, esophagus, stomach and small intestine, and the hindgut consisting of the cecum, large and small colon, and rectum. Horses are called hindgut fermenters because they have a high concentration of microbes (i.e., bacteria, yeast, and protozoa) in their cecum and large colon that help the horse digest the tough fibrous portions of the forage in the diet. Remembering that a horses' digestive tract is best suited for digestion of diets high in forages is important to proper feeding management. Also, each part of the digestive tract has a particular anatomy or function that affects digestion and nutrient utilization, and that in turn affects how we feed horses to ensure optimal health.

Mouth

The horse has strong, mobile, and sensitive lips that select grasses, hay, and grains for consumption. The lips are also used to funnel water into the mouth. The upper and lower incisors shear forages close to the ground and then the tongue helps move ingested material to the cheek teeth for grinding. The horse chews its food in an up and down and side to side motion, which helps to initiate the breakdown of the feed in the first step of the process known as digestion. In response to eating and chewing food, horses produce approximately 3 gallons of saliva every day. The saliva helps to wet and lubricate the chewed feed or digesta as it moves through the digestive tract, and buffer the high acid production in the stomach. One of the most important aspects of feeding management is to make sure the horse has healthy teeth capable of grasping the feed easily and then grinding it into small particles before it is digested. Chewing the feed into smaller particles is important because it allows for nutrients like glucose, calcium, and

vitamin A to be readily absorbed in later sections of the digestive tract. Some horses do not wear their teeth evenly when they chew the feed, so sharp edges on the teeth may develop and eventually impair their ability to chew feed properly. Horses that do not have healthy teeth or cannot chew their food properly may suffer problems including a decrease in feed intake, dropping feed from the mouth, tilting head while chewing, cuts in the mouth, weight loss, and a condition known as choke. Dental care provided by a veterinarian should begin in the foal and continue up through the ages. A thorough exam should be performed every 6 months with floating or filing of the teeth and other necessary dental techniques performed as needed.

Esophagus

The esophagus is approximately 4 feet in length and mainly functions to move the chewed feed, known as digesta, from the mouth to the stomach. At the end of the esophagus, there is a tight muscular valve nicknamed the one-way cardiac sphincter. It is named this because its function is to ensure movement of digesta into the cardiac region of the stomach, but not back into the esophagus. Because this tight muscular valve makes it difficult for horses to regurgitate and expel what has been eaten, horses should be fed good quality feed and forage.

Stomach

The kidney-bean shaped stomach holds and mixes approximately 2-4 gallons of digesta. This is a surprisingly small amount given the large size of the horse. The horse does not need a large stomach because it evolved eating small amounts of forage over the course of the day as opposed to large meals eaten less frequently throughout the day. When horses are fed a meal that is too large for the stomach to hold, as in the case of a mischievous pony that breaks into the feed bin, the stomach may become distended causing abdominal pain or colic, and in some cases may even rupture. Therefore, horses should have their daily feed ration divided up into 2-3 small meals throughout the day. The stomach's main digestive function is to secrete hydrochloric acid and an enzyme known as pepsin, which initiates the breakdown of protein into amino acids.

The hydrochloric acid lowers the pH of the stomach's contents, also contributing to the breakdown of feed particles. It takes on average 2-4 hours for digesta that has entered the stomach to move into the small intestine. However, the range is quite variable depending on the type of diet consumed with some digesta moving through in as fast as 15 minutes and some remaining even after an overnight 12-hour fast. The internal lining of the stomach is divided into two halves. The top half of the stomach, nearest to where food enters from the esophagus, consists of a whitishpink non-glandular epithelial tissue that does not have much secretory function in relation to digestion. The lower half of the stomach consists of a reddish-pink glandular epithelial tissue covered in mucus where hormones, enzymes, and hydrochloric acid are secreted. The two sections are divided by a demarcation known as the margo plicatus. Because the lower section of the stomach is lined by a coat of mucus, it is more protected against the highly acidic environment of the stomach than the upper portion. The upper portion of the stomach can become exposed to the acid when the stomach is less filled and/or during exercise, such that the highly acidic fluid damages the lining of the stomach causing ulcers to develop. The best way to reduce the risk of stomach ulcers in horses is to avoid long periods of feed restriction by keeping the stomach filled with forage and to decrease the stress the horse is under (e.g., elite competition horse). Forage is the preferred choice of feed to use to keep the stomach filled because diets high in cereal grain concentrates tend to lower the pH in the stomach making the digesta even more acidic.

Small Intestine

The small intestine is approximately 70 feet long and its main function is to continue to break down the digesta into smaller particles and to begin absorption of the nutrients across the small intestinal lining into the horse's blood supply. The majority of fat, protein, simple sugars, vitamins, and minerals are digested and absorbed in the small intestine. The fibrous components, like the structures that make up the cell walls of the stems and leaves of grasses, are not digested to any great extent here, and therefore pass through to the next section of the digestive tract known as the cecum. It

is important to feed only good quality feed free of mold, toxins, and foreign objects because if present, they may be absorbed by the small intestine and cause the horse to become sick. The pancreas and liver assist the small intestine with digestion. The pancreas secretes a mixture containing enzymes into the small intestine, which aids in breaking down protein into amino acids and carbohydrates into simple sugars. The mixture also helps raise the pH of the digesta for optimal microbial fermentation or digestion of feed by gut microbes. The liver produces a compound known as bile, which assists with fat absorption by the small intestine. In other animals, bile is stored in the gall bladder and secreted when a meal is eaten. However, bile is continuously secreted by the liver because the horse does not have a gall bladder. Despite evolving on low fat/ high forage diets, horses are surprisingly capable of digesting and absorbing fat from diets that contain as much as 15 percent fat. Fat is an important energy source for horses and it is often increased in diets fed to exercising horses. Feeding too much fat at one time or over the course of the day can result in a horse refusing to eat its feed and developing greasy stool. Grain fed to horses often contains large amounts of starches and sugars that are readily digested and absorbed by the small intestine. These compounds are broken down into glucose and other simple sugars and absorbed into the bloodstream within several hours of consumption. Diets containing high amounts of starch and sugar may overload the digestive capacity of the small intestine causing spillage of the grain particles into the cecum. Horses should not be fed more than 4-5 pounds of grain at any one time. It takes on average about an hour from when the 4 horse first consumed the meal for the digesta to move through the small intestine and into the cecum.

Cecum

The comma-shaped cecum is approximately 4 feet in length and is called a “blind sac,” because the entrance of digesta into the cecum is located 3-4 inches from where the digesta will eventually exit into the large colon. The close proximity of the openings, and the shape of the cecum, allows the long fibrous portions of the diet to spend an adequate amount of time there in order to be properly digested. In fact, digesta may stay in the cecum for several days before moving on to the large colon. The main function of the cecum is to provide an optimal site for the slow fermentation of fiber by microbes. It also provides a site for the absorption of fermentation products and other nutrients. Fermentation is a process whereby the microbes help digest fiber that the horse cannot digest on its own to any great extent. Microbial fermentation results in the production of vitamins B and K, and compounds used in energy production called volatile fatty acids, all of which can be absorbed by the horse. Although some microbial fermentation takes place earlier in the digestive tract, the majority occurs in the cecum and later in the large colon. Feeding the horse to maintain a healthy and effective microbial population is very important. When too much concentrate is fed, it may enter the cecum incompletely digested, in which case the microbes quickly ferment the starch and sugar into lactic acid and gas. A buildup of lactic acid and gas may lead to digestive upset in the horse, similar to colic. In addition, microbes adjust fairly slowly to new diets, so it is best to change the diet of the horse gradually. For example, increase or decrease the amount of grain by one pound per day over the course of several days or allow horses access to lush pasture for a few hours for several days before turning them out permanently. Lastly, the microbial population can decrease substantially when forage is withheld from horses for longer than 8 hours or in cases where a horse experiences bouts of diarrhea. In these situations, it is important to remember that it may take a few days to a week for a horse to naturally increase the numbers of gut microbes so that it can efficiently utilize forages in its diet again. Horses should be fed diets containing no less than 1 percent of the body weight in forage (pasture, hay, chaff). The average horse at maintenance can meet its nutrient requirements by consuming high quality forage at about 2–2.5 percent of its body weight. Feeding horses high forage diets also reduces boredom and decreases their risk for developing stable vices like wood chewing and cribbing.

Table 1. Summary of Main Points

Part	Management practice
Mouth	**Horses' teeth may wear unevenly over time and should be checked every 6 months and filed by a veterinarian if needed.**
Esophagus	**A horse cannot regurgitate its food, so feed and forage of good quality must be offered at all times.**
Stomach	**A horse should be fed small amounts frequently with their total allotment of feed divided into at least 2-3 meals per day. Keeping the stomach filled with forage helps buffer the acidity and lowers the risk of stomach ulcers.**
Small Intestine	**Avoid feeding more than 4–5 lbs of cereal-based concentrate at one time because the sugar and starch may exceed the capacity of the small intestine, leading to digestive upset in the cecum and colon.** **A horse can tolerate ~ 15 percent of its total daily diet in fat before it refuses its feed and/or develops greasy stool.**
Cecum	**Feed high forage diets, which will be digested with the help of microbes in the hindgut.** **Changes to the diet should be done slowly over time to allow the microbes to adjust.** **Do not withhold forage from a horse for longer than 8 hours because the number of microbes in the gut may decrease causing a horse to be less efficient at digesting and utilizing its diet.**
Large Colon	**Offer ample fresh, clean water at all times to keep the digesta moving through the digestive tract and to prevent impaction colic.**

Large Colon

The large colon is approximately 12 feet long and can be divided into four main sections. Each of the sections are separated by a curvature or flexure that allows the large colon to curve around and fit into the horse's abdomen. The large colon functions to provide an additional location for fermentation of fibrous digesta and a site where absorption of the products of fermentation can occur. Another important function is absorption of water from the digesta so that the horse can recycle its water to stay hydrated. Water is very important for digestion because it helps move the digesta through the digestive tract. When a horse is dehydrated, it may be at a higher risk for developing impactions or blockages of feed and forage, especially in the curvatures of the large colon. Providing fresh clean water to a horse at all times is very important to ensure movement of digesta through the gut and adequate hydration. An average horse at rest will consume about 7 gallons of water daily. That amount may double for horses exercising in hot and humid climates or for lactating mares. It takes approximately 2 hours for the digesta to move from the cecum through the large colon.

Small Colon and Rectum

The small colon is approximately 10 feet long. Its main function is to absorb water and form fecal balls. The rectum is approximately 1 foot long and it stores and excretes feces.

Summary

There are many unique aspects of the horse's digestive tract that dictate how and why we feed horses for optimal health and performance. Table 1 has a summary of the main points that the audience should learn from a discussion on how the anatomy and physiology of the digestive system relate to good feeding management practices. Teaching those concepts to horse owners allows them to make better feeding management decisions. By using the model equine digestive tract (Teaching Basic Nutrition, Part I: Making the Equine Digestive Tract Model) and the information presented in this publication, a basic lecture in proper feeding management can be fun and informative. Be sure to review the top ten feeding management "take-home" messages at the end of the discussion or, even better, see if your audience can remember them when given the specific sections of the digestive tract. Feeding horses properly is a science, but it also can be made relatively simple by relating digestive anatomy and physiology to everyday feeding management practices.

References

Frape, D.L. 2004. Equine Nutrition and Feeding, 3rd ed. Blackwell Publishing Professional, Ames, IA.
Lewis, L.D., 1996. Feeding and Care of the Horse, 2nd ed. Lippincott Williams and Wilkens, Media, PA.

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