The Horse's Digestive System

Understanding the complicated gastrointestinal tract of your horse will help you manage him better to avoid complications

BY HEATHER SMITH THOMAS

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The equine digestive system is designed to process forage and works best if the animal eats small amounts more or less continuously, as he does when grazing.

Brushing up on our knowledge about how the horse's digestive tract functions can help us feed horses more wisely, avoiding some of the feed-related problems that might lead to colic and other gastrointestinal (GI) tract ailments. The equine digestive system is designed to process forage and works best if the horse eats this forage more or less continuously, or if he's given frequent small meals of concentrated feed. The horse evolved as a grazing animal, but we often confine him, giving him large meals once or twice a day, and using high-energy feeds, such as grain.

Stephanie C. Mathis, DVM, Dipl. ACVS, an equine surgeon at Pioneer Equine Hospital in Oakdale, Calif., says that by domesticating horses and putting them in stalls, we're not working with the equine GI tract as it was designed to function.

The Equine GI Tract

The GI tract of an adult horse is a tube about 100 feet long that holds 50 to 60 gallons, depending on the size of the horse. This tube consists of the esophagus, stomach, and small intestine (together called the foregut), followed by the cecum, large colon, small colon, and rectum (together called the hindgut). Digestion in the foregut is primarily accomplished through the action of enzymes. The hindgut is where fibrous parts of the diet are digested by microbes through fermentation. Different types of feed pass through the tract at different rates.

"Grain is digested more quickly than hay," says Mathis. Pelleted feeds and lush, green grass also pass through more swiftly than hay.

Processing of feed begins in the horse's mouth. The horse bites off grass or uses his

lips to pick up hay or grain, and he grinds food into smaller particles, mixing it with saliva to ease chewing and swallowing.

This need to produce adequate amounts of saliva is one reason a horse drinks a lot. "Saliva not only moistens the feed, but also contains enzymes that start the digestive process," explains Mathis.

The horse has three sets of paired salivary glands that secrete 6 to 10 gallons of saliva daily—moisture that is continually recycled within the body. Saliva not only assists with passage of food through the gut, it also acts as a buffering solution to help maintain proper gut pH. This helps counteract acidic gastric fluids in the stomach and bile in the small intestine (produced by the liver and released in the small intestine), and it keeps ingested material at a pH between 6.8 and 6.5 (slightly acidic) for optimal fermentation in the cecum and large colon. (A pH of 7 is neutral, above 7 is increasingly alkaline, and below 7 is acidic.)

After food is thoroughly chewed, the horse's tongue pushes it into the pharynx at the back of the throat. The funnel-shaped pharynx keeps it out of the windpipe as the horse swallows. The soft palate in the roof of the mouth helps keep food and water from coming back into the mouth once it enters the pharynx. This is one reason horses don't breathe through their mouth (the soft palate drops down and blocks the windpipe) and why horses don't generally vomit or burp.

"Another reason this is difficult in horses is that their relatively high distal esophageal sphincter muscle tone prevents movement of material back up the esophagus," says Mathis. "The vomiting reflex is also poorly developed in horses. Their inability to regurgitate increases their risk (compared to other species) for colic and gastric rupture (stomach rupture). Veterinarians often pass a nasogastric tube into colicky horses to enable excess gas or fluid/feed in the stomach to exit, relieving the pressure and preventing gastric rupture."

The esophagus is a muscular tube that runs alongside the windpipe. It's a one-way street with peristalsis (contracting movements in rhythmic waves traveling toward the stomach). After food moves into the stomach, it is subjected to hydrochloric acid and pepsin secreted by the stomach walls. The fluids begin breaking down feed and start the digestion of proteins.

The stomach holds only 3 to 5 gallons or about 8% of the total capacity of the digestive tract. This small size also contributes to the reason why a horse has a hard time vomiting—the stomach doesn't touch the ventral (lower) body wall, so the horse's body can't form a high-pressured abdominal press like other species. Most feeds pass through the stomach rapidly, often entering the small intestine within 15 minutes of being eaten by the horse. Whenever the stomach becomes at least two-thirds full, food begins passing into the small intestine.

"The horse's stomach continually produces hydrochloric acid," says Mathis. "The pH of the unfed (empty) equine stomach can drop far below 4.0, becoming extremely acidic, and is at risk for mucosal injury and ulcers. If horses are fed often or graze at pasture, the stomach always has food in it to help absorb acid, and risk of ulcers is diminished. The type of feed can also be a factor in whether or not a horse develops ulcers."

Jennifer G. Barrett, DVM, PhD, Dipl. ACVS, an assistant professor of equine surgery at Virginia Tech's Marion duPont Scott Equine Medical Center in Leesburg, Va., explains that the equine stomach is more sensitive to gastric ulceration than that of some other species. This is because part of the stomach lining "lacks cells that secrete the mucus that helps protect the stomach," she explains, which makes it similar to the esophageal lining. The pastured horse, however, grazes all day and is able to keep a uniform pH.

> **"Stabled horses fed two or three large meals that are high in concentrates are at increased risk for ulcers."**
>
> DR. JENNIFER G. BARRETT

Mathis notes, "Stabled horses fed two or three large meals that are high in concentrates are at increased risk for ulcers. They tend to consume those meals very rapidly, resulting in less saliva production to help buffer the stomach contents. The concentrates also result in an overall more acidic environment due to their breakdown products and the horse's own physiologic response to consuming carbohydrates, which results in increased production of hydrochloric acid."

Barrett helps us continue the journey: "From the stomach, food passes into the duodenum (the first part of the small intestine), which leads to the jejunum (the long middle segment), much of which is freely movable within the abdominal cavity."

NEEDED: "GUT BUGS"

Many plant cell walls are composed of cellulose, which enzymes of a simple stomach or small intestine do not affect. Cellulose can only be broken down by microbes that change it into energy-producing fatty acids.

"What makes horses better than humans in digesting roughage is that humans don't have as many helpful bacteria, and the horse also has greater ability to absorb short-chain fatty acids produced in the fermentation process," explains Anthony Blikslager, DVM, PhD, of North Carolina State University. "Horses have transporters in the gut lining that can absorb these breakdown products."

The horse is unable to digest forage when he is born. His cecum is not functional because it has no microbes to facilitate fermentation. He depends on his simple stomach and small intestine for digesting milk. As he comes in contact with bacteria, he develops the ability to digest solid food. Foals eat some of their dam's fresh manure to gain the proper microflora. The amount of solid food a foal can utilize is limited at first because of the small size of his gastrointestinal tract, but as the hindgut increases in size and function, he can eat more forage, with less dependency on milk.

"When we have to 'jump-start' the horse's digestion after colic surgery or illness, we give yogurt and commercial products containing bacteria, but we don't know how well these actually work in replenishing the microflora," says Blikslager. "With cattle we use rumen fluid from another cow. In the horse, however, the microbes have to make it through stomach and intestines to get to the hindgut. The stomach is acidic, and most of what we give may be killed and never make it to the hindgut. It's easier with cattle because we're putting the microbes directly (via stomach tube) into the organ that does the digesting."

—Heather Smith Thomas

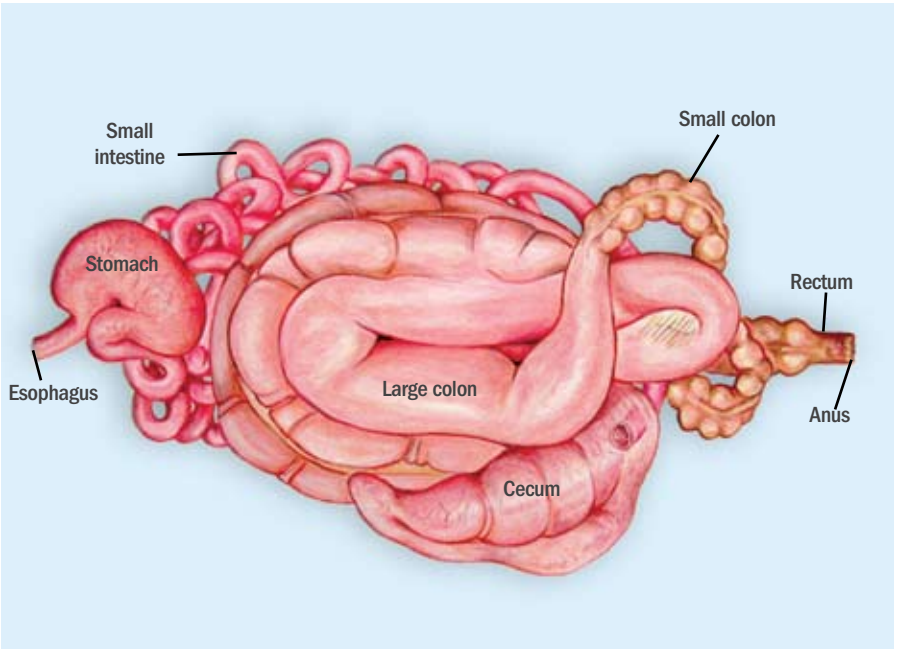
The loops of small intestine are attached to the upper body wall with a long, fan-shaped membrane (mesentery), which contains the blood supply to the intestines.

"These structures (the vessels in the mesentery) can be involved in obstruction of flow of food, or even create strangulation of the intestine in some causes of colic," explains Barrett.

Protein digestion continues in the small intestine, along with breakdown of starches and sugars and, to some extent, fats. The entire small intestine is only 2 inches in diameter, but about 70 feet long, and it holds 12 to 17 gallons (about 30% of the digestive tract's total capacity).

"The last portion of small intestine, the ileum, empties into the cecum through the muscular ileocecal orifice, which keeps food from backing up into the small intestine from the cecum," says Mathis. "If blockage occurs and feed plugs up in the small intestine, it can back up no farther

THE GASTROINTESTINAL TRACT



DR. ROBIN PETERSON

DIGESTIVE STRATEGIES

Horses are unique in that they digest most of their feed in the hindgut (cecum and colon) rather than the stomach. Some mammals, such as humans and pigs, have simple stomachs, while others, such as cattle and deer, have a complex foregut with multiple stomachs.

Anthony Blikslager, DVM, PhD, a professor of equine surgery at North Carolina State University, says there are four digestive strategies: "Animals like cattle are foregut fermenters and horses are hindgut fermenters. Carnivores have a different strategy—eating meat that's digested in the stomach and small intestine. Omnivores such as humans, pigs, and bears can digest meat and some kinds of vegetable matter. The various types of digestion developed during evolution of these animals."

There are few hindgut fermenters. This is a very unusual digestive strategy and occurs in equids, rhinos, elephants, hamsters, rabbits, and flying lemurs. "Most herbivores are foregut fermenters (camels, goats, sheep, deer, etc.)," says Blikslager. "Foregut fermenters have complex stomachs, but differ in number of stomach compartments. For example, cattle have four compartments, whereas llamas have three."

Prehistoric ancestors of the horse started as small, browsing animals. They changed to grazers as forests receded and grass began to cover the plains. "Early horses were prey for a number of animals," says Blikslager. "Ultimately they developed the ability to run fast and survive on grass. They continuously moved and grazed in herds."

Horses on the open prairies had no adequate defense against predators (no horns to fight them off), so they came to depend on keen senses to detect the approach of predators, swift reflexes to leap into action, and speed to move to safety.

"At the same time, their GI tract is designed to digest only grass," notes Blikslager. "These two factors together (eating grass and the necessity for athleticism and speed) make a difficult challenge for GI tract structure. The most efficient way to digest forage is how cattle do it, eating grass and predigesting it in the large rumen."

A cow can quickly eat a large amount of forage and rechew it later using a process organized by the brain to require her to rechew feed until the particle size is the right length to flow through the rest of the gut. The bovine rumen (first stomach) holds 15 to 20 gallons, compared with the horse's small stomach that holds 3 to 5 gallons. "The ruminant is a much better digester of grass because the fermentation process is up front," explains Blikslager. "As feed goes through the GI tract, the cow absorbs all the nutrients. She can process coarser feeds and a wider variety of types and quality of feeds than a horse. But she can't run as fast with the largest part of the digestive tract up front.

"Cattle compromised by living in large herds and sacrificing a few individuals on the outside of the herd," notes Blikslager. "Horses, by contrast, developed speed. So they put the fermentation part of their GI tract in the back. Their digestive system is upside down. They have all these useful nutrients produced in the hindgut by fermentation via helpful bacteria, but this happens near the end of the tract."

There's not as much opportunity for optimal absorption of these nutrients. Also, more care must be taken in feeding horses. A byproduct of fermentation is gas. In the horse this release of gas is predominantly produced in the cecum and colon, which can cause problems. By contrast, in cattle this occurs in the first stomach, and they can burp gas up the esophagus and get rid of it.

"The horse's tract is designed to get food to the cecum and colon as swiftly as possible," says Blikslager. This doesn't give opportunity for maximum absorption, and if a horse is fed a lot of grain or sweet feed, he can't absorb all the sugar before it gets to the cecum and colon.

"This changes the (gut) pH and the type of bacteria," says Blikslager. "Those that can digest sugar quickly multiply and form a lot of gas in the process." Certain bacteria might form toxins as they proliferate and die off. These sudden changes in the hindgut can lead to colic or laminitis.—*Heather Smith Thomas*

Keeping your horse's hindgut healthy can be a challenge when so many factors contribute to imbalances in the hindgut's microfloral population

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than the stomach. The one-way valve between stomach and esophagus keeps it from coming up the esophagus."

If the stomach becomes too full—distended with feed or gas—it causes extreme pain and in some cases might rupture. "This scenario also results in small intestinal distention, which is extremely painful and a relatively common cause of colic," says Mathis. "If the intestine is distended, this can be detected during rectal examination performed by a veterinarian, or identified with ultrasound examination of the abdomen. Cases involving small intestinal distention necessitate immediate attention—medical or surgical—not only to relieve discomfort and buildup of pressure within the stomach/small intestine, but also to prevent more serious injury to the small intestine that results from prolonged distention and stretching of the walls."

> "To maintain hydration, the large intestine must absorb 20-30% of the horse's body weight in water per day."
>
> DR. STEPHANIE C. MATHIS

Even though food passes in liquid form through the small intestine quite rapidly (taking anywhere from 30 minutes to three hours), this is where much of the digestion and absorption of protein, sugars, and starches takes place. End products of soluble (dissolvable) carbohydrates are glucose and other sugars. It's important that they're efficiently digested in the small intestine.

"If large amounts pass on to the large intestine, this disrupts the fermentation process by altering the pH, adversely affecting the microbe population—with risk for colic or diarrhea," she says.

The horse has no gall bladder. In other animals the gall bladder stores bile to be released in the intestine for breaking down fats. In horses bile is secreted continuously in small amounts in the small intestine. People once thought horses couldn't utilize fat, due to lack of gall bladder, but research has shown they handle fat quite well. Fat as an energy source (often added in the forms of oils or rice bran) can be beneficial to horses that need more calories. It can be healthier than adding a lot of grain to the diet.

The Hindgut

"The cecum and large colon are where fiber is broken down and other nutrients are extracted that weren't already absorbed by the small intestine, and where water and electrolytes are absorbed," says Mathis.

Another reason (besides all that saliva production) a horse needs a lot of water is the fermenting of hay or grass in the cecum and colon. The GI tract pulls fluid from the bloodstream almost continuously, and it absorbs and recycles it in the colon during the last phase of digestion.

"To maintain hydration, the large intestine must absorb 20-30% of the horse's body weight in water per day, roughly 200 to 300 pounds (25-35 gallons) per day in the average 1,000-pound horse," she says.

This water is supplied by drinking and

recycling fluids within the body; the salivary glands and foregut take it out of the bloodstream and put it back into the digestive tract for the next journey through.

The walls of the cecum and large colon purse out with many small ridges and sacs that slow passage of food so microbes have more time to work on it. Rate of passage through the cecum and large colon is 36 to 72 hours.

"The cecum is not as freely movable as the jejunum," says Barrett, "but it can become twisted, displaced, or impacted." Typically, twisting of the cecum accompanies initial twisting of the large colon.

Animals cannot digest cellulose and other fibrous parts of forage without assistance from organisms *a lot* smaller than they are. Helpful microbes digest fiber by changing it through fermentation into energy-producing fatty acids. Fermentation also produces amino acids (from which the horse gets usable protein) and B vitamins.

The horse's cecum holds 6 to 8 gallons. "This fermentation vat is similar to the cow's rumen in function. This is where feed begins to ferment through action of the normal gastrointestinal microbial population," says Mathis.

The large colon is about 10 to 12 feet long and holds about 15 to 20 gallons.

"The large colon is a wide tube folded back on itself with its mesentery holding the two halves of the fold together," says Barrett. "The beginning and end of the large colon are firmly attached within the abdomen, but the long folded part is freely moveable. Horses can have motility disturbances that cause the large colon to migrate into an abnormal location. A large colon displacement can kink off the flow of ingesta and gas and cause pain. Additionally, the large colon can twist on itself, which is a cause of severe colic that requires immediate surgery to correct."

Functions of the colon include absorbing water, electrolytes, and short-chain fatty acids. These fatty acids are the main source of energy in the horse.

"From the large colon material moves into the transverse colon (which is secure along the body wall), then into the small colon, which is more movable within the abdomen," says Barrett.

Mathis adds, "Any remaining excess water is absorbed from the residue passing through the small colon and formed into fecal balls by the contractile actions of two longitudinal muscular bands and a layer of circular muscle throughout its length." The small colon is 2.5 to 4 inches in diameter and 9 to 10 feet long, and it holds about 4 gallons.

The fecal balls then pass out through the rectum and anus.

Take-Home Message

The horse's GI tract is a unique body system, all 100 feet of which must function properly for the horse to absorb nutrients and thrive. Knowing how this complex system works will help you understand how things can go wrong and help you better manage horses to avoid complications.

ABOUT THE AUTHOR

Heather Smith Thomas *ranches with her husband near Salmon, Idaho, raising cattle and a few horses. She has raised and trained horses for 50 years, and she has published 20 books and more than 9,000 articles for horse and livestock publications.*