**Week 1: Digestive Tract**

Small errors in feeding can result in problems occurring: deficiencies and excesses.

In their natural environment, horses will roam more than 8 to 26 kilometers (5 to 16 miles) per day. They are nomadic, grazing little and often for 16 to 20 hours per day. Their types of feed vary. The plants vary. They are typically low in quality and high in fiber.

Horses are very social animals. They developed this as a survival skill.

Horses are prey animals. Their natural instinct in the presence of danger is to run away or hide.

The fight or flight instinct is present in horses. If out in the open and scared, they will run, then stop to see from what they're running.

They wouldn't choose to put themselves into a confined situation, but if they find themselves there, they will fight if exposed to danger.

Horses communicate with body language. And they can pick up on ours.

They also communicate through vocalization.

**Types of diets**

Their gastrointestinal system is set up to deal with high amounts of low quality forage to be digested on an almost continual basis. The principal diet of the horse should be forage, because that's the type of feed the tract has evolved to process.

Think about how we manage horses and how this differs from their natural state.

Thinks about the stabled horse. This is a huge departure from the horse's natural state. It can't roam. There's no social aspect. The horse can't graze on an almost continual basis. Even with horses on pasture, these are typically much smaller areas than the horse would encounter in its natural state. And horses don't have access to the wide range of plants they would have if kept in a natural state.

Also, we've changed way we've used horses.

In the early 19th century, horses worked on the farm. This has changed substantially through the mechanization of agriculture. Horses have moved away from being working animals to being more of a leisure or sport horse.

We've had to include much higher levels of more energy-dense feed stuffs in the diet.

For example, the racehorse has high energy requirements to undertake the level of work required.

We have done this through the provision of cereal grains in the diet, such as oats, barley and maize.

Also, we've changed the feeding management. We've moved away from continual feeding to meal feeding, often two large meals of cereal grain in bucket form. Also, forage is provided at set times of the day rather than the horse having unlimited access.

The amount of grains fed often overshadow the amount of forage.

But forage should be the principal component.

Research has shown there's a minimum requirement of forage for the horse's digestive track to maintain its health and integrity: 1 kilogram (**2.2 pounds)** of dry matter of forage to 100 kilograms **(220.4 pounds)** of live weight, according to the Natural Resource Council's recommendations.

While the intestinal system of horses is largely unmodified, we've changed how we're feeding, and we're encountering problems.

These include disorders such as:

Gastric ulceration

Hindgut acidosis

Azoturia

Laminitis

Colic

This can lead to poor performance, irreparable damage, or euthanasia.

We need to:

Understand the physiology of the gastrointestinal tract to provide diet for gut health and integrity.

Understand the behavior needs of the horse, maintain good welfare.

Develop dietary management regimes that overcome dietary problems.

**Equine Digestive Tract: Overview**

The horse is classified as a nonruminant herbivore.

If you look at a nonruminant such as the pig, it relies on enzymatic digestion of feed stuffs in the stomach and small intestine, with very little fiber digestion in large intenstine.

If you look at the ruminant, such as the cow, it has a large ruminant enviroinment where lots of fiber degredation takes place, but, again, very little fermentation in the large intestine.

The horse sits in between.

The horse has enzymatic digestion in the forward gut (stomach and the small intestine) and microbial fermentation taking place in the large intestine.

The gastrointestinal tract (GIT) begins at the lips and ends at the anus.

It GIT has three functional regions: the stomach and small intestine (referred to as the foregut) and the large intestine (referred to as the hindgut).

The whole tract is approximately 100 feet long in a mature horse. It changes in diameter at various sections of the tract.

Overall, it is lined with mucus membranes.

It consists of the:

Mouth

Pharynx

Oesophagus

Stomach

Small Intestine

Caecum

Large colon

Small colon

Rectum

There ares some associated organs, which are the:

Teeth

Tongue

Salivary glands

Liver

Pancreas

**Mouth**

Digestion begins in the mouth. Food is torn by the upper and lower incistors, of which there are 12.

The molars and premolars grind the feed to reduce the particle size. There are 12 premolars and 12 molars.

It's important that the particle size is reduced. It aids enzymatic digestion in the foregut and microbial fermentation in the hindgut. Chewing is very important in the digestive process. It's important that the teeth are in good order.

Horse can chew 70 to 90 times per minute, depending on the feed stuffs.

Saliva is produced as a direct response to chewing.

If a horse is eating a lot of forage, it has to chew that forage a lot more to reduce it the particle size compared to cereal grain. More saliva is produced as a result of chewing the forage compared to cereal grains.

**The stomach**

The size is relatively small compared to the remainder of tract. It's also relatively inelastic.

It has a capacity of approximately 8 liters (2.1 gallons). It's the size of a rugby ball.

It's important not to overfill the stomach.

Per meal, we don't want to be giving more than 2 kilograms (4.4 pounds) for a mature adult horse, less for a pony.

The reason we feed little and often is in part because of this relatively small stomach.

The stomach is divided into two sections, the nonglandular and glandular.

The first section is the nonglandular, where the food enters stomach. There is no protective mucus layer here.

Food then moves to the glandular section, where hydrochloric acid is produced. There's a much lower pH in this area, about 1.5 to 2. This area is protected by a mucus layer.

Chewing is important in the nonglandular part. This pH, which is much higher in this area, is maintained through saliva buffering the acidity in this part of the stomach. If the horse is eating a lot of cereal grains, this top part of the stomach can become more acidic and develop disorders such as gastric ulceration.

Very little digestion occurs in the stomach. There's a little bit of protein breakdown but no absorption of nutrients.

The rate of passage is relatively rapid, and some feed stuffs some can move through the stomach in 20 minutes.

**Small intestine**

The small intestine is basically a long narrow tube. It connects the stomach with the large intestine.

The length is 21 to 25 meters (68 feet ,10 inches, to 82 feet). It's called the small intestine because of the diameter of the tube. In fact, the length of the tube is 75 percent of the total tract, but the volume is about 30 percent of the tract.

It has three main parts: the duodenum, jejunum and ileum.

In the duodenum, a lot of mixing and neutralizing of digesta takes place.

In the jejunum and ilium, the majority of absorption of nutrients digested by enxymatic digestion takes place.

PH of the digesta coming out of stomach and into the small intestine ranges from 2.5 to 3.5.

The lower part of the stomach was a very acidic environment. The digesta leaving that environment is very acidic.

This is neutralized in the duodenum by the presence of bile secreted by the liver.

The horse has no gall bladder. Instead, bile is secreted in an almost continual basis due to the fact that a horse does graze for a significant amount of the day. This bile buffers the pH to 7 to 7.5, a neutral environment in the small intestine.

Brunner's glands located in the small intestine also secrete bicarbonates into the lumen into this area, and this further neutralizes the digesta before it travels into the large intestinal environment.

It's important that the pH in the small intestine is neutral, because this facilitates the transport of the nutrients across the gut wall, and it's also required for optimal activity of the enzymes released into this area to break down the feed constituents, such as amylases that degrade starch and lipases that degrade lipids.

The surface area of small intestine is further increased by the presence of villi on the wall of the small intestine and also crypts, which are covered by columnar epithelium.

The absorption in the small intestine is at its greatest at the **proximal** jujenum. And, then, in the ileum, the remainder of absorption takes place. This is the site of absorption for many of the minerals.

The rate of passage in the small intestine is fairly rapid, ranging from 45 minutes to two hours, depending on the types of feed stuffs ingested, the meal size and the amount of forage present in diet.

Food moves through the digestive tract by peristalsis, or waves of muscular contraction that push the feed through the digestive sytem.

**Large intestine**

Feed then enters the large intestine, which we often refer to as the hindgut.

It's much shorter in length, about 7 meters (22 feet, 11 inches), but with a much greater capacity of about 150 liters (39.62 gallons).

This is 60 percent of the volume of the GIT.

It has **three** main parts: the cecum, large colon, small colon and then the rectum.

Large intestine is lined with mucus-secreting glands. There are no digestive enzymes secreted in the large intestine. It depends on microbial fermentation of the feed residues that come through from the small intestine.

The cecum is the first part. It is approximately 1.2 meters (3 feet, 11 inches) long and has a capacity of 30 liters (7.92 gallons). It makes up 15 percent of the horse's GIT volume. It can be described as a large blind-ended sack-like structure.

Digesta enter the cecum through the ileocecal valve, located at the top end. The cecum can be described as a large fermentation vat, something similar to that of the rumen of the cow.

From the cecum, digesta travel into the large colon through the cecalcolic valve.

The large colon is about 3 meters long (9 feet, 10 inches), with a capacity of about 90 liters (23.7 gallons). Digesta moves from the right ventral colon to the left ventral colon to the left dorsal colon to the right dorsal colon. These four parts of the large colon are connected by bends, known as flexures. These can be sites of impactions in a horse.

Digesta then moves to the small colon. This is similar in length to the large colon, but it has a smaller diameter. Its main function is absorption of water.

There are no enzymes secreted into the large intestine. Instead, horses digest fiber through microbial fermentation. The horse itself does not produce enzymes to digest fiber. It makes use of microbial populations that are present within this large intestine environment. These microbes ferment the fiber. They ingest it and degrade it. They produce these end products, which are known as volatile fatty acids, and gases. The main VFAs are acetate, butyrate and propionate, and these are absorbed across the gut wall and used as a source of energy.

The gases are predominantly carbon dioxide and methane, a byproduct of fermentation.

In terms of microbes, there are estimated to be about 400 species present in the hindgut, probably more. We don't know how many or the diversity. It is estimated that there are 10 to the power of 9 bacteria present per milliliter (.03 ounces) of large intestinal contents. There are a smaller number of fungi, the estimate is 10 to power of 3 per mil. For protozoa, it is 10 to the power of 4 per mil.

Microbes sit there predominantly to digest fibrous materials. They're breaking down the fibrous components of feed. The horse is unable to break down fibrous components in the small intestine, so they travel from the small intestine into the large intestine for microbial fermentation.

The pH of the large intestine is somewhere between 6 and 7, closer to 7, somewhere in the region of 6.7.

The microbes, particularly the fiber degrading bacteria, need this pH level to be maintained from 6.7 to 7 for them to remain healthy and be able to degrade the fiber effectively.

Bicarbonates and phosphate salts are also secreted into large intestine environment to maintain the pH, coupled with the regular absorption of the fatty acids produced. These are absorbed across the wall to enable the pH to stabilize.

In terms of practicality in feeding, we need to make changes gradually. Microbes present in the hindgut need to adapt. Any abrupt changes can result in reduced digestibility and problems such as colic, acidosis and laminitis.

To reiterate, the hindgut is designed to process fiber, not feed stuffs that are high in other components such as starch or soluble sugars. When these enter the hindgut in sufficient amounts, they can cause destruction to this environment.

High amounts of sugar and starch entering the large intestine is extremely undesirable. The animal can become very unhealthy.

To give you a breakdown of the processes involved when high amounts of sugar and starch enter the hindgut:

The rapid ingestion of starch and sugars leads to a drop in pH. This is because we get a lot of VFAs produced extremely rapidly. They are absorbed across wall to maintain the pH. If they are produced too rapidly, this overwhelms the absorption systems, and the pH of the hindgut begins to decrease.

If you recall, these fiber degrading bacteria prefer pH of 6.7. If this pH starts to reduce, we see a decrease in the number of fiber degrading bacteria and an increase in lactic acid bacteria. These lactic acid bacteria like to degrade starch. They degrade the starch further, and they produce lactic acid as a byproduct. Lactic acid is a stronger acid than the VFAs, and this further decreases the pH. When the pH drops to a very low level, we can see some erosion of the gut wall. In that case, we can often see toxins released through the death of these fiber degrading bacteria being absorbed into the blood stream. This can have disastrous effects, one of them being laminitis.

In conclusion, the horse is designed to eat fiber on an almost continual basis grazing little and often. It needs fiber to maintain gut health, particularly in the large intestine, and also to satisfy its behavior needs. The horse it motivated to chew and eat on an almost continual basis.

Sudden changes to diet or inappropriate diets can lead to gastrointestinal tract disturbance, reduced diet digestibility, and ill health.

Feed sufficient amounts of forage.