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**Ruminant Digestive Anatomy and Function**

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Ruminant livestock include cattle, sheep, and goats. Ruminants have a unique digestive system that allows them to better utilize energy from fibrous plant material than other herbivores. Unlike monogastrics such as swine and poultry, ruminants have a digestive system designed to ferment feedstuffs and provide precursors for energy for the animal to utilize. By better understanding how the digestive system of the ruminant works, livestock producers can better understand how to care for and feed the ruminant animal.

The ruminant digestive system uniquely qualifies ruminant animals such as cattle to make efficient use of high roughage feedstuffs such as forages. Anatomy of the ruminant digestive system includes the mouth, tongue, salivary glands, esophagus, 4-compartment stomach (rumen, reticulum, omasum, and abomasum), pancreas, gall bladder, small intestine, and large intestine.

A ruminant uses its mouth and tongue to harvest forages during grazing or to consume harvested feedstuffs. Cattle harvest forages during grazing by wrapping their tongue around the plants and then pulling to tear the forage for consumption. On average, cattle take from 25,000 to over 40,000 bites to harvest forage while grazing each day. They typically spend over one-third of their time grazing, one-third of their time ruminating (cud chewing), and slightly less than one-third of their time idling where they are neither grazing nor ruminating.

The roof of the ruminant mouth is a hard/soft palate without incisors. The lower jaw incisors work against this hard dental pad. The incisors of grass/roughage selectors are wide with a shovel-shaped crown, whereas those of concentrate selectors are narrower and chisel-shaped. Premolars and molars match between upper and lower jaws. These teeth crush and grind plant material during initial chewing and rumination.

Saliva aids in chewing and swallowing, contains enzymes for breakdown of fat and starch, and is involved in nitrogen recycling to the rumen. Saliva's most important function is to buffer pH levels in the reticulum and rumen. A mature cow produces up to 50 quarts of saliva per day, but this varies depending on the amount of time spent chewing feed, as that stimulates saliva production.

Forage and feed mixes with saliva containing sodium, potassium, phosphate, bicarbonate, and urea when consumed to form a bolus. That bolus then moves from the mouth to the reticulum through a tube-like passage called the esophagus. Muscle contractions and pressure differences carry these substances down the esophagus to the reticulum.

Ruminants eat rapidly, swallowing much of their feedstuffs without chewing them sufficiently (< 1.5 inches). The esophagus functions bi-directionally in ruminants allowing them to regurgitate their cud for further chewing, if necessary. The process of rumination or “chewing the cud” is when forage and other feedstuffs are forced back to the mouth for further chewing and mixing with saliva. This cud is then reswallowed and passed into the reticulum. Then the solid portion slowly moves into the rumen for fermentation while most of the liquid portion rapidly moves from the reticulorumen into the omasum and then abomasum. The solid portion left behind in the rumen typically remains for up to 48 hours and forms a dense mat in the rumen where microbes can use the fibrous feedstuffs to make precursors for energy.

True ruminants such as cattle have one stomach with four compartments: the rumen, reticulum, omasum, and abomasum. The ruminant stomach occupies almost 75 percent of the abdominal cavity, filling nearly all of the left side and extending significantly into the right side. The rumen is the largest stomach compartment, holding up to 40 gallons in a mature cow. The reticulum holds approximately 5 gallons in the mature cow. Typically, the rumen and reticulum are considered one organ because they have similar functions and are only separated by a small muscular fold of tissue. They are collectively referred to as the reticulorumen. The omasum and abomasum hold up to 15 and 7 gallons, respectively, in the mature cow.

The reticulorumen is home to a population of microorganisms (microbes or “rumen bugs”) that include bacteria, protozoa, and fungi. The purpose of these microbes is to ferment and break down plant cell walls into their carbohydrate fractions and produce volatile fatty acids (VFAs) from these carbohydrates. These VFAs are later used by the animal for energy.

The reticulum is called the “honeycomb” because of the honeycomb appearance of its lining. It sits underneath and towards the front of the rumen lying against the diaphragm. Ingesta flow freely between the reticulum and rumen. The main function of the reticulum is to collect smaller digesta particles and move them into the omasum while the larger particles remain in the rumen for further digestion.

The reticulum also traps and collects heavy/dense objects consumed by the animal. When a nail, wire, or other sharp heavy object is consumed by a ruminant, it is very likely that the object will be caught in the reticulum. During normal digestive tract contractions this object can penetrate the reticulum wall, and make its way to the heart, where it can lead to hardware disease. The reticulum is sometimes referred to as the “hardware stomach”.

The rumen is sometimes called the “paunch”. It is lined with papillae for nutrient absorption and divided by muscular pillars into sacs. The rumen acts as a fermentation vat by hosting microbial fermentation. About 50 to 65 percent of starch and soluble sugar consumed is digested in the rumen. Rumen microorganisms (primarily bacteria) digest cellulose from plant cell walls, digest complex starch, synthesize protein from non-protein nitrogen, and synthesize B vitamins and vitamin K. Rumen pH typically ranges from 6.5 to 6.8. The rumen environment is anaerobic (without oxygen). Gases

produced in the rumen include carbon dioxide, methane, and hydrogen sulfide. The gas fraction rises to the top of the rumen above the liquid fraction.

The omasum is spherical in shape and connected to the reticulum by a short tunnel. It is called the “many piles” or the “butcher’s bible” in reference to the many folds or leaves which resemble pages of a book. These folds increase the surface area, which increases the area that absorbs nutrients from the feed and water. Water absorption occurs in the omasum. Cattle have a highly developed, large omasum.

The abomasum is the “true stomach” of a ruminant. It is the compartment that is most similar to a stomach in a non-ruminant. The abomasum produces hydrochloric acid and digestive enzymes such as pepsin (breaks down proteins) and receives digestive enzymes secreted from the pancreas such as pancreatic lipase (breaks down fats). These secretions help prepare proteins for absorption in the intestines. The pH in the abomasum generally ranges from 3.5 to 4.0. The abomasum secretes mucous to protect the its wall from acid damage.

The small and large intestines follow the abomasum as further sites of nutrient absorption. The small intestine is a tube up to 150 feet long with a 20-gallon capacity in a mature cow. Digesta entering the small intestine mix with secretions from the pancreas and liver which elevate the pH from 2.5 to between 7 and 8. This higher pH is needed for enzymes in the small intestine to work properly. Bile from the gall bladder is secreted into the first section of the small intestine to aid in digestion. Active nutrient absorption occurs throughout the small intestine including rumen bypass protein absorption. The intestinal wall contains numerous "finger-like" projections called villi that increase intestinal surface area to aid in nutrient absorption. Muscular contractions aid in mixing digesta and moving it to the next section.

The large intestine functions to absorb water from material passing through it and then to excrete the remaining material as feces from the rectum. The cecum is a large blind pouch at the beginning of the large intestine that serves little function in a ruminant, unlike its role in horses. The colon is the site of most of the water absorption in the large intestine.

Immature ruminants such as young, growing calves from birth to about 2 to 3 months of age are functionally non-ruminants. The reticular (esophageal) groove present in these young animals is formed by muscular folds of the reticulum. It shunts milk directly to the omasum and then abomasum, bypassing the reticulorumen. The rumen in these animals must be inoculated with rumen microorganisms. This is thought to be accomplished through mature ruminants licking calves and environmental contact with these microorganisms.

Immature ruminants must undergo reticulorumen-omasal growth including increases in volume and muscle. Rumen papillae (sites of nutrient absorption) lengthen and decrease in numbers as part of rumen development. Because immature ruminants do not have a functional rumen, feeding recommendations differ for developing ruminants compared with adult ruminants. For instance, it is recommended immature ruminants

are not allowed access to feeds containing non-protein nitrogen such as urea. Developing ruminants are also more sensitive to gossypol and dietary fat levels than mature ruminants. Design nutritional programs for ruminants considering animal age.

For more information about beef cattle production, contact an office of the Mississippi State University Extension Service.