INTRODUCTION

Ruminants are grazing animals that possess a four-chambered polygastric stomach enabling them to digest plant forages and concentrates. Some example species would include cattle, sheep, goats, deer, giraffes and camels. The unique digestive system common to these animals is capable of breaking down plant proteins and carbohydrates which are indigestible to monogastrics. The digestive process is achieved through microbial fermentation and cud-chewing, or the process of “rumination”. This chapter will discuss the anatomy and function of rumination with respect to the bovine gastrointestinal tract.

OVERVIEW OF ANATOMY

Cows are perhaps the easiest of all ruminants to study because of their size and the significant amount of research that has been done on the bovine species. Throughout this chapter, reference will therefore be made to the cow. However, it should be noted that the principles of the ruminant stomach apply to all of the grazing animals previously listed. In order to understand the process of how the digestive system works, it is crucial to understand the anatomy and of the four stomach chambers (Figure 1). In order, ingesta passes through:

A. The Rumen
B. The Reticulum
C. The Omasum
D. The Abomasum

Figure 1: Anatomy of the Ruminant Stomach
Rumen

Once feed enters the body through the esophagus, it passes into the rumen (Figure 2). By far, the rumen is the largest stomach compartment with a total capacity of up to 40 gallons. It is primarily adapted for fiber digestion, and serves as a giant fermentation vat. This compartment is divided into several sacs lined with tiny finger-like projections called papillae, which resemble the texture of shag carpet. The papillae serve to significantly increase the surface area (3,000-6000%) for improved absorption of volatile fatty acids that are produced by the microbes.

Ruminants rely heavily on a host of bacteria and protozoa. The symbiotic relationship between these microbes and the cow is essential for rumen health, as the acetate, butyrate, and propionate that the microbes produce are responsible for 70-80% of the cow’s energy. However, too much of these acids causes rumen pH to drop. If it falls below ~5.5 the acidic conditions can have devastating effects on the microbes and cause sickness to the animal. Because maintaining rumen pH is critical for a cow’s health, cows have evolved the ability to secrete up to 30 gallons of sodium bicarbonate-containing saliva per day to act as a buffer for maintaining relatively a neutral rumen pH.

Often referred to as the “powerhouse” or “engine” of the cow, the rumen and its microbes are the most important considerations when meeting the nutritional demands of cattle. Time spent ruminating is directly correlated to increased milk production. Lactating cows spend an average of 12 hours a day chewing their cud, which is accomplished with the help of the reticulum.

Figure 2: The Rumen

Papillae in the rumen absorb 3000-6000% more volatile fatty acids, which contribute to three quarters of the cow’s energy needs.
RETICULUM

After rumination, the dense ingesta that has been thoroughly chewed accumulates in the reticulum (Figure 3). The main function of this compartment is to aid in the regurgitation of less dense feed, and to collect denser feed for further processing in the rest of the digestive tract.

The reticulum is located close to the heart, and is frequently forgotten when feeding cows out on pasture. Pastured grazers often have tendencies to eat barbed wire or other dense objects from broken farm equipment that they find in the field. Consuming sharp pieces of metal can puncture the reticulum and pin it to the abdominal wall or the heart, causing a problem known as “hardware disease”. This can be fatal to the cow if she is not fed magnets or promptly operated on by a veterinarian.

Due to its close association with the rumen, the reticulum is considered by some to be another one of the rumen lobes, and is jointly referred to as the “reticulo-rumen”. The reticulum similarly contains tiny absorptive projections, which are arranged in a characteristic honeycomb pattern. Once the reticulum is full of completely ruminated feed, it uses the honeycomb pattern as traction to propel the ingesta to the omasum.
OMASUM

Once in the omasum (Figure 4), the ingesta loses massive amounts of water as it is absorbed throughout the numerous folds of the omasum. The folds function very similarly to the papillae in the rumen, but resemble the pages of a book. They provide an enormous surface area, accounting for approximately one third of all the absorptive area in the fore-stomachs. Since it only contains the dense feed that has been passed to it from the reticulum, the omasum is a very firm stomach compartment. While ingesta still resembles feed entering the omasum, it becomes noticeably dry upon exiting to the abomasum.

The omasal folds account for nearly one-third of the forestomach surface area and water absorption capacity.
ABOMASUM

The abomasum is the fourth and final chamber of the ruminant stomach that serves as the intermediary between the omasum and the intestines (Figure 5). This chamber has a smooth glandular lining that secretes gastric acids for the breakdown of remaining digesta. Digestive enzymes and hydrochloric acid from the abomasum are particularly necessary for breaking down rumen undegradable protein into amino acids for absorption in the small intestine. As the dry matter exits from the omasum and is attacked by the abomasal secretions, it finally begins to liquefy and resemble manure rather than a part of the diet.

The harsh acidic environment of the abomasum most closely resembles the stomachs of monogastrics. However, it is still incapable of digesting cellulose and hemicellulose, the two primary plant components that are exclusively digestible by the rumen microbes. During the Irish Potato Famine in the mid-1800’s many people attempted to graze with animals to combat starvation. Since humans do not have a rumen or a symbiotic microbial population, their efforts were futile. Many died of sickness and famine.
In this chapter, we have learned why ruminants are capable of digesting plant material more efficiently than monogastrics. Ruminants thrive off of volatile fatty acids produced by a large microbial population in the rumen. Here, feed is partially chewed, ingested and fermented. The reticulum aides the cow in cud-chewing to repeat the process, and passes more digested matter down to the omasum for extensive water absorption. After the feed has been dried, the abomasum decomposes the remaining matter into feces, which is passed into the intestines for expulsion from the body. Figure 6 illustrates this entire process. Unlike single stomached animals, the four-chambered stomach of the cow allows plant carbohydrates to be broken down and digested for metabolic energy and milk production. Thus, without a healthy bacterial symbiosis it is impossible for any animal to graze.
CHAPTER REFERENCES


