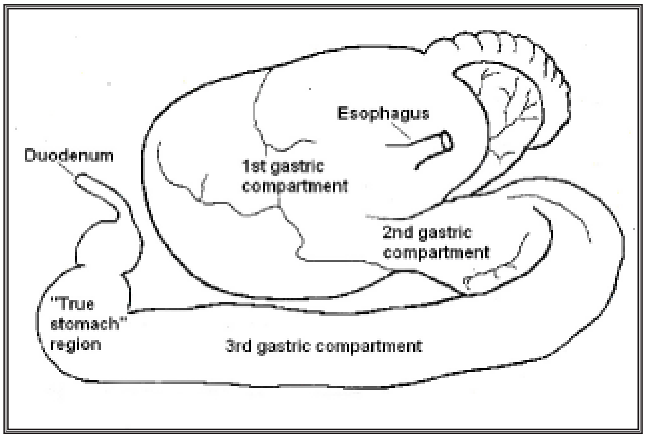
Ruminants vs. Pseudo-ruminants vs. Equines: The Stomach, Part II

By: Lark Burnham, PhD

All mammals lack the enzymes necessary to degrade roughage, or fibrous material. In their place, mammals have evolved a symbiotic relationship with microorganisms that degrade, or "ferment" fiber. Although all mammals rely on microbial fermentation to some extent, none depend on it more than herbivores. This relationship is taken to the extreme in ruminants and pseudo-ruminants. These herbivores have evolved compartmentalized stomachs that are specifically designed to promote microbial fermentation.

The bovine stomach is said to contain four compartments — rumen, reticulum, omasum, and abomasum. In reality, cattle only have three compartments, the reticulum is just an area of the voluminous first compartment, which is generally referred to as the reticulo-rumen. Alpacas and llamas also have stomachs with three compartments, conveniently labeled the first, second, and third gastric compartments (C1, C2, and C3, respectively).

In both bovines and camelids, the first, and largest, compartment is the primary fermentation chamber (reticulo-rumen and C1, respectively). There are a number of requirements for productive microbial fermentation:



1. An aqueous environment - microorganisms, nutrients and end-products all float in a large quantity of water. Water facilitates the two conditions outlined below.
2. Movement of nutrients and end-products - because most rumen microorganisms are either attached or otherwise non-motile, nutrients must be brought to them, and end-products of fermentation carried away.
3. Maintenance of temperature and pH within a narrow range - this requirement is very important because fermentation generates heat, and the end-products, volatile fatty acids, or VFA, are acidic. Both generated heat and VFA must be continuously removed or energy production will be curtailed or cease altogether.

Fermentation is promoted by frequent and thorough mixing of rumen/C1 contents. This is accomplished by sequential waves of contractions by muscles in the walls of these compartments. Fermentation products, predominantly the VFA acetic, propionic, and butyric acids, are carried to the rumen/C1 walls, where they are absorbed into the bloodstream. In cattle, absorption is facilitated by finger-like projections, or papillae, that cover the interior of the rumen. Papillae greatly increase surface area to maximize prompt VFA absorption. Camelids lack papillae. A fretwork of veins covers the walls of the rumen and C1. These blood vessels transport VFA to the liver, where they are converted to energy.

Digesta is concentrated as it moves from the primary fermentation chamber towards the small intestine. Water is removed in all compartments except the bovine abomasum and the last 1/5 of the third gastric compartment (C3) in camelids. In cattle, water removal is the priority of the omasum, a muscular compartment that literally squeezes out excess liquid. This water is then either recycled or excreted. In the process, digesta is compressed and particle size further reduced.

The final stomach compartment in the bovine, the abomasum, and the last fifth of C3 in camelids, is known as the "true" or secretory stomach. As in the equine and nonruminant stomach, hydrochloric acid is secreted by cells in the stomach walls. Hydrochloric acid further degrades whatever material manages to escape rumination (regurgitation and re-chewing) and bacterial fermentation. This promotes maximum nutrient extraction in the small intestine, which will be covered in the next installment.

Although the rumen and C1 are the primary fermentation chambers in cattle and camelids, respectively, fermentation continues throughout the stomach complex. Fermentation slows down considerably as digesta passes through either the abomasum or end of C3, since both water removal and acid secretion reduces microbial activity.

Ruminants and pseudo-ruminants have evolved both a dependency on microorganisms which can degrade fibrous materials, as well as compartmentalized stomachs that promote fermentation. We will see that other nonruminant species, including equines, have evolved analogous adaptations, but in the hindgut.

About the author:

Lark Burnham received a B.S. in Animal Science (1979), from Kansas State University and a M.S. in non-ruminant nutrition (1995) from Kansas State University, Manhattan, and a Ph.D Doctorate in ruminant nutrition (2004) from Texas Tech University, Lubbock. Her special interests are comparative nutrition, the role of the micro flora in all mammels, fiber digestion, and probiotics. Lark currently works for Natur's Way. Inc., Horton, KS, which produces MSE probiotics.