Digestion

As members of the order Ruminata, deer have a kinship with all other animals that chew their cud, such as cattle and sheep. The similarities in anatomy and morphology of the digestive systems of ruminants are much greater than their differences. For this reason, it was once thought that deer could be raised and maintained on hay and grain. This basic misconception has often led game managers, sportsmen, and landowners astray in the management of habitat and the supplemental feeding of deer, including food plots.

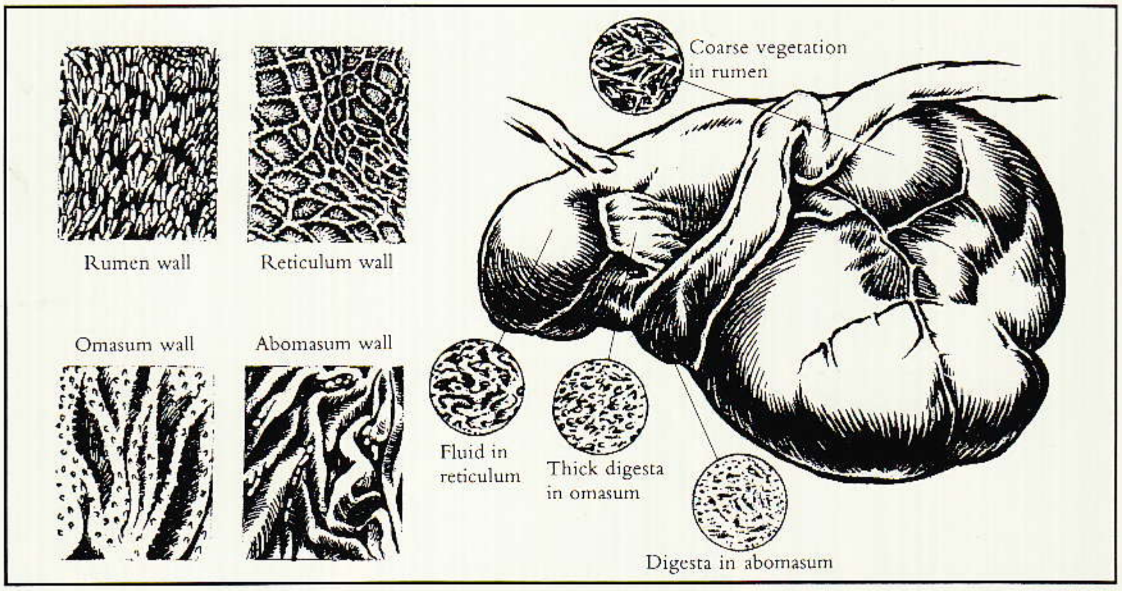
The Digestive System

When a ruminant eats, its food is actually digested–prepared for absorption–by four means. During mechanical digestion, plant parts are broken down into smaller particles by chewing and mixing. In chemical digestion, hydrochloric acid in the stomach dissolves plant particles. During enzymatic and microbial digestion, enzymes and microbes break the chemical bonds of larger compounds, such as starch or protein, to produce smaller nutrients, such as glucose or amino acids, which can be absorbed directly into the bloodstream. These enzymes are produced by the walls of the small intestine, the pancreas, and also by microbes in the digestive tract.

As a deer eats, it chews its food only enough to allow swallowing. While being chewed, the often dry and fibrous food mixes with saliva, which helps it pass more smoothly down the esophagus. Saliva production is impressive in ruminants, reaching levels of several gallons a day in large animals, and several quarts a day in small ones. From the esophagus the food passes through a valve and into the first of the stomach's four compartments–the rumen.

The rumen is where the main digestive process takes place. Here the food is mixed further with other rumen contents, especially microbes (bacteria and protozoa) and more saliva. Buffers in the saliva help keep the rumen from becoming too acidic. Microbes attack the food particles, breaking them down into nutrients, some of which are absorbed directly; others are digested more fully farther down the tract. The rumen is lined with papillae, small fingerlike projections that increase surface area for absorption. The fermentation process, that is, the breakdown of food in the rumen by enzymes produced by bacteria and protozoa, is the main difference between ruminants and monogastric, or simple-stomached, animals.

As food is digested, it circulates through the second compartment of the stomach–the reticulum, a heavily muscled chamber at the front of the rumen. Often called the "honeycomb" because of its many folds, the reticulum helps send boluses of food back up the esophagus for cud chewing. Depending on how fibrous the food is, it may stay in the rumen for a few hours or for a few days before being passed along to the next chamber of the stomach.



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In the rumen, microbes ferment the deer's food. The strong muscles of the reticulum roll the fermented mass into a bolus and send it back up the esophagus for further chewing. After passing back through the rumen, the food enters the omasum, which pumps the moisture out. Finally, in the abomasum, the digesta are bathed in acids that break down the food particles for absorption through the walls of the small intestine.

The third compartment, the omasum, serves as a pump to move the more fluid contents of the rumen farther down the tract. It is heavily muscled and has large leaves, like the pages of a book. As the rumen contents pass through the omasum, much of the water is absorbed.

The abomasum, or fourth stomach, is the deer's true stomach. This chamber is nearly identical to the stomach of monogastric animals, although the food entering the abomasum has been fermented. The hydrochloric acid produced here chemically dissolves food particles. The enzymes pepsin and rennin are released to aid in the digestion of proteins, including microbes that came along from the rumen.

Once the contents, called digesta, pass into the small intestine, enzymes from the intestinal walls or the pancreas help to digest simple sugars, peptides, and lipids. The acid from the abomasum is neutralized so that the enzymes can work. Although deer (with the exception of the musk deer) have no gall bladder in which to store bile, they nonetheless produce bile in the liver to help emulsify fats in the intestine. The small intestine's main function is to absorb into the bloodstream the many nutrients from the food that has been digested.

From the small intestine, the digesta passes into the large intestine, or colon, where more water is absorbed. Some enzymatic digestion continues to occur here, and microbial digestion may continue as well. Most animals have an outcropping of the intestinal tract called a cecum, where microbial digestion can occur, but this varies greatly among species.

Benefits of Rumination

Ecologists have long argued the advantages of the ruminant's digestive system. Some have suggested, for instance, that even though deer may be below carnivores in the food chain, these ruminants may really have a higher niche in that they can convert foods that are not usable by "higher order" animals. The main advantage of the deer's digestive process is that it can digest cellulose and hemicellulose, the complex carbohydrates found in browse, grass, and other fibrous foods. Monogastric animals, such as humans, pigs, and dogs, lack the enzymes needed to break the bonds of these nutrients. Actually, ruminants themselves do not have the enzymes, either, but their rumen microbes do.

During the fermentation process, cellulose, along with sugars and starches, is broken down in the rumen into simple sugars, then fermented into compounds known as volatile fatty acids (VFAs). These are very small and can be absorbed right through the rumen wall. The deer uses these VFAs for energy and converts some of them back to sugars or fats for storage or for milk.

Another advantage the ruminant has is that its rumen microbes can actually produce protein. When a deer's diet lacks highquality proteins, for example, the microbes can simply create them using whatever amino acids and other nitrogen are available. Monogastric animals do not share this ability. Of the twenty amino acids that make up proteins, about half are not manufactured in the monogastric body and have to be provided through diet; thus, protein quality depends on how many of these essential amino acids are present in the food. These animals must take in protein not only in sufficient quantity, but also of appropriate quality. Ruminants, on the other hand, need be concerned with only the quantity of protein in their diet; their rumen microbes can compensate for deficiencies of quality.

In this process, plant protein coming into the rumen is digested by the microbes first into peptides, then into amino acids, and finally into ammonia. From this the microbes build new proteins, largely in the form of new bacteria and protozoa. These apparently have about the right mix of amino acids needed by the animal because they are digested in the abomasum and absorbed in the small intestine. Thus, the deer has no need for essential amino acids–it makes its own. In addition, ruminants can use nonprotein nitrogen to make new protein. Whereas humans eliminate excess nitrogen from their bodies via urine, deer recycle urea back through the saliva into the rumen, allowing the microbes another chance to make new protein. Deer are also able to produce vitamins B and K in their digestive tracts and therefore have no need for these vitamins in their diets.

The above system is not perfect, though, as we now know. In some ruminants, such as dairy cattle, the microbes do not always produce the very best mix of amino acids. This has not been studied in deer, however.

There is one other advantage to the rumination process. Since deer are often the prey of carnivores, it is to their advantage not to expose themselves for long periods while grazing or browsing. If they had to chew their food completely as they consumed it, they would spend most of the day in this activity. As it is, deer can simply select what they want to eat, chew it just enough to get it down, then retire somewhere safe and hidden where they can regurgitate the food and chew their cuds. Hence their exposure to enemies while feeding is minimized.

Diet

There are forty-one species of deer, and we now know that there are some subtle and some not-so-subtle differences among these species in their ability to digest their food. Evolutionists disagree as to whether different diets led to these differences in the morphology of the deer species' digestive tracts or whether the deer choose different diets because their digestive tracts differ.

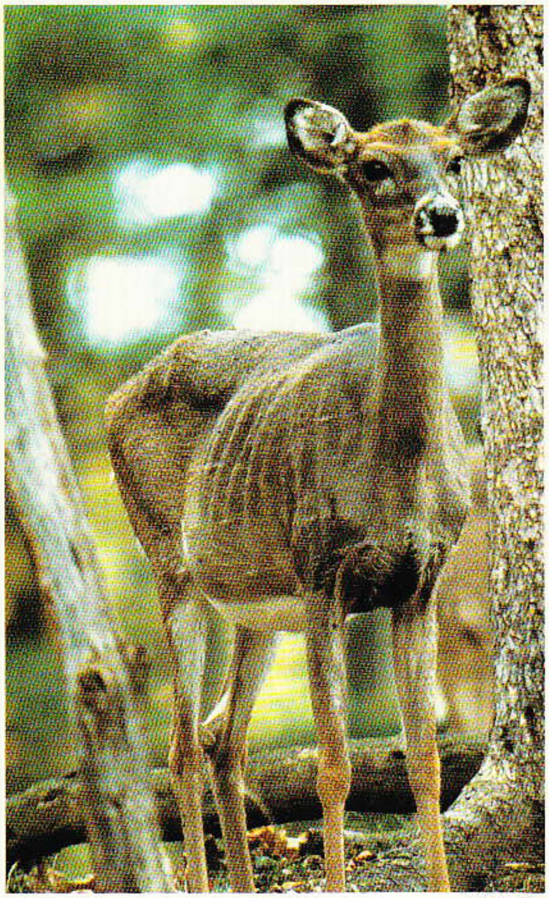
Hofmann of Germany has classified all ruminants into three types: grass or roughage eaters (grazers), intermediate feeders (adaptable mixed feeders), and concentrate selectors (browsers). Grazers, such as cattle, have very large rumens and a slow rate of passage of their digesta, which allows time for the microbes to act. Most deer tend to fall into the intermediate category; they are opportunistic, mixed feeders that will browse when they can but will graze when necessary. In general, they have rumens that are smaller in proportion to their body weight than do grazers, and they have larger salivary glands to help neutralize their more acidic diet. Controlled studies have shown that deer are often less efficient than cattle and sheep at digesting low-quality forages. The domestication of red, axis, and fallow deer, however, shows that they can be raised on pastures.

Some deer species, such as white-tailed and mule deer, are concentrate selectors. They have even smaller rumens and larger salivary glands. They must be highly selective, choosing browse that is easily digested. They must also feed more frequently, since digesta passes through their digestive tracts more quickly. There seems to be a relation-

SMITH

Deer are concentrate rather than bulk feeders: they select the most nutritious plant parts available instead of consuming vast amounts of less digestible food. In the Northwest the Coues whitetail may resort to evergreen forage for the winter.

The rumen's microbes – essential for digestion – adapt to the deer's diet. When a deer accustomed to twigs and other starvation food is fed corn and hay, the rumen needs several weeks to adjust; meanwhile, the deer starves with its stomach full.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ship here between body size and feeding strategy, since large cattle graze, large deer are mixed feeders, and smaller deer are opportunistic. The anomaly is the moose, which most certainly is a concentrate selector, despite being the largest of living cervids. These differences in digestive tract anatomy and feeding strategies have implications for managing deer habitat or supplemental feeding. For example, food plants or supplemental foods for white-tailed or mule deer should be more digestible than those intended for axis deer or elk.

Harmel's studies in Texas illustrate the differences in food habits between two deer species. Six whitetails and six sika deer were put in a fenced rangeland pasture. In nine years, the sika deer population increased to sixty-four. The whitetails increased to a total population of nineteen, then they died out completely. No doubt there was an overpopulation of deer in the pasture, and when droughts hit, the adaptable sika deer were able to survive on a lower-quality, higher-fiber diet; the concentrate-selecting whitetails could not.

The digestive tract of whitetails and mule deer can change with diet, but it does so gradually. Saliva production, papilla development, and rumen size change with the seasons to adjust to fibrous winter diets or the more luscious foods of the spring greenup. Reports abound of well-meaning but ill-fated efforts to save starving deer in North America in the winter. Uninformed sportsmen and landowners often put out corn or hay for deer to get them through the winter. But it takes two to three weeks for rumen microbes to completely adjust to a new diet. Thus, deer adapted to a winter diet of highly fibrous food will die of acidosis – a buildup of lactic acid in the rumen – if they overconsume grain.

Remarkably, deer need little food in the winter, and in fact, they voluntarily reduce their food consumption and lose 20 percent or more of their body weight by using their fat stores. This is because deer have evolved to withstand the stresses of feed restriction in the winter. In fact, Hershberger and Cushwa found in Pennsylvania that deer can survive at least a month with no food at all! On occasion, supplemental hay is put out too late, and deer overeat when their rumen microbes are not present in sufficient quantities to digest the hay. Those deer can starve to death with their rumens full.

Deer also face the problem of lignin. The substance that makes woody browse woody, it is present in many deer foods, especially winter ones. Not only is it indigestible, but it can make other nutrients in the food less digestible by binding to them. And secondary plant compounds such as tannins and other phenolics can make both protein and cellulose less digestible.

The ability of deer and other ruminants to utilize natural forage and browse is an ecological advantage. Some species of deer can be domesticated, as deer farmers in Europe, New Zealand, and North America have proven. But efforts to treat deer in the wild as though they were cattle, by excessive supplemental feeding, diminishes the place of deer in our lives and culture and also may leave them vulnerable to the predation, disease, and nutritional inadequacies that they have become adapted to avoid.

– Robert D. Brown