

Popular Article

Microbes of Rumen

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Introduction

Ruminant livestock have a unique digestive system that allows them to use energy from fibrous plant material better than other herbivores. Ruminant livestock include cattle, sheep, goats, etc. Unlike monogastric animals, ruminants have a digestive system designed to ferment feedstuffs and provide precursors for energy for the animals to use. Thus an understanding of ruminal microflora, enable livestock producers to care for and feed ruminant animals in a better way.

Ruminal microbes

The rumino-reticulum and omasum complexes are characterized by an anaerobic environment. The constant temperature of about 40° C, the buffering system that keeps the pH near neutral, and the microenvironment are ideal for the development of anaerobic bacteria, fungi, and protozoa. Despite digestion of food mixed with oxygen-containing air and materials, the redox potentials of the rumino-reticulum contents are held at a strong reducing level by the activity of these microorganisms.

A newborn animal acquires an inoculum for its rumino-reticulum by licking its mother and other members of the herd. The various substances for microbial growth are provided by the feed. The various microbial species differ in their ability to utilize these substrates and to compete for them. Special growth-promoting and growth-inhibiting factors are present in the rumino-reticulum media. In addition, the rumination and eructation cycles influence microbial growth by macromixing and soaking ingesta, by grinding coarse media, by removing gases (notably carbon dioxide and methane), by removing end-products through mucosal absorption, and by propelling indigestible materials onward. The gas bubbles formed during fermentation as well as the movements of the microbes themselves also contribute to important mixing of the ingesta. A predator-prey relationship exists between certain protozoal species and between many protozoa and bacteria.

Rumen microbes use carbohydrates along with ammonia and amino acids to grow. The microbes ferment sugars to produce VFAs (acetate, propionate, and butyrate), methane, hydrogen sulfide, and carbon dioxide. The VFAs are then

absorbed across the rumen wall, where they go to the liver for metabolism.

Rumen bacteria

Bacteria are the most abundant microbes in the foregut of ruminant animals, with approximately $10^{10} - 10^{11}$ cells/ml and over 200 species. The composition of the bacteria found in the rumen is dictated by a number of factors including preference for certain substrates (i.e. diet), energy requirements, and resistance to certain metabolic end-products that may be toxic to some species. The rumen bacterial composition is mainly Gram negative when animals are being fed high forage diets, with more Gram positive bacteria, such as *Lactobacillus*, present in animals fed high grain diets, with ruminal pH levels dropping after the consumption of easily fermented carbohydrates.

Ciliate protozoa

Ciliate protozoa are found in the range of $10^4 - 10^6$ cells/ml in rumen fluid and are responsible for 30 to 40% of overall fiber digestion. They are also relatively active in lipid hydrolysis and can produce hydrogen via their hydrosomes. The *Entodinium* genus is the most dominant protozoan in high grain diets. This genus rapidly degrades starch, engulfing it and converting it to an iodophilic storage polymer. Degradation occurs through a combination of debranching, amylase and glucosidase enzymes. More research may be needed in order to determine their immediate role in methanogenesis and therefore create a better understanding of the value of manipulating this population as a means of reducing methane emissions in ruminants.

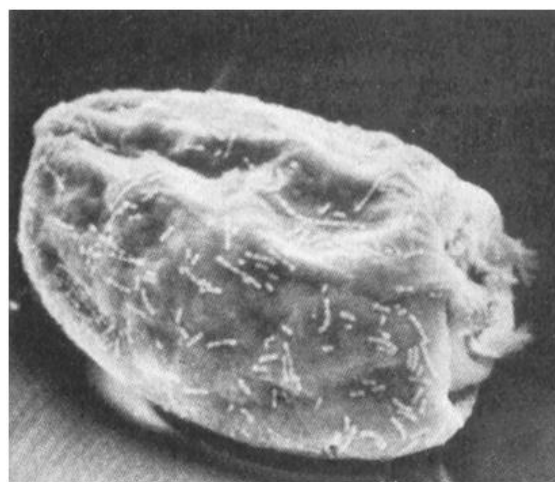


Fig. Scanning electron micrograph of *Diplodinium anisacanthum* protozoa with attached bacteria (Ogimoto and Imai, 1981).

Fungi

Rumen fungi are anaerobic and their number in rumen is $10^3 - 10^6$ zoospores/ml. It has been proposed that these fungi evolved through horizontal transfer of genes from bacteria. Anaerobic fungi may influence the rest of the microbial community as they produce H_2 during initial degradation of plant tissue and it can be used as fuel for the degradation mechanisms of other communities. Fungi colonize plant cell walls and account for approximately 8–12% of total microbial biomass in the rumen, but this figure varies widely depending on diet. Although bacteria are the most prominent microorganisms in the rumen, fungi are the best degraders. They produce high levels of cellulases and hemicellulases, as well as possessing the ability to break down xylan due to the production of xylanases.

Microbial interactions

Microbiotas are symbiotic with all macroorganisms. The growth, development, and health of macroorganisms are affected by microbes in their environment that

determine the physiology, behavior, ecology, and evolution of the host. Biology is undergoing a paradigm shift, and individual phenotypes are now regarded as the result of interactions between the host genome and related microbiome. The mammalian digestive system is colonized by complex microorganisms, including bacteria, archaea, fungi, and protozoa, which play an important role in diet fermentation and host energy supply. There is a strong symbiotic relationship between animal gut microbiota and the host, which helps the host digest and assimilate food, and thereby provides energy and nutrition to the host. For example, intestinal microorganisms can aid the decomposition of cellulose, hemicellulose, and other non-digestible substances in the host, so that these compounds can be utilized by the host. The rumen epithelium is a unique location for host-microorganism interactions, and these interactions can affect the net use of nutrients by the host. The availability of food, nutrient intake patterns of animals, and geographical resources change with time and season. Different food sources or geographical environments have significant effects on microbial composition in the host gut.

The rumen can be viewed as an anaerobic and methanogenic fermentation chamber that contains microorganisms that have the ability to utilise, and increase the productivity of, cellulolytic feeds (i.e. straw, hay, silage and grass). There are considerable benefits associated with understanding rumen function, as rumen dynamics are almost solely responsible for providing nutrients to the host animal. As a result of fermenting feedstuffs, carbon dioxide (CO₂) and hydrogen (H₂), which are the main electron acceptors and donors

of the ecosystem, are produced in the rumen. The rumen microbiome, i.e., the community of microorganisms that inhabits the rumen, is characterized by its high population density, extensive diversity (encompassing bacteria, archaea, protozoa and fungi) and complexity of interactions. The continuous fermentation carried out by these microorganisms leads to ingested compounds being broken down into their subcomponents. There are three intersecting micro-environments found in the rumen that contain these microbes; the liquid phase making up 25% of the microbial mass, the solid phase making up 70% of the microbial mass, and the rumen epithelial cells and protozoa, containing 5% of the microbial mass. A nutritionally balanced diet is important as it provides an environment that maximises the growth and activity of these microbes. A rumen microorganism is anaerobic or facultatively anaerobic, and produces end products that are either utilised directly by the host or by other microorganisms as energy. The pH of the rumen is kept relatively constant, typically 6–7, but may vary depending on diet. Such variations can result in a change in the microbial populations, and the levels of volatile fatty acids (VFAs) produced by them. Buffering of the rumen to maintain a relatively constant pH is facilitated by the large quantity of saliva produced by the ruminant, which is high in sodium and potassium bicarbonate and urea. The saliva is swallowed into the rumen and then absorbed through the rumen walls. Further buffering is provided by ammonia produced during fermentation, which can then be used for microbial growth in the rumen.

Conclusion

The digestive system of ruminants

optimizes use of rumen microbe fermentation products. This adaptation lets ruminants use resources (such as high-fiber forage) that cannot be used by or are not available to other animals. Ruminants are in a unique position of being able to use such resources that are not in demand by humans but in turn provide man with a vital food source.