Microbial ecology of the rumen: impact on nutrition and the environment

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Ruminal microbiology.
The rumen is the first stomach of cattle, sheep and goats. All digestion in this organ is carried out by a microbial population that consists of ciliate protozoa, anaerobic eubacteria, anaerobic fungi and methanogenic archaea. The bacteria are genetically very diverse, deriving from many different origins, whereas the protozoa are monophyletic, thought to have evolved from a symbiotic protozoan which established in the rumen 30 - 40 million years ago. The fungi have several morphotypes, but these are very closely related to each other. Fungi are associated with fibrous materials in the rumen and are therefore difficult to see in the mixed community. The archaea are almost as diverse as the eubacteria, using H_2 and CO_2 to form methane. This mixture of organisms combines to digest the food, and it is the products of microbial digestion which form the nutrients that become available to the ruminant animal itself.

Impact on nutrition.
Fibre is digested incompletely by ruminal microorganisms: increasing its digestion would improve productivity. Proteolysis destroys high quality protein in the feed and should be slowed if high-protein diets are to be used efficiently. Protozoal activity is detrimental to the efficiency of microbial protein synthesis, by breaking down bacteria and introducing a cycle of turnover of microbial protein. Bloat and acidosis are distressing disorders which result from malfunction of microbial digestion in the rumen.

Impact on the environment.
Methane is a potent greenhouse gas and ruminant methane emissions are a small, but significant, contributer to global warming. Possible methods for decreasing methane emissions include the use of plant-based feed additives. Excessive protein breakdown results in the loss of ammonia across the rumen wall, which is converted to urinary urea, the excretion of which leads to groundwater pollution and further greenhouse gas emissions in the form of nitrous oxide.