# LOW COST COW/CALF PROGRAM

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## Dank and Dark

It is absolute chaos in there. In the rumen, that is. It is crowded. There is pushing and shoving and murder and mayhem. Occasionally, gangs of one species can be found to cooperate with gangs from other species (cross feeding). Bacteria, protozoa and fungi exist together in the rumen. Estimates of the numbers are all over the place - depending on sampling technique, timing of the sample relative to eating, drinking and cud chewing. The kind of feed (grain/forage) and particle size do change the numbers and the numbers vary from animal to animal. Roughly, there are $10^{10}$ to $50^{10}$ bacteria per gram of rumen fluid. Protozoa are much less numerous but 40 times larger so they occupy about an equal amount of space. The fungi take up about 8% of the space. Collection of a representative sample of rumen microorganisms is not easy. It is not as simple as reaching into the rumen through a fistula, retrieving a cup of fluid, placing a drop on a slide, putting it under a microscope and counting. Tons of the microbes are adhered to the epithelium that lines the rumen wall. Others are attached to feed particles and clusters are found within the feed particles. Bacteria piggyback on the larger protozoa. New bugs are being born continuously. Parallel to this is a continual die-off but not necessarily at the same rate, thus the variation in numbers. A bacterium has a life span of 15 to 20 minutes. After that there will be one dead bacterium or two live bacteria, depending on the rumen environment. Figuratively speaking, the dead ones pass on to the abomasum and small intestine where they are digested; thus, they provide nutrients to the host animal. Protozoa follow a similar life cycle but at a much slower rate, more than 15 to 24 hr.

## The Bacteria

Fermentation (digestion in the absence of oxygen) of carbohydrates terminates in the formation of short-chain fatty acids. The kinds (of fatty acids produced) depend upon the substrate (cellulose/starch) being fermented. The fiber digesters (or cellulolytic) are some of the fussiest bacteria in the rumen. They are very sensitive to pH. They function well when the pH is >6.2. When the pH is <6, they do not perform well at all. The predominant acid produced is acetic ($CH_3COOH$), followed by a lesser amount of propionic acid ($CH_3CH_2COOH$). Even with all-fiber diets, the cellulolytic bacteria seldom make up more than about 25% of the rumen microbial population. Some are susceptible to ionophores. Their speed of reproduction is slow. Starch and sugar-digesting (amylolytic) bacteria make up a significant part of the rumen's population. While they are the predominant species when the diet contains nonstructural carbohydrates, *i.e.* starch and sugar, they also cross-feed off the byproducts produced by the fiber digesters. When starch is fed, the fatty-acid profile shifts to a reduced acetic:propionic acid ratio. Most of the amylolytic bacteria are not sensitive to the ionophores. Their speed of reproduction is much faster than the cellulolytic bacteria.

## Rumen Fungi

The experts don't say much about the fungi. That's probably because there is not much known about them. It has been suggested that they help with fiber digestion by chopping the big pieces into kindling.

## Protozoa

Actually, the rumen functions well without (defaunated) the protozoa. With a sudden shock from a large quantity of starch, resulting in the formation of lactic acid (lactic acidosis), the rumen can be defaunated completely. Some report that, with the continual feeding of grain-rich diets, *i.e.* feedlot, the rumen becomes defaunated - while others say that a few protozoa still hang around. There is a feed additive on the market (an extract from the yucca plant) that is claimed to improve animal performance by defaunation. The rumen protozoa produce the same end-products as do the bacteria, particularly acetic acid and hydrogen. In fact, the methanogenic ($CH_4$) bacteria actually attach to the protozoa for convenient access to the hydrogen. The protozoa eat large amounts of starch and store it in their bodies. This may help in preventing a rapid drop in pH when starch is fed. Protozoa hide out with the fiber particles, particularly in the fibrous mat that floats on top of the rumen fluid. By this means, they can remain in the rumen for a longer period of time. Low-roughage diets reduce the retention of fiber, which can decrease the number of protozoa in the rumen. The protozoa are predators of the bacteria—they eat them for lunch. Unlike the bacteria, the protozoa have a nucleus that contains DNA.

## CLA

Since the development of polymerase chain-reaction (PCR) techniques by geneticists, criminologists, etc. in 1983, the identification of individual genes (and their function in protozoa) has blossomed. Subsequent advances of the technique have resulted in a plethora of studies with rumen protozoa. CLA's are derived from the microbial conversion of dietary linoleic acid in the rumen. Vaccenic acid, a precursor of CLA, also is formed by the rumen microorganisms. Studies have shown that mixed protozoa (that have reached the small intestine) contain two to three times more unsaturated fatty acids than bacteria. Larger species of protozoa contain more than 10 times more CLA and vaccenic acid than do their smaller cousins. The protozoa do not manufacture CLA or vaccenic acid. They obtain them by eating the bacteria that do. The critical role played by the protozoa is the transport of CLA and vaccenic acid to the places where they are available to the animal. Grass-feeding folks everywhere—nurture and pamper those precious protozoa.

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