The animal has a complex biological system comprised of a variety of chemical structures and a community of microorganisms that facilitate the breakdown of plant material. Because of the complexity of this system, it is essential to understand the biology of these microorganisms, the role they play in facilitating nutrient utilisation and their sensitivities to certain compounds that may have either deleterious or beneficial effects on nutrition and health. Investigating these issues using a non-invasive method are Dr Marshall D. Stern and colleagues from the University of Minnesota.

Ruminant Biology

Herbivorous animals such as cattle possess a complex system of microorganisms in the gut which facilitate the breakdown of plant material. Pioneering studies in ruminant microbial ecology and health are being conducted by Dr Marshall D. Stern and Dr Andres M. Gomez from the University of Minnesota. Using a dual flow continuous culture system to mimic in vivo conditions, Dr Stern and Dr Gomez are investigating effects of various compounds on microbial fermentation and ecology using the in vitro system.

Non-Invasive Methods

In vitro models provide a non-invasive way of studying the “the rumen” which is the first compartment of the stomach. Dr Stern and colleagues from the University of Minnesota utilise the continuous culture system to study various factors that affect rumen microbial fermentation and ecology. This in vitro study system is said to mimic in vivo conditions by maintaining microbes in an environment similar to that of the rumen. Conditions such as temperature, pH and digesta
Recently, Dr Stern and his graduate student, Isaac Salfer, and other colleagues examined similarities and differences between bacterial and archaeal communities in the rumen of dairy cattle compared to the in vitro continuous culture system. Previous research using culture systems and oligonucleotide techniques established that some microbial populations in vitro may be maintained at abundances similar to the in vivo conditions in ruminants. By sequencing ribosomal bacterial and archaeal genes, Dr Stern’s laboratory investigated whether microbial communities and their abundances differed between the in vitro and in vivo conditions. Their results showed that while communities differed, the most abundant species were maintained across both study systems. This lends weight to the efficacy of in vitro culture systems for studying rumen conditions in a non-invasive way.

IN VITRO IN ACTION
This continuous culture system enables Dr Stern’s research group to study potentially negative effects of certain compounds on microbial growth and fermentation. One such compound is patulin, a secondary metabolite of toxigenic strains of Penicillium, Aspergillus and Byssochlamys species which are common contaminants of fermented feeds. It is understood that patulin is toxic to many organisms and possesses an antimicrobial effect. In fact, Penicillium-contaminated silage has been found to be associated with hemorrhagic disorders in cattle. With this understanding, Dr Stern and colleagues evaluated the effects of varying concentrations of patulin on microorganisms in the in vitro continuous culture fermenters. Results of this study confirmed that patulin can alter metabolic processes associated with nutrient absorption and disrupt the production of bacterial end-products. Dr Stern and colleagues have postulated that due to the interconnectedness of ruminal microbial populations, these changes could be have come about by direct inhibitory effects of patulin on bacterial growth or through a lack of essential nutrients from an altered food chain. Thus, these alterations may have negative consequences on the health and performance of ruminants such as cattle and sheep.

Using the same fermenter system, Dr Stern and colleagues also investigated the effects of the sulphur binder bismuth subsalicylate (BSS) on the production of hydrogen sulphide gas, H2S. In vitro models provide a non-invasive way of studying the rumen compartment of cattle and sheep.
may require researchers to investigate the effects of other sources of dietary roughage on H2S production.

**FUTURE STUDIES AND IMPLICATIONS**

Studies by Dr Stern and colleagues have examined the detrimental effects of microbial toxins and methods to mitigate harmful gas production. Future studies by Dr Stern and Dr Gomez aim to investigate key components of the rumen system by looking at the effects of enzymes on microbial ecology and nutrition. Using state-of-the-art DNA sequencing and biochemical fingerprinting methods, they are investigating the effect of three enzymes: a beta-glucanase, a protease and a cellulase, on rumen microbial composition and function. Results from their studies will contribute to a better understanding of how the in vitro system can be used to mimic in vivo conditions and thus may have implications for health and efficiency.

This study along with future research will contribute to a wide body of data on rumen microbial communities and thus contribute to the understanding of in vitro and in vivo systems. Dr Stern’s and Dr Gomez’s collaborative research will hopefully inform others on the best ways to improve animal efficiency, performance and health.

**Compared to using animal models, this system is less harmful, less expensive, less time-consuming and more controlled.**
Dr Marshall D. Stern and Dr Andres M. Gomez from the University of Minnesota and their team are interested in how an in vitro dual flow continuous culture system may be used to investigate ruminant microbial ecology. By simulating in vivo conditions through controlled means, Dr Stern and Dr Gomez aim to better understand factors that affect rumen microbial ecology and how best to remedy performance and health issues that ruminants encounter.

**Research Objectives**

Dr Marshall D. Stern and Dr Andres M. Gomez from the University of Minnesota and their team are interested in how an in vitro dual flow continuous culture system may be used to investigate ruminant microbial ecology. By simulating in vivo conditions through controlled means, Dr Stern and Dr Gomez aim to better understand factors that affect rumen microbial ecology and how best to remedy performance and health issues that ruminants encounter.

**Details**

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**Bio**

Morse Alumni Distinguished Professor of Animal Science with expertise in rumen fermentation and microbiology. Research emphasis has been to improve the efficiency of nutrient utilisation by ruminants. Recent research uses continuous culture fermenters to study mycotoxins, reduce gas emissions from the rumen and evaluate factors affecting ruminal microbial ecology using metagenomics.

**Funding**

National Institute of food and agriculture (NIFA)
Title of Project: Impact of Factors that Affect Rumen Microbial Ecology and Fermentation on Protein Supply to the Small Intestine of Ruminant Animals

**Collaborators**

- Dr Martin Ruiz-Moreno
- Dr Ofelia Tapia
- Dr Alex Bach
- Dr Samuel Fessenden
- Dr Abigail Carpenter
- Elizabeth Binversie
- Isaac Salfer
- Dr Tom Jenkins
- Dr Michael Sadowsky
- Dr Christopher Staley
- Dr Alfredo DiCostanzo
- Haley Johnson

**References**


**Personal Response**

**What are the biggest downfalls to using an in vitro system?**

"The biggest downfall is that the microbial community in vitro is not identical to that found in vivo. While many bacterial species may be similar, ciliated protozoa found in the rumen cannot be well maintained in vitro. In spite of this downfall, research from Dr Stern’s laboratory demonstrated similarities in fermentation in vitro and in vivo, indicating that the dual flow continuous culture fermentation system is an excellent “rumen model”."