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Info Note

Model of enteric methane emissions supports climate change mitigation in Colombia's cattle sector

RUMINANT model validated using field measurements

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Key messages

- The RUMINANT model qualifies as an advanced or "*Tier 3*" method for estimating emissions from enteric fermentation in ruminant livestock.
- The RUMINANT model was validated for enteric methane emissions from cattle in the tropical lowlands (Cauca Valley) of Colombia using six different diets given to feeder steers in 2017.
- There was a good **correlation** between field measurements of enteric fermentation using the polytunnel technique and estimates made using the **RUMINANT** model.
- Based on findings from the validation process, **RUMINANT** has been used to improve Colombia's National Greenhouse Gas Inventory to the United Nations Framework Convention on Climate Change (UNFCCC) and the preparation of the sustainable bovine livestock Nationally Appropriate Mitigation Actions (NAMA) information note.
- The RUMINANT model could support the measurement, reporting and verification (MRV) phase of the NDCs of Colombia and other countries.

Introduction

RUMINANT is a model that simulates the digestive and metabolic processes of ruminant livestock. Based on the characteristics of the animal and the quality of the feed available (which must be entered by the model user), RUMINANT models nutritional needs and fermentation kinetics and estimates potential consumption, production of milk and meat, manure, excretion of nitrogen, and methane emissions (Herrero et al. 2013).

In order for the user to have confidence in the predictions of a simulation model, this must be validated—compared against field measurements for the conditions in which is going to be used. Modelers use a variety of statistical techniques to assess the precision and accuracy of a model. Precision refers to the relationship between the modeled values. Accuracy refers to how close the modeled values are to the true value (in this case, the measured value).

RUMINANT has been validated in other countries, and its component models have been validated with a variety of temperate and tropical feed species (Illius and Gofrdon 1991). However, the predictive potential of the model has not been validated until now for the conditions of Colombian pastures and common cattle breeds.

The results of the validation described in this Info Note will contribute to future work aimed at improving the precision of the model as a method of predicting emissions in future greenhouse gas inventories, as an MRV methodology for Colombia's Bovine Livestock NAMA, and as a way to evaluate potential low emissions development strategies for the Colombian cattle sector.

Materials and methods

The study was carried out in a beef cattle fattening system using six diets with a combination of different forage species (Table 1). The diets were offered to 25 Brahman steers (*Bos indicus*) with an approximate weight of 180 kilograms (kg) each, and who also had free-choice availability of mineral salt. Each steer received the same health treatment (vaccination, removal of internal and external parasites).

Enteric methane emissions produced by steers fattened on each diet were measured using the polytunnel methodology. A polytunnel is a large inflatable tent-like tunnel made of heavy duty polyethylene fitted with end walls, in which each compartment is large enough for animals to move freely. In the method, a single steer is housed and fed there for several days. After the animal is accustomed to the tunnel, the air is homogenized with a fan system, sampled at the exhaust port and analyzed for methane concentration regularly, from which the production of methane by the animal is calculated.

Figure 1. Polytunnels used for measuring enteric methane production by steers fed with six different diets.

All of the diets also underwent laboratory analysis to determine the forage quality parameters (such as protein, fat and starch content) that serve as input to the RUMINANT model. Forage quality parameters were entered into the RUMINANT model, from which the estimated methane emissions were obtained (L animal^{-1} day^{-1}).

To assess the performance of the model, the observed and simulated data were compared using the coefficient of determination, mean bias, and adjustment factor Y=X.

Table 1. Feed species and combinations used for the validation of RUMINANT

Diet	Description
Cy	100% Cayman (*Brachiaria* hybrid *cv.* Cayman CIAT BR 02/1752)
T	100% Toledo (*B. brizantha* cv. Toledo CIAT 26110)
CyLd	70% Cayman + 30% *Leucaena diversifolia*
CyLl	70% Cayman + 30% *Leucaena leucocephala*
TLdCa	70% Toledo + 15% *L. diversifolia* + 15% *Canavalia brasiliensis*
EK	70% Stargrass (*Cynodon nlemfuensis)* + 30% Kudzu (*Pueraria phaseoloides*)

Results

In most cases, RUMINANT was able to correctly predict relative differences in enteric methane emissions produced by steers fed with different diets. In field measurements using the polytunnel technique, a feed ration combining Cayman grass with species of *Leucaena* (a legume tree; CyLl-CyLd) produced the highest rates of enteric methane emissions per animal per day, and a combination of stargrass and kudzu (a legume vine; EK) produced the lowest rates of enteric methane emissions per animal per day. Results simulated by the RUMINANT model were similar (Figure 2).

The determination coefficient (R^2), a measure of precision, was 0.7; a perfectly precise model would have a value of 1. The mean bias (average difference between the modeled and measured values, an indicator of accuracy) was 48.1 and the mean difference (observed value / simulated value) was 1.4. Taken together, these results suggest that RUMINANT was **highly precise** and of **medium accuracy,** as it tended to **slightly underestimate** enteric methane emissions when compared to the measured values (Figure 2, Figure 3). The mean difference of 1.4 can be used as a correction factor to adjust for the underestimation.

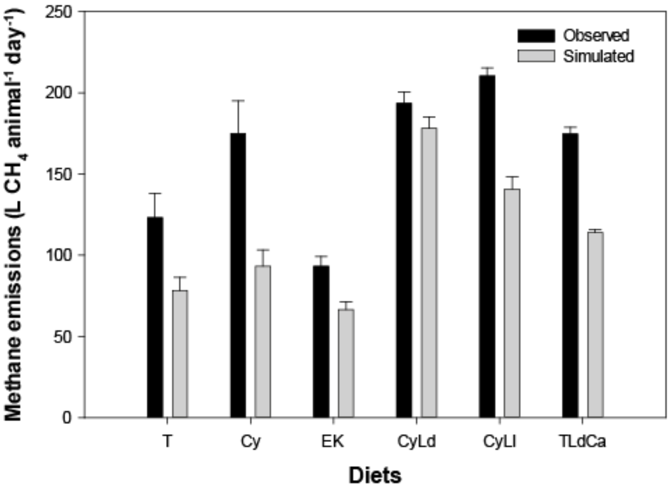

Figure 2. Emissions of enteric methane from steers fed different diets as measured using the polytunnel method and simulated using the RUMINANT model.

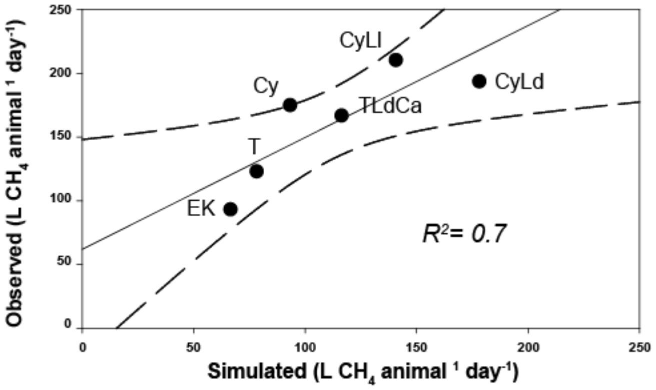

Figure 3. Comparison between enteric methane emissions observed by the polytunnel methodology and those simulated by the RUMINANT model. Emissions are expressed as liters of methane produced per animal per day. Dotted lines indicate confidence intervals of 95%

Conclusions

The RUMINANT model provides a valuable tool for predicting enteric methane emissions when the nutritional composition of forages is known. In Colombia, the Alimentro database maintained by Agrosavia (Corpoica) provides nutritional composition information for common forage species. Since validation, RUMINANT has been used in Colombia both for the preparation of a NAMA Information Note and in preparation of Colombia's Greenhouse Gas Inventory that is shared with the UNFCCC.

The NAMA Information Note identified mitigation activities for the cattle sector as part of the Colombian strategy of low carbon development (ECDBC 2015). The goals of the NAMA are to sustainably intensify cattle production, establish areas of cattle farms for conservation and restoration, and better manage manure. RUMINANT was used to identify feeding strategies that could reduce enteric methane emissions intensity from 113 kg CO_2e per kg protein to 92 kg CO_2e per kg protein. Assuming overall increases in beef production in Colombia by 2032 (the time frame of the NAMA), 4 Mt CO_2e of enteric methane emissions could be avoided annually. This model confirmed that the EK diet was able to reduce enteric methane emissions intensity by 20% per productivity unit.

The team preparing Colombia's Third National Communication to the UNFCCC used RUMINANT and data on regional characteristics of cattle production to estimate separate emission factors for multiple livestock production systems in the country, as methane emissions differ among the systems according to their feed regimen, productivity and efficiency. This is important because it allows the inventory to capture the effects of mitigation actions, which will be necessary for MRV of Colombia's bovine livestock NAMA.

Further reading

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