



An evaluation of the performance and efficiency of nitrogen utilization in cattle fed tropical grass pastures with supplementation



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ARTICLE INFO

Article history:

Received 25 September 2013

Received in revised form

29 January 2014

Accepted 30 January 2014

Keywords:

Mixed models

Nitrogen balance

Nitrogen status

Nitrogen supplementation

Tropical forage

ABSTRACT

The objective of this study was to evaluate the efficiency of nitrogen utilisation (ENU) and animal performance in cattle fed tropical grass pastures and receiving nitrogen supplementation, using a meta-analytical approach. The dataset used to evaluate the ENU was compiled from 10 experiments carried out in Brazil, which were published between 2009 and 2012, totalling 47 treatment means. To compose the dataset for animal performance evaluation, mean treatment values were collected from 44 experiments involving grazing beef cattle, which were published in Brazil from 2001 to 2012, totalling 182 treatment means. The relationships between variables were evaluated using linear or non-linear mixed models, taking into account the random variations among experiments. There was no association between ENU and the balance of nitrogen in the rumen and the efficiency of microbial synthesis in the rumen ($P > 0.05$). The ENU was linearly associated with the dietary content of digestible organic matter in the diet (DOM) and relative production of microbial nitrogen in the rumen (NMICR), which was positive with DOM ($P < 0.04$) and negative with NMICR ($P < 0.03$). The relationships between ENU and dietary crude protein (CP) and the concentration of rumen ammonia nitrogen (RAN) were described using hyperbolic models ($P < 0.05$). The estimated values that correspond to the apparent equilibrium point (i.e., $ENU = 0$) were 108 g CP/kg of dry matter and 6.30 mg RAN/dL of rumen fluid. There was a positive response on weight gain as the amount of supplement increased ($P < 0.01$). However, this relationship was interactively affected by CP content in the supplement ($P < 0.02$) and in the forage ($P < 0.01$). Through this way, the response of weight gain to supplement is improved by increasing the CP content of the supplement, but decreased as the CP in the forage increases. From this it can be conclude that there is a positive response to nitrogen supplementation with regards to ENU and animal performance. The main benefit of supplementation is the improvement of the nitrogen status in the animal's metabolism.

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1. Introduction

Tropical grasses are rarely available as a balanced diet for grazing cattle because they exhibit nutritional constraints

that limit pasture intake and digestibility. For this reason, there is a demand to identify the nutritional limitations of tropical pastures, in order to avoid constraints on animal production via an appropriate supplementation programme.

During the dry season, there is a drastic decrease in the nutritional quality of tropical grasses, as mainly indicated by decreased crude protein (CP) content. The limited CP availability has been recognised as the critical threshold

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for adequate microbial growth on the fibrous carbohydrates in basal forage (Hennessy et al., 1983; Leng, 1990), which results in decreased intake and animal performance (Egan and Doyle, 1985; Leng, 1990; Paulino et al., 2008). Under these circumstances, the supplementation with nitrogenous compounds is the primary nutritional tool to improve the utilisation of low-quality forage by grazing cattle (Hennessy et al., 1983; Leng, 1990; Sampaio et al., 2010; Souza et al., 2010).

On the other hand, during the rainy season the available forage is of better quality than in the dry season. However, despite improved animal performance, the utilisation of basal forage during the rainy season is not considered to be optimal. According to Detmann et al. (2010), there is a nutritional unbalance in tropical pastures during rainy season which is characterised by a relative excess of energy in relation to available CP (Detmann et al., 2010). Therefore, there is an unused potential growth of approximately 200 g/animal/d, which can be achieved by using supplements (Poppi and McLennan, 1995; Paulino et al., 2008).

For that reason, it can be inferred that nitrogen can be considered the main component of supplements for grazing cattle in the tropics throughout the year. The efficiency of nitrogen utilisation become an important parameter either to define supplement composition or to understand the efficiency of animal production.

Therefore, the objective of this study was to evaluate the efficiency of nitrogen utilisation and animal performance in cattle fed tropical grass pastures and supplemented with nitrogenous compounds by using a meta-analytical approach.

2. Material and methods

2.1. Data acquisition

2.1.1. Nutritional characteristics and efficiency of nitrogen utilisation

The dataset used to evaluate the nutritional characteristics and the efficiency of nitrogen utilisation was compiled from 10 experiments carried out in Brazil, published between 2009 and 2012, totalising 47 treatment means (Appendix 1). The following variables were considered: digestible organic matter (DOM) and CP concentrations in the diet, average daily concentration of rumen ammonia nitrogen (RAN), forage dry matter intake (FDMI), DOM intake (DOMI), nitrogen intake, production of microbial nitrogen in the rumen, total nitrogen flow to the abomasum, and apparent balance of nitrogen in the animals' body (nitrogen intake – faecal nitrogen – urinary nitrogen). All experiments were conducted with grazing cattle (*Brachiaria* sp.) or cattle fed with tropical grass hays (*Brachiaria* sp. or *Cynodon* sp.) that were cut from pasture areas. The experiments were carried out according to Latin square designs using Zebu or crossbred (Zebu × Holstein) animals. Each study included a control treatment without supplementation. In all experiments highly rumen degradable protein sources were used in the supplements (casein, albumin, urea, soybean meal or a mixed of more than one

source). The average daily RAN concentration was calculated as the mean of the collections that were made along a 24 h period. The production of microbial nitrogen was estimated by using either purine flow in the abomasum or by the urinary excretion of purine derivatives. The flow of nitrogenous compounds in the abomasum was only evaluated in six experiments, totalling 28 treatment means. The nitrogen balance in the animal's body was not evaluated in one of the experiments. The forage intake in grazing experiments was estimated using one external (titanium dioxide) and one internal (indigestible neutral detergent fibre) marker. The diet sampling in grazing experiments was performed using hand plucked samples.

To minimise the interference due to differences in the intake and size of the animals, the variables associated to the efficiency of nitrogen utilisation were expressed as ratios according to the following equations:

$$\text{NMICR} = \frac{\text{NMIC}}{\text{NI}} \quad (1)$$

$$\text{RNB} = \frac{\text{NI} - \text{NFA}}{\text{NI}} \quad (2)$$

$$\text{ENU} = \frac{\text{NB}}{\text{NI}} \quad (3)$$

$$\text{EMS} = \frac{\text{NMIC}}{\text{DOMI}} \quad (4)$$

where NMICR is the relative production of microbial nitrogen in the rumen (g/g ingested N), NMIC is the production of microbial nitrogen in the rumen (g/d), NI is the nitrogen intake (g/d), RNB is the apparent relative nitrogen balance in the rumen (g/g ingested N), NFA is the nitrogen flow to the abomasum (g/d), ENU is the apparent efficiency of nitrogen utilisation in the animals' body (g/g ingested N), NB is the apparent nitrogen balance in the animals' body (g/d), EMS is the efficiency of microbial synthesis in the rumen (g microbial N/kg DOM), and DOMI is the DOM intake expressed as kg/d.

In two experiments there were some treatments where supplements were provided in the abomasum. In these cases, the nitrogen infused in the abomasum was not used to estimate RNB.

It must be emphasised that nutritional dataset is not broad enough to allow inferring about class variables as sex, genetic group and season. Despite this, the season variation was indirectly taken into account by using continuous variables associated with forage quality (i.e., CP and DOM content).

2.1.2. Animal performance

To compose the dataset for the animal performance evaluation, mean treatment values were collected from experiments with grazing beef cattle. These experiments were carried out in Brazil between 2001 and 2012. The minimum prerequisite for including a study in the dataset was for it to provide information concerning the average daily gain (ADG), the amount of supplement fed to the animals (SUP), the crude protein content in the supplements (SCP), the body weight (BW) of the animals at the beginning of the experiment and the length of the

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