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Use of faecal components as markers to estimate intake and digestibility of grazing sheep

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ABSTRACT

This research was carried out to evaluate the use of faecal components as markers to estimate intake and digestibility of Italian Ryegrass (*Lolium multiflorum* Lam.) of grazing sheep. The research had two phases. In Phase 1 seven indoor experiments were carried out using individual metabolic cages with 16 lambs in each experiment (four treatments with four animals each). Three phenological stages of the pasture (vegetative, pre-flowering and flowering) were evaluated and four different allowances of Italian Ryegrass, collected by grab sampling daily, of 1.5, 2.0, 2.5 kg of dry matter/100 kg of live weight and *ad libitum*. The indoor experimental design was completely randomized and the experiments were grouped according to the phenological stages. Organic matter intake (OMI, g/day), total daily production of faeces, faecal crude protein amount (fCP, g/day), faecal crude protein concentration (fCPc, g/kg of organic matter), faecal acid detergent fibre amount (fADF, g/day), faecal acid detergent concentration (fADFc, g/kg of organic matter) and organic matter digestibility (OMD) were assessed in the indoor experiment. In Phase 2, male sheep were used in two grazing experiments to graze Italian Ryegrass under different management conditions, which were herbage allowance, pasture phenological stage and rotational or continuous system. This phase was designed to validate the equations previously obtained. The stocking rate was controlled according the treatment defined, and the herbage mass, sward height, herbage and faecal chemical composition, OMI and OMD were measured. In Phase 1 significant linear regression equations were found between OMI and fCP in each phenological stage ($P < 0.05$). The intake equations were compared by contrasts analysis and found to be different ($P < 0.001$) between phenological stages, confirming the need to use the data separately by maturity stage. Two equations (simple and multiple hyperbolic) were tested for the relationship between OMD and fCPc, and the multiple hyperbolic, which includes fCPc and fADFc showed best accuracy. In Phase 2 the regression between the actual and estimated had a correlation coefficient of 0.94 and relative prediction error of 9.28%, showing the feasibility of using the generated equations.

Abbreviations: ADF, ash free acid detergent fibre; CP, crude protein; DM, dry matter; fADF, faecal acid detergent fibre amount; fADFc, faecal acid detergent fibre concentration; fCP, faecal crude protein amount; fCPc, faecal crude protein concentration; MSPE, mean square prediction error; N, nitrogen; NDF, ash free neutral detergent fibre; OMD, organic matter digestibility; OMI, organic matter intake; RPE, relative prediction error

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1. Introduction

Pasture intake is critical in determining animal performance in grazing systems. However the measurement of herbage intake of grazing animals is difficult because there are no easy and precise methodologies (Penning, 2004). Many techniques have been used to estimate herbage intake and nutritional parameters in grazing ruminants such as external (n-Alkanes, chromium oxide, rare earths) and/or internal (faecal protein and fibre compound) markers.

Results from external marker techniques are variable, when different experiments with the same marker were compared. Smit et al. (2005) comparing techniques for measuring herbage intake concluded that use of n-Alkanes was the better technique; however Ferri et al. (2008) considered that this external marker overestimates the intake, compared to the faecal protein method. The external markers methods depend on the herbage hand-plucking, to estimate the digestibility (ytterbium, chromic oxide) or to establish a relation between compounds present in the pasture and dosed (n-Alkane) and it needs several attention to collect a representative sample, especially if the sward is heterogeneous (Peyraud, 1997). It is important due to the difficulty in sampling the exact portion of herbage that is ingested by the ruminant. Often it is difficult to reach a consensus between the various researchers (Carvalho et al., 2007), as stated above, analysing Smit et al. (2005) and Ferri et al. (2008) results. Even Smit et al. (2005) concluded that n-Alkanes technique can be used to estimate herbage intake, considering that in different years tested, there was difference in the intake estimation depending on the pair of alkane used.

To overcome the problem of herbage sample, several studies have evaluated faecal crude protein as an index to estimate intake (David et al., 2014; Peripolli et al., 2011) and digestibility (Boval et al., 2003; Fanchone et al., 2009; Lukas et al., 2005). The faecal protein technique is based on the direct relationships between the amount of faecal crude protein (fCP, grams/day) and the organic matter intake (OMI, g/d) (Lancaster, 1949). There is also a relationship between the concentration of faecal crude protein (fCPc, grams/kg of organic matter) and organic matter digestibility (OMD) that is based on the increased relationship between faecal protein and faecal organic matter due to increase in digestibility. If the digestibility decreases, the concentration of fCPc in the OM is diluted by the increasing amount of faecal OM and is, therefore, an indicator of digestibility (Lukas et al., 2005).

The advantages of using faecal crude protein, in comparison with other markers, are that it allows an intake measure through just the amount of protein in the faeces and most of the external marker methods used to assess herbage intake require complex method of analysis, not always available in all research centres (Berchielli et al., 2005). The use of the faecal protein method depends only on equipment and techniques commonly available in most laboratories that perform routine tests of forage quality. In addition, estimations of intake and digestibility can be done without a dosing or sampling of the forage and, just for organic matter digestibility estimation, only the protein concentration in a spot faecal sample is needed; hence there is no need to use sheep fitted with a faecal collection harness.

In order to establish the correlations between protein in the faeces and digestibility and intake it is important to carry out experiments in metabolic cages with similar forage to that offered to grazing animals as this relationship can change depending on herbage species and season (Coates and Penning, 2000). Results using the protein faecal index technique have been promising compared with other markers used to estimate herbage intake in grazing animals (Ferri et al., 2008; Schneider et al., 2011).

The aim of this experiment was establish the relationships between chemical content of faeces and intake and digestibility at different phenological stages of Italian Ryegrass and then to assess these nutritional parameters at pasture based on the equations previously obtained.

2. Material and methods

2.1. Location and experimental design

The indoor and grazing experiments were conducted at the Agronomic Experimental Station of Federal University of Rio Grande do Sul (UFRGS), located in Eldorado do Sul (30°05′S, 51°40′W), Brazil. The climate was humid subtropical (Cfa) according to the Koppen classification (Moreno, 1961). The local mean precipitation was 1440 mm and the mean temperature varied between 9 and 25 °C, according to the season (Bergamaschi et al., 2003). The research was divided into two phases: Phase 1 – generation of the equations to estimate intake and digestibility of Italian Ryegrass (*Lolium multiflorum* Lam.) through indoor trials with sheep in metabolic cages in a completely randomized experimental design with four replicates (animals), four forage allowances and three phenological stages of the herbage; Phase 2 – the equations were then evaluated with sheep grazing Italian Ryegrass under different management conditions. All the procedures were in accordance with accepted principles for the care and welfare animals of the UFRGS guidelines.

2.2. Phase 1: indoor experiments

Seven experiments with sheep fed with Italian Ryegrass in metabolic cages were carried out during the years 2007–2010. All seven experiments had a similar experimental design and sampling schedule. In each experiment 16 male sheep (Texel, 12 months old, average live weight year 2007: 39.8 ± 4 kg; 2008: 36.5 ± 3.3 kg; 2009: 31.1 ± 4.1 kg and 2010: 29.6 ± 4.7 kg) were randomly allocated to one of the four levels of forage allowance: 1.5, 2, 2.5 kg of dry matter (DM)/100 kg of live weight (LW) or *ad libitum* allowing for 20% refusals, of the total offered. Three phenological stages were studied in seven experiments: vegetative (2009 and 2010), pre-flowering (2008 and 2009) and flowering (2007, 2008 and 2010). The phenological stages were defined as vegetative – leaf growth and development in most of the plants; pre-flowering – stem elongation and inflorescences begin to appear; and flowering – inflorescences completely exposed in most of the plants. Three phenological stages were studied to determine

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