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Behavioural mechanisms of intake rate by heifers grazing swards of contrasting structures

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ABSTRACT

The relationship between herbage intake by herbivores and herbage available depends on the interaction between sward structure and animal behaviour. This relationship is a crucial component determining the stability, function and productivity of grazing systems. The present study aims at quantifying the mechanisms by which intake rate is determined in swards of contrasting structure and forage species, and it reveals the importance of animal choice in the interaction between animal and sward. We hypothesised that as sward height and herbage mass increased, bite mass and intake rate would increase. The relationship between intake rate and bite mass should exhibit a higher asymptote for the more succulent, less fibrous *Avena* than for *Cynodon* due to differences in chewing requirements per unit dry mass of intake. In four different experiments, *Cynodon* sp. cv. Tifton 85 and *Avena strigosa* cv. Iapar 61 swards of different heights were obtained by various durations of short time high-intensity grazing or by different growth periods. Bite mass and intake rate were estimated by the double-weighing technique with correction for insensible losses. Number and timing of jaw movements and bites were measured with behaviour recorders. Bite mass was the main variable determining intake rate. Contrary to expectations, bite mass first increased and then decreased with increasing sward height, a result that seems due to animal choice and not from restrictions imposed by the swards. As expected, *Cynodon* sp. swards required more chewing per unit DM intake due to their higher DM content (39.5 vs. 22.6, $P < 0.0001$) and higher fibre (67.8 vs. 51.3, $P < 0.0001$) content than *A. strigosa*. Harvesting and chewing jaw movements, the components of total jaw movements and time per bite, had different time costs, and values were remarkably similar to previously published values. On average, each harvesting jaw movement took 1 s and a chewing jaw movement took 0.68 s. The reduction in bite mass with increasing sward height in tall swards is discussed as a destabilising mechanism that generates spatial heterogeneity in sward height and mass.

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1. Introduction

Allden and Whittaker (1970) defined herbage intake as the combined effect of ingestive behaviour, bite mass, bite rate and grazing time. This work is the foundation for understanding the influence of sward structure on bite mass and the relationship between bite mass and bite rate. Small bite mass requires fewer chewing jaw movements per bite, so a greater number of jaw movements can be used to harvest bites (Spalinger and Hobbs, 1992; Fonseca et al., 2013; Mezzalira et al., 2013). When bite mass is large, mastication needs are large and bite rate is low, because the maximum rate of jaw movements is almost constant (Penning, 1986). However, to harvest a bite, animals require a fixed time to open and close the jaws. Newman et al. (1994) and Parsons et al. (1994) estimated it for sheep, and Laca et al. (1994) estimated it for cattle. Because of the fixed cost per bite represented by a minimum of one harvesting jaw movement, bite rate cannot increase sufficiently to compensate for a small bite mass. When grazing animals are subjected to sward structures that severely limit bite mass, inability to maintain intake rate, and competition for time to graze, ruminate and conduct social and general maintenance activities leads to reduced daily intake (Hodgson et al., 1997). Da Silva and Carvalho (2005) suggested that these compensatory relationships result in low animal performance in tropical pastures due to their structural characteristics more than relate their low nutritional value. Sollenberger and Burns (2001) demonstrated that tropical pastures produce low-quality forage with high bulk density of pseudostems (leaf/stems + sheaths) and are suitable only for low levels of animal intake and performance.

However, the principles of grazing management and animal production in tropical pastures need to be re-evaluated (Da Silva and Carvalho, 2005). New management targets should be proposed based on the predominant influence of sward structure in herbage intake by herbivores (Carvalho et al., 2007).

Sward structure is constantly changing as a result of plant growth, defoliation and senescence. In rotational method there is an increase in the bulk density and a decrease in leaf/pseudostem ratio throughout grazing down (Barrett et al., 2001; Ungar et al., 2001). Consequently, there is a progressive reduction in short-term intake rate (Fonseca et al., 2013) and bite area (Ungar et al., 2001), resulting in a daily herbage intake reduction (Barrett et al., 2001; Baumont et al., 2004). Throughout this process, temperate and tropical pastures may impose different constraints on consumption due to the increased abundance of pseudostems (Griffiths et al., 2003). Because of the selectivity of leaves by herbivores (Benvenutti et al., 2006; Drescher et al., 2006), the distribution of the stem component has distinct effects on tropical and temperate pastures to the point that, by imposing high grazing down levels, animals can stop grazing and wait to enter a new plot (Ribeiro Filho et al., 2003; Amaral et al., 2013).

We hypothesise that the potential forage intake of animals grazing tropical pastures will be reduced due to higher constraints in bite formation when compared to temperate pastures. Thus, this study aimed to investigate the intake process of heifers under the influence of different sward heights and grazing down levels in two contrasting – tropical and temperate – forage species.

2. Material and methods

2.1. Experimental setting

Two experiments (1 and 3) were performed with *Cynodon* sp. cv. Tifton 85 (*Cynodon* sp.) in Pampa Itália Farm—Brazil (25°45′00″S, 53°03′25″W) between January and March 2011. The *Cynodon* sp. pasture was established in 2008. The experimental area had 1.3 ha and was divided into 18 paddocks of 500 m^2 each. An adjacent area of *Cynodon* sp. was used to maintain the animals during the experimental period. Prior to the grazing tests, each paddock was grazed down to 10 cm of sward height by non-experimental animals and then mowed to 6 cm above ground. The experimental period started when the sward height of each paddock reached the pre-set sward height reported below. Throughout the experimental period, 80 kg ha^{-1} of N and 20 kg ha^{-1} of P_2O_5 and K_2O were applied.

Two additional experiments (2 and 4) were carried out with *Avena strigosa* cv. IAPAR 61 (*A. strigosa*) in Research Station of the Federal University of Rio Grande do Sul, Brazil (30°05′27″S, 51°40′18″W), between July and September 2011. The *A. strigosa* pasture was uncut prior to the experimental period. In order to obtain different sward heights at the same moment, the experimental area of 2.6 ha was sown on four different occasions, on June 15th and 23th, and on July 13th and 28th of 2011. The sowing was performed with rows spaced 17 cm and a seed density of 80 kg ha^{-1}. At sowing, 20 kg ha^{-1} of N and 100 kg ha^{-1} of P_2O_5 and K_2O were applied, and 20 days after sowing, 60 kg ha^{-1} of N was applied. The same cultural practices were performed in all experimental areas.

Because of logistical constraints, experiments with different forage species were conducted at different locations and with a different set of experimental animals. Lack of randomisation and spatiotemporal interspersion of treatments preclude unequivocal identification of plant species as the factor that caused differences between the two sets of experiments. Each experiment was analysed separately and the potential causes of differences between experiments are discussed in the context of grazing mechanisms and published literature.

2.2. Treatments

In experiments 1 and 2 swards of different heights and structures were created through the process of plant growth and development. Conversely, in experiments 3 and 4 swards of various heights and structures were obtained by high-density grazing (ca. 15 head/500 m^2) of originally similar swards during 0–4 h in 1-h sessions. Short grazing sessions were used to prevent fouling of swards. The tallest swards in experiments 3 and 4 were ungrazed prior to the grazing test, and thus are comparable to swards of equal height in experiments 3 and 4.