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Technical note: A simple model to estimate changes in dietary composition of strip-grazed cattle during progressive pasture defoliations

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ABSTRACT

Methodological problems occur in measuring herbage intake and diet quality during short-term (4–24 h) progressive defoliations by grazing. Several models were developed to describe pasture component selection by grazing ruminants, particularly sheep. These models contain empirical coefficients to determine preferences that require laborious and data-demanding calibration. The objective was to develop a simple and practical model of changes in diet composition (green:dead) of pastures strip-grazed by dairy cows. The model was based on 3 premises when cows are strip-grazed in relatively homogeneous swards: 1) cows eat dead material only when green leaf and uncontaminated material have been removed; 2) dead material increases toward the bottom of the sward canopy; and 3) cows progressively defoliate pasture in layers. The main simplification in this model was assuming a linear decrease of green mass from the top to the bottom of the sward canopy. Thus, the proportion of green mass in the stratum eaten depended on the proportion of green in the entire sward canopy and its vertical profile. The model offers a simple solution to estimate changes in dietary compositions in pastures strip-grazed by dairy cattle during progressive pasture defoliations. It uses 2 inputs, the green mass proportion of the total herbage mass and the proportion of total herbage mass eaten during grazing. This can be optionally complemented with inputs of herbage chemical composition. The main outputs of the model are the proportions of green and dead herbage mass in the diet. For example, if the green proportion in the sward was 0.5 and the proportion of herbage mass eaten was 0.5, then the diet would be 0.75 green:0.25 dead; assuming 0.8 and 0.4 digestibility for green and dead material, respectively, the diet digestibility would be 0.7.

Key words: dairy cow, diet composition, strip grazing

In relatively homogeneous grazing environments such as vegetative perennial ryegrass (*Lolium perenne* L.)-dominated swards, an inverse relationship exists between herbage mass depletion and dietary quality (i.e., reduced digestibility and protein content and increased fiber content) of herbage consumed. Green leaf is the sward canopy component that stimulates herbage intake (Peyraud and Delaby, 2005; Gregorini et al., 2009) and quality of herbage consumed (Bailey, 1995). In a homogeneous grazing environment, strip-grazed cattle ate available herbage in successive layers when the area offered and time were restricted (Waite, 1963; Wade and Carvalho, 2000). Thus, the quality of the diet consumed depends on grazing severity, there being less green leaf and more dead material in the lower stratum (Chacon and Stobbs, 1976).

Measuring herbage intake and diet quality during short-term (4–24 h) progressive defoliations is time consuming, methodologically challenging, and costly; however, it is critical to obtain a good estimate of dietary intake to make pasture management decisions. Several models were developed to describe pasture component selection by grazing ruminants, particularly sheep (Pittroff and Kothmann, 2001). These models contain empirical coefficients to determine preference by animals for pasture components, which require demanding, laborious data calibration. Also, empirical coefficients usually cannot be extrapolated beyond the conditions (sward state, herbage allowance, animal type, age, and physiological state) for which they were determined. In view of this complexity but taking cognizance of the need for estimates of diet composition, a simple model, requiring few inputs and capturing the essence of the process, is preferable to a more elaborate model requiring many inputs that are impractical and costly to measure. Pregrazing herbage mass and herbage residual after grazing and green and dead proportions of the sward are likely available.

Therefore, the objective was to develop a simple and practical model of changes in dietary quality of pasture strip-grazed by dairy cows based on 3 premises when cows are strip-grazed in relatively homogeneous swards: 1) cows eat dead material only when green material and uncontaminated material have been removed; 2)

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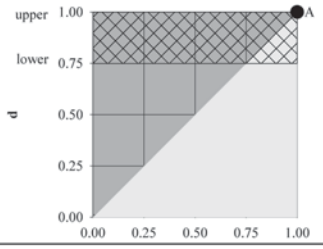
greenPropUL = Example

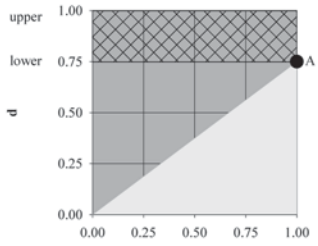
Case a)

$$\frac{\mu + b \times (1 - \text{upper}) + \left(\mu + b \times (1 - \text{lower})\right)}{2} \quad \text{if } \nu = 1$$



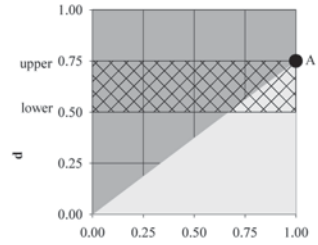
Case b)

$$1 \quad \text{if } \nu \leq \text{lower}$$



Case c)

$$1 - \frac{(\mu + b \times \text{upper}) + (\mu + b \times \text{lower})}{2} \quad \text{if } \nu \geq \text{upper}$$



Case d)

$$1 - \frac{|\nu - \text{lower}| \times (\mu + b \times \text{lower})}{\frac{2}{\text{upper} - \text{lower}}} \quad \text{lower} < \nu < \text{upper}$$

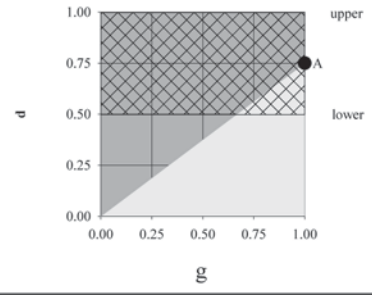


Figure 1. Schematic representation of a model of a cross-sectional cut of a sward canopy showing the vertical distribution of green (dark gray) and dead (light gray) masses and the proposed calculation of the proportion of green material for a stratum (depicted as trellis pattern) between an upper and a lower limit (greenPropUL). The vertical axis (d) represents the cumulative vertical distribution of the herbage mass (from the bottom to the top), and g is the proportion of green mass at any given value of d. The coordinates (μ: horizontal, ν: vertical) of point A (●) depend on the green mass proportion of the total herbage mass before grazing (greenProp; see Equations 1 and 2). Case a: greenProp is 0.5 ($\nu = 1$); case b: the lower limit of the stratum is at or above ν; case c: the upper limit (0.75 in this example) is below or equal to ν; case d: ν is between the upper and lower limits. The parameter b is explained in the main text.

dead material increases toward the bottom of the sward canopy; and 3) cows progressively defoliate pasture in layers from top to bottom.

The proportion of green mass in any stratum depends on the proportion of green in the entire sward canopy and its vertical profile. The main simplification in this model, based on previous research of Milne et al. (1982) and Collins (1989), was assuming a linear decrease of green mass from the top to the bottom (ground level) of the sward canopy.

The sward canopy was modeled as a series of horizontal strata, each containing a certain proportion of the total herbage mass. The proportion of green mass in a stratum between any upper and lower limits (**greenPropUL**) on the vertical axis was calculated as in Figure 1 (and Appendix).

Note that the vertical axis (d in Figure 1) represents the cumulative proportion of the herbage mass from ground level to top, not height. The horizontal axis (g) represents the proportion of green mass at any given

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