MODELING INTAKE OF GRAZING COWS FED COMPLEMENTARY FEEDS

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ABSTRACT

A model suitable for predicting intake for grazing or non-grazing dairy cows is presented. The model integrates the potentially intake limiting factors of physical fill, physiological energy demand, wet mass, herbage availability, herbage cover, and grazing time. Integration of these factors with a simple set of linear ration balancing constraints yields a model suitable for predicting supplemental feed requirements as well as potential animal production from a grazed land. The model is semi-theoretical, being descriptive in structure, but containing empirical relationships.

KEYWORDS

Dairy, grazing, intake, model, ration balancing, supplement

INTRODUCTION

Worldwide, the importance of grazing by ruminant animals — particularly dairy cows — is clear (Hodgson, 1989). In the United States, this approach towards dairying is increased due to the potential to significantly increase income over feed costs, reduce negative environmental impacts, and react to urbanization. In grazing situations, intake of grazed forage must be reasonably known for ration balancing and feed budgeting. Good models of intake can be used to determine management factors (e.g., pre grazing mass and stocking density) for maximum intake (McCall et al., 1986).

Many models of intake have been proposed and are in use. Empirical approaches are common (Leaver, 1989; Minson and Wilson, 1994; Waldo, 1986), but many of these models are limited to prediction of intake as a function of only one or two relevant factors such as days in milk, bodyweight, or herbage cover. Some semi-theoretical models of intake (Mertens, 1994) fit data while physically explaining the phenomena. These approaches are also limited in the number of factors they can embrace. A model which integrates effects of factors such as herbage availability, herbage cover, bodyweight, daily animal production, and time available for grazing is needed. The objectives of this work were to develop a model that links several factors affecting intake by lactating dairy cows during grazing and explore implications of management and feed quality on intake through the use of the model.

METHODS

Because of the several factors affecting intake of grazed pasture by dairy cows, independent phenomena were considered to have independent effects on intake (Waldo, 1986). Considering each factor to put an upper bound on intake (Doyle et al., 1989), the pasture intake is the minimum of values determined from limitations of physical fill, physiological energy demand, total mass of daily intake, herbage availability, herbage cover, and allowable grazing time.

Fill. Physical fill has been documented as an important factor affecting intake when high forage or high fiber diets are fed (Mertens, 1994). Previous efforts have used neutral detergent fiber as the fill indicator and expressed an NDF intake limit as a fraction of bodyweight. Recognizing that not all NDF has similar digestibility rate and extent, and that particle size can be a factor, the following relationship for physical fill was used (Mertens, 1994):

$$\sum_{i}^{\#\,feeds} DMI_i \bullet NDF_{,i} \bullet F_{NDF,i} - fic \bullet BW$$

where:
***DM_i* = daily intake of feed i, kg DM/d**
***NDF_i* = neutral detergent fiber concentration of feed i**
***$F_{ndf,i}$* = fill effect of NDF in feed i**
***fic* = fiber intake capacity, kg NDF/kg BW/d**
***BW* = bodyweight, kg**

The fiber intake capacity (fic) is typically near .012 kg NDF/kg BW/day, but there is evidence that it varies with stage of lactation and growth (Mertens, 1994). Pasture DMI is simply DMIi when i indicates the pasture. For this reason, pasture intake as limited by fill is not explicit, but is implicitly a function of other feeds being fed.

Energy. Physiological energy demand is commonly accepted as one determinant of intake (NRC, 1989). Assuming intake stops when daily energy demand is met, the following is true:

$$\sum_{i}^{\#\,feeds} DMI_i \bullet NE_{l,i} = NE_l^{req'd}$$

where:
***$NE_{l,i}$* = net energy for lactation of feed i, Mcal/kg DM**
***$NE_l^{req'd}$* = net energy for lactation requirement Mcal/d**

For dairy animals, energy requirement is a function of milk production, weight change, body weight, and pregnancy and is adjusted for multiples of the maintenance requirement (NRC, 1989). Again, potential intake of pasture — bounded by energy demand — is not explicit but can be affected by DMI of other feeds and energy content of other feeds and pasture herbage.

Mass. Sometimes intake is limited by just plain mass due to the water content of pasture (Waldo, 1986). Regardless of other factors, mere mass of grazed pasture limits pasture intake to 15.4% of bodyweight. If the pasture is 20% dry matter, this amounts to an upper limit of about 3.1% of DM.

Availability and Cover. Two agronomic-animal interaction factors can affect intake during grazing — availability and cover (Bircham and Sheath, 1986; Forbes, 1995; Hodgson, 1989; Loewer et al., 1987). Even though there may be plenty of cover, availability may limit intake because there is not enough for the entire animal group. Conversely, even though there may be plenty of herbage available, it may be so sparse that intake is limited due to a "fetch" factor. With availability based on a residual height of 8 cm (Dougherty et al., 1989), these two related, yet controllably-independent factors were modeled as (Figure 1):

$$PDMI_{availability} = .03 + 12(1 - e^{-12.A)})$$

$$PDMI_{cover} = 15(1 - e^{-002\bullet(C - 500)})$$

where:
$PDMI_{availability}$* = pasture intake if limited by herbage availability, *kg DM/(kg BW)$^{.75}$/d
***A* = herbage availability, *kg DM* above 8 cm/(*kg BW*)$^{.75}$**
$PDMI_{cover}$* = pasture intake if limited by herbage cover, *kg DM*/(*kg BW*)$^{.75}$ / *d
C* = herbage cover, *kg DM/ha

Time. Given that many times grazing is only part of a feeding/management system, it is likely that time allotted for grazing can limit pasture intake (Forbes, 1995). Typically, dairy animals graze 5-10 hours per day. Any adjustment for lack of time to graze would not affect physical fill or physiological energy demand. However, limited time to graze would result in a requisite reduction in expected intake (given adequate time) as predicted from herbage availability or cover. A multiplier to these pasture dry matter intake limits is fitting when grazing time is limited:

$M = 1$ if potential grazing time > 8 h/day
$M = t/8$ if potential grazing time < 8 h/day

Concept integration. The partitioned approach towards modeling intake during grazing was implemented in a model which predicts pasture intake while balancing a dairy ration for NDF, roughage, net energy, degradable protein, and undegradable protein. The non-intake portions of the model are similar to the model developed by Buckmaster (1989) and implemented in the DAFOSYM model (Rotz et al., 1989).

RESULTS AND DISCUSSION

The intake and ration balancing model as constructed makes substitution of other feeds for grazed material an implicit consideration. Substitution rate is not an explicit function based on any one criteria, but varies with feed quality (Waldo, 1986) and may vary due to fill and the supply of energy, crude protein, and ruminally degradable protein (Forbes, 1995). With the linear programming structure, feed cost is minimized recognizing each alternative feed has value; even so, rations can be arbitrarily constructed to maximize or minimize forage intake by "rigging" relative prices. The model as presented is intended for use in simulation models such as GRASIM (Mohtar et al., 1996) and DAFOSYM (Rotz et al., 1989). In these models, the intent is to predict animal response (feed requirements and milk output) under different feed quality and quantity scenarios. In models such as these, it is imperative that agronomic and animal factors affecting intake be linked and models of response be descriptive. While there are many intake models existing in the literature, the approach taken in this work links the pertinent factors in a wholistic manner; with the proposed model, effects of forage quality, pasture status, grazing management and animal factors on intake are integrated. References to literature cited above indicate that the concepts used are valid; however, validation of the specific relationships used and the composite animal model are needed.

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Figure 1
Model of the affect of herbage availability herbage cover on potential (maximum) intak grazed pasture by dairy cows.