Using Cuticular Wax Alkanes and Computer Simulation to Estimate Diet Selection, Herbage Intake and Nutrient Cycling in Grazing Sheep

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ABSTRACT

In grazing ewes, plant cuticular wax alkanes were used as markers to estimate diet selection, herbage intake, N intake and N excretion in faeces. Pasture and animal data were then used as inputs to the decision-support system **GrazFeed**, which simulates grazing and digestion to predict herbage intake, N intake and N excretion. Estimated and predicted intakes agreed closely, especially for N intake, and it is concluded that, subject to further investigation of the possibility that **GrazFeed** slightly under-estimated faecal N excretion, the close agreement between estimated and predicted OM and N intakes suggests that this combined use of alkane methods and simulation could provide a simple means of estimating the urinary return of N or other nutrients to pasture.

KEYWORDS

Alkanes, plant wax, diet selection, intake, nutrient cycling, simulation, **GrazFeed**

INTRODUCTION

In grazing systems in temperate Australia, there is a need for management systems which prevent increasing soil acidity and which optimise the cost-effectiveness of fertiliser application. Computer models of the cycling of nutrients under grazing offer an ideal way of testing new management options but until recently, the techniques available for estimating diet composition and herbage intake by animals were not accurate enough to allow estimates of nutrient inputs from different sward components. Moreover, urinary nutrient returns were difficult to estimate in the absence of reliable and non-invasive techniques to estimate urine output. This paper reports the use of direct measurement of intake and faecal output of nitrogen (N), combined with the use of computer simulation to predict both these and the urinary N output.

MATERIALS AND METHODS

Our work was conducted within a larger study of soil water and N dynamics under limed and unlimed perennial and annual pasture/cropping systems, in a 650 mm rainfall area near Wagga Wagga, New South Wales. Responses to pasture type and lime will be discussed elsewhere, and this paper will concentrate on the combined use of direct measurement and computer simulation to estimate components of N cycling in grazed pastures. The four permanent pasture treatments used for estimates of diet composition and intake were the limed and unlimed perennial pasture, consisting of phalaris (*Phalaris aquatica*), cocksfoot (*Dactylis glomerata*), subterranean clover (*Trifolium subterraneum*) and lucerne (*Medicago sativa*), and the limed and unlimed annual pasture, consisting principally of annual ryegrass (*Lolium rigidum*) and subterranean clover.

Animal measurements. Measurements were made in winter (June) and spring (September-October) 1994, but results did not differ between seasons and are not reported separately. Sixteen plots (each 0.135 ha) were rotationally grazed by Merino ewe weaners (5-6/plot) dosed with intra-ruminal, controlled-release devices delivering a known daily amount of both C32 and C36 alkane to allow intake estimation (Mayes et al., 1986; Dove et al., 1991). Estimates of diet composition (grass, legume, weed, dead material) were made from the cuticular wax alkane concentrations in these plant fractions and in faeces, using the least-squares optimisation method of Dove and Moore (1995). Estimates of total intake were calculated from the average alkane concentrations of the estimated consumed diet, and the faecal concentrations of plant alkanes and the dosed C32 alkane (Mayes et al., 1986). Since C36 alkane derived only from the intra-ruminal dose, its dilution in faeces provided an estimate of faecal output and thus digestibility (for details, see Mayes et al. 1986; Dove et al., 1991).

Simulations. To obtain an indirect estimate of urinary N return, we used version 2.0.6b of the decision-support system **GrazFeed** (Freer et al., 1996), which couples the simulation of grazing with the simulation of digestion and utilisation of nutrients, to establish the nutritional status of grazing animals on a given day. Inputs required by the model were animal live weights, the weight, protein content and average digestibility of the green and dead fractions of the sward, and the sward legume content. Model output consisted of predicted intakes of herbage, N and energy transactions in the rumen and the animal, and a predicted daily N balance. Model predictions and alkane estimates were compared by linear regression and were regarded as significantly different if the regression slope differed from unity or the intercept from zero.

RESULTS AND DISCUSSION

The estimated intakes of OM and components of daily N balance are shown in Table 1, together with those predicted by **GrazFeed**. The digestibility of consumed herbage had the main effect on intake ($P<0.001$), though the relationship was not pronounced ($r^2 = 0.419$), possibly because of the narrow range in digestibilities in both winter (65.3-74.3%) and spring (72.0-77.1%). Overall, a unit increase in digestibility was associated with an increase of 17±3.7 g OM/day or approximately 19 g DM/day, similar to the value of 19.8 g DM/day reported by Freer and Jones (1984) as the intake response per unit increase in OM digestibility in pooled grass/legume data.

Intakes of OM predicted by **GrazFeed** from pasture and animal data (Table 1) were linearly related to ($P<0.001$, $r^2 = 0.585$), but not significantly different from intakes estimated using alkanes. Similarly, N intakes predicted by **GrazFeed** were linearly related to those estimated using alkanes ($P<0.001$; $r^2 = 0.597$) but not significantly different from them. In turn, daily urinary N outputs predicted by **GrazFeed** were closely related to alkane-based estimates of N intake ($P<0.001$; $r^2 = 0.653$). This implies that the combined use of the alkane techniques and **GrazFeed** simulation successfully allowed the quantification of urinary N return to pastures. However, there may be a small bias in the data, since the measured faecal N excretions were slightly but significantly higher ($P<0.001$) than the faecal N outputs predicted from **GrazFeed**, so that **GrazFeed**-predicted urinary N outputs are higher by this same amount. Further work is needed to establish whether this is a consistent bias, and if so, to identify its source.

Although our approach may have over-estimated urinary N excretion by about 2 g/day, within a total urinary N excretion of 15-40 g/day, this error is likely to be acceptable compared with those arising from the disturbance to grazing arising from the use of devices to estimate total daily urine output and thus N excretion. We conclude that, since herbage OM and N intakes estimated using alkanes were also well predicted using **GrazFeed**, there is considerable promise in using the **GrazFeed** predictions of urinary N excretion as a simple approach to estimating urinary N cycling from grazing animals back to pasture.

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Table 1
Estimated and predicted OM and N intakes and N excretion in faeces and urine in grazing ewes

	OM intake g/day	OM digestibility[x] %	N intake g/day	Faecal N g/day	Urinary N g/day
Estimated	947±31.0y	71.5±1.12	25.3±1.20	8.3±0.23	Not estimated
Predicted	1012±40.3	-	26.2±1.69	6.0±0.26	18.5±1.32

[x]Estimated OMD used as input for simulations.
[y]Mean ± standard error of mean (32 values; 16 plots, winter and spring)