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USING FAECAL NEAR INFRARED REFLECTANCE SPECTROSCOPY (F.NIRS) TO MEASURE THE PROPORTION OF GRASS IN THE DIET SELECTED BY CATTLE GRAZING TROPICAL PASTURES

D.B. Coates[1,4], R.M. Dixon[2] and M. Sullivan[3]

[1]Davies Laboratory, CSIRO, PMB, PO, Aitkenvale, Townsville Qld 4814
[2]Department of Primary Industries & Fisheries, PO Box 6014, Rockhampton, Qld 4702
[3]Department of Primary Industries & Fisheries, PO Box 1333, Mt Isa, Qld 4825
[4]Corresponding author. Email: david.coates@csiro.au

ABSTRACT

A F.NIRS calibration equation was developed for predicting the $\delta^{13}C$ ratio in faeces, and therefore the proportions of C_4 tropical grasses to C_3 non-grass plants (primarily forbs, legumes and browses) selected by grazing cattle. This calibration equation was used to measure seasonal profiles of dietary non-grass intake for a NE Qld speargrass site with and without introduced pasture legume, and for a NW Qld Mitchell grass site. In addition, results are presented for cattle grazing savannahs in the monsoonal tropics of central, northern Australia. Non-grass can form a substantial component of the diet even where there is ample grass on offer and may contribute substantially to diet protein content during the dry season.

INTRODUCTION

In the tropics and subtropics of northern Australia the native and introduced pasture grasses are predominantly C_4 species. Conversely, most of the non-grass vegetation comprises C_3 species. Diet C_4 and C_3 proportions can be determined from faecal $^{13}C/^{12}C$ ratios ($\delta^{13}C$, Jones 1981). The $\delta^{13}C$ is usually measured by mass spectroscopy, but Near Infrared Reflectance Spectroscopy (NIRS) provides a rapid and inexpensive alternative (Clark *et al.* 1995, Coates 2004). This paper reports the development and application of F.NIRS for the measurement of $\delta^{13}C$ of faeces for cattle grazing tropical pastures in northern Australia.

METHODS

NIRS measurements

A calibration equation to measure the $\delta^{13}C$ was developed from faeces of cattle grazing a wide range of pastures comprised of C_4 grasses and C_3 non-grasses. Faecal $\delta^{13}C$ was measured by mass spectroscopy, while reflectance (700-2500 nm) of dried and ground faeces was measured using a Foss 6500 scanning monochromator. Calibration and validation statistics for $\delta^{13}C$ calculated in a MPLS model with first derivative of log 1/R spectra and SNV-detrend transformed data were excellent (n 1501; range -12.27 to -27.65‰; SEC 0.78; SECV 0.78; R^2_{cal} 0.94; SEP 0.83). Diet proportions of non-grass were calculated as: % non-grass = (faecal $\delta^{13}C$ - 13.5) * 7. This assumes that the average faecal $\delta^{13}C$ for C_4 grass and C_3 non-grass diets are -13.5‰ and -27.5‰, respectively.

Sampling procedure

F.NIRS measurements examined the seasonal profiles of diet non-grass and crude protein (CP) at two sites grazed by young *Bos indicus* cross cattle. At Swans Lagoon near Townsville in the northern speargrass pasture region, heifers grazed a paddock of unimproved native pasture (NP) or NP oversown with seca and verano stylos (NP+stylo). At Toorak near Julia Creek, measurements were made with two drafts of steers grazing Mitchell grass downs pasture in 2002 and 2004. Pasture composition was assessed at the end of the wet season at both sites. In addition F.NIRS measurements were made on two properties in the monsoonal tropics. Samples representing cattle located at various watering points were collected on two occasions (March-April and June-July) at Newcastle Waters (south of Daly Waters) and one occasion in August at Carlton Hill (near Kununurra). Samples were stored frozen, dried (65° C), ground, and then scanned.

RESULTS

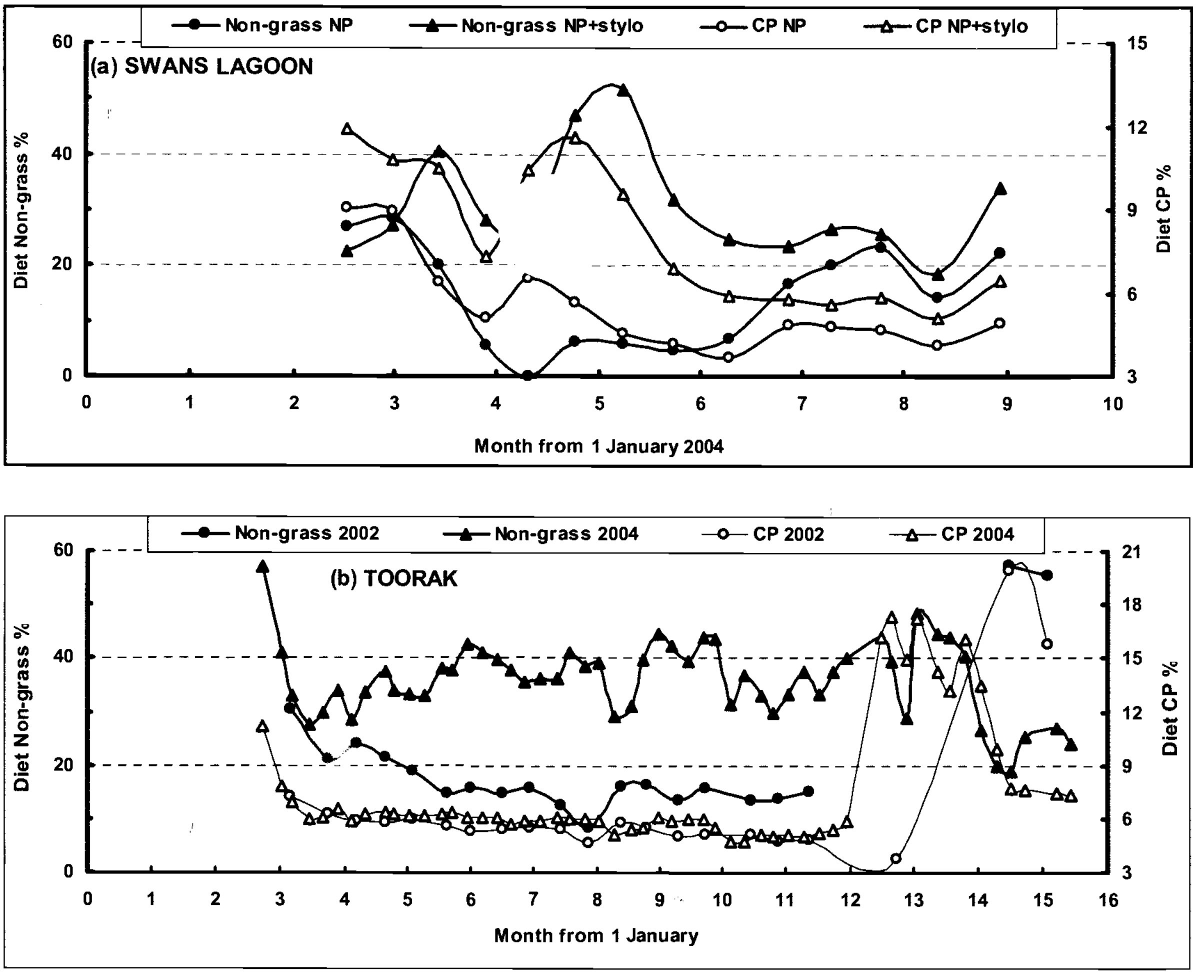

Figure 1: Faecal NIRS predictions of diet non-grass proportions and crude protein concentration at (a) Swans Lagoon and (b) Toorak Research Station

At Swans Lagoon, in heifers grazing NP, the diet non-grass was 20-27% from March to mid-April, declined to 0-7% in the mid dry season, but increased again in the late dry season (Fig.1a). Diet CP declined from about 9% in March to 3-5% from June to September. In April, native legumes and forbs comprised 8% of the 3.1 t/ha of total pasture DM on offer. Presence of stylos in the pasture (NP+stylo) resulted in much more non-grass in the diet selected through the dry season, and this was >50% in early June. Diet CP was correspondingly higher (mean of 6.4% June-September). In April the stylo, native legume and forbs comprised 32% of the total 3.1 t/ha pasture DM on offer.

At Toorak, rainfall in the wet seasons preceding F.NIRS measurements was only 54% (236 mm) and 70% (308 mm) of the long-term average for the 2002 and 2004 drafts respectively. Pasture on offer in May was 1.11 and 1.43 t/ha, respectively. Non-grass, which consisted of native legumes and forbs, comprised <2% of pasture DM in May 2002 but almost 19% in May 2004. In 2002 the non-grass was 30-20% of the diet in April and May, declining to

8-19% (mean 14%) from mid-June to December (Fig.1b). Diet CP of 7.2-5.8% in April and May declined progressively and was <5% by the late dry season. In 2004 non-grass in the diet was much higher and averaged about 36% through the dry season, April-December. Diet CP in 2004 was only slightly higher than in 2002 (means of 5.8 and 5.5% respectively for the period April-December). In both drafts of steers diet non-grass and CP concentration increased sharply following the break in the dry season.

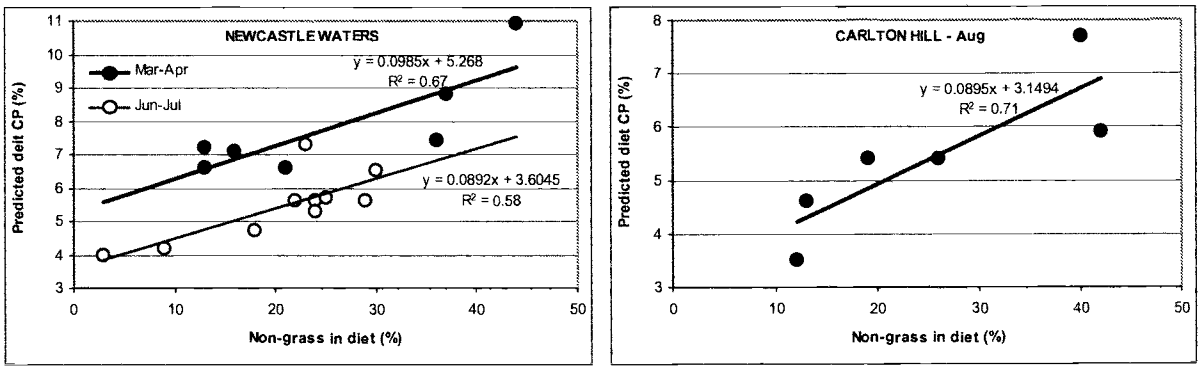

Figure 2: Relationship between predicted diet CP% and diet non-grass% for samples collected from different cattle watering points at Newcastle Waters and Carlton Hill

The linear relationships ($P < 0.05$) between diet CP and non-grass at both sites in the monsoonal tropics (Fig.2) indicated that the protein content of the non-grass was higher than that of the grass. The intercepts of the regressions provide a measure of the protein content of the grass selected (3.1-5.3%), while the slopes indicate that the protein content of the selected non-grass ranged from 8.9-9.9%. For every 11% increase in diet non-grass, CP of the entire diet increased by >1%. The regressions for the two sampling at Newcastle Waters suggested that the grass selected decreased from 5.3 to 3.6% CP, while the non-grass selected decreased from 9.9 to 8.9% CP, during the interval between samplings.

DISCUSSION

Errors in the F.NIRS measurement of the non-grass % were potentially associated with both the use of faecal $\delta^{13}C$ for this purpose, and the F.NIRS prediction of faecal $\delta^{13}C$. First, calculation of dietary non-grass from faecal $\delta^{13}C$ did not allow for any differences in the digestibility of the grass and non-grass fractions of the diet (see Jones 1981). Higher digestibility of the non-grass fraction, as often occurs, leads to slight under-estimation in diet non-grass proportions. If the non-grass is lower in digestibility than the grass, as may occur when browse is ingested, diet non-grass may be over-estimated. Second, the presence of C_4 forbs in the diet may also lead to errors. Third, there will be variable analytical errors bearing in mind that the standard error of prediction (SEP) of 0.83 is equivalent to 6% non-grass.

The F.NIRS measurements presented demonstrate a number of characteristics of the diets selected by cattle through the seasonal cycle in northern Australia. First, diets devoid of non-grass would appear to be uncommon and only rarely occur where grass is either completely or extremely dominant, or at certain times of the year. Secondly, the non-grass species can often comprise a substantial, and sometimes the dominant, component of the diet. The proportion of diet non-grass appears to be associated with the amounts and types of species present, and also with seasonal effects. A high degree of selection for non-grass during the dry season was clearly demonstrated on the NP+stylo pasture at Swans Lagoon, and on the Mitchell grass downs at Toorak. At the latter site, although the proportion of non-grass in the pasture in May 2002 was <2%, diet non-grass averaged almost 15% through the dry season May-December

(Fig.1b). Comparable amounts in 2004 were <20% in the pasture in May but 36% in the diet through the dry season, May-December. Extreme examples of selection for non-grass commonly occur when little grass is available such as during drought.

The results presented, together with numerous comparable F.NIRS measurements of the diet selected by grazing cattle across northern Australia (D.B. Coates, unpublished data), indicate that non-grass often comprises a substantial proportion of the diet selected and that protein in the non-grass components of the diet is often much higher than in the grass fraction. The selection of non-grass material would therefore delay the onset and reduce the severity of the dry season protein deficiency often observed in northern Australia. At Toorak, the similar diet protein concentrations during the two dry seasons, despite the substantial difference in diet non-grass proportions, appeared to contradict this hypothesis. However, it seems likely that this was an unusual situation due to the protein in the grass being lower in 2004 than in 2002. DM digestibility of the diet was lower in 2004 than in 2002 (data not shown) and this would be consistent with a lower leaf-stem ratio and lower grass CP. The late dry season increase in diet non-grass of cattle grazing NP at Swans Lagoon probably reflected an increase in browsing behaviour stimulated by very low grass protein levels and the lack of herbaceous non-grass components in speargrass pastures at that time of year. In contrast, cattle grazing the NP+stylo pasture had access to the perennial seca stylo.

CONCLUSIONS

The contribution of non-grass to the diets of cattle grazing the rangelands of northern Australia can be easily and reliably estimated using faecal NIRS. The non-grass fraction can make a substantial contribution to the diet in terms of proportional DM and protein status. Since the protein level of grass during the dry season is generally well below maintenance requirements for cattle, the edible non-grass components of the vegetation form an important part of the fodder resource, even where grasses dominate.

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