PATTERNS OF METHANE PRODUCTION AND FEED INTAKE IN RUMINANTS

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In Australia greenhouse gas emissions from ruminant livestock industries are significant components of estimated total greenhouse gas emissions from agriculture (Australian Greenhouse Office 2002), the principal emissions being methane (CH_4) and nitrous oxides. There is an increasing effort world-wide to quantify CH_4 emissions from free-ranging ruminants relative to measurements of CH_4 production from ruminants penned in respiration chambers, where the latter have been part of databases used for estimation of metabolisable energy consumption. The rate of CH_4 production in the rumen appears to be limited by the rate of hydrogen production by hydrogenogens and by competition in that environment for hydrogen. Methane production is greatest soon after feeding (Clapperton and Czerkawski 1969; Johnson *et al*. 1994; Machműller *et al*. 2003) when the partial pressure of hydrogen is highest (Smolenski and Robinson 1988) and when substrate availability, and in turn, the rate of fermentation, is greatest. The partial pressure of hydrogen due to the pattern of fermentation in the rumen may be influenced by variation amongst sheep in their feeding behaviours and rates of feed intake (Baker and Car 1999). Grazing ruminants show distinct circadian patterns in eating and ruminating behaviours. For example, Corbett and Pickering (1983) showed circadian variation in the volume of distribution of ^{51}Cr-EDTA during continuous intra-ruminal infusion of the marker indicating circadian variation in mean retention time of digesta in grazing sheep, as has been observed in penned sheep. Methane emissions by grazing sheep, quantified at 1-h intervals, vary between 1.6 and 0.5 L CH_4/sheep/h, and follow patterns in eating and ruminating behaviours, where peaks in CH_4 production generally correspond with peaks in eating activity (Lockyer and Champion 2001).

Murray *et al*. (1999) quantified CH_4 emissions at 1-h intervals from sheep (L CH_4/sheep/h) fed twice daily; CH_4 emissions were high (*ca.* 2.2 L/h) immediately following feeding and declined (to a minimum of *ca.* 0.5L/h) with time after feeding. These data are used here to estimate variation in daily CH_4 emissions if the daily CH_4 emission is estimated by extrapolation from 8-h subsets of measurement of CH_4 emissions. Daily CH_4 emissions were overestimated by 30% if data from the first 8 h after the first daily feeding of the animals are used, overestimated by *ca*. 5% if data from the 8 h after the second daily feeding are used, and underestimated by *ca*. 30% if data from the final 8 h in the 24-h of measurement period are used.

Thus, in a protocol for estimation of daily CH_4 emissions by either grazing or penned ruminants, daily behaviours of the animals must be recognised to accommodate circadian variation in voluntary feed intake and rates of consumption of feed (whether they are imposed or are natural variations). This analysis also supports earlier analyses that 'between animal' and 'between day' variations in CH_4 emissions must be accommodated in experiment protocols and statistical analyses to determine CH_4 emissions by grazing ruminants (Ulyatt *et al*. 1999; Baker *et al.* 2000).

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