Optimum level of ammonia in the rumen liquor of cattle fed tropical pasture hay

A.N. Boniface*, R.M. Murray* and J.P. Hogan**

Summary

Fermentation of Heteropogon contortus in nylon bags in the rumen of steers was studied during stepwise infusion of urea and sulphate that increased dietary N from 4 to 15 g/kg organic matter (OM) and rumen ammonia from <2 to 140 mg N/l. Maximum fermentation was observed at ammonia levels of about 45 mg N/l. However feed intake rose at all levels of N infusion and despite a decline in in vivo OM digestibility at the higher levels of infusion, digestible OM intake also rose throughout the experiment. (Key words: rumen ammonia, intake, digestibility, tropical pasture, cattle).

Introduction

The grazier in northern Australia must decide each dry season when to supplement native pasture with non-protein nitrogen. Ideally the decision should be based on knowledge of the levels of rumen ammonia. Although these can now be measured rapidly in the field (Stephenson et al. 1984), the problem remains of defining optimum ammonia levels since literature reports vary from 50 mg/l (Satter and Slyter 1974) to 190 mg/l (Miller 1973). Further, definitions also vary between optimal ammonia for "maximal rate of fermentation" (Mehrez, Ørskov and McDonald 1977) and "maximal microbial protein production" (Satter and Slyter 1974; Miller 1973). With the animal grazing mature forage, emphasis must be placed on the first definition, for feed intake and nutrient supply both depend on the rate of fermentation, and microbial protein synthesis is an important but secondary consideration. Therefore the level of ammonia which gives maximal rate of digestion must define optimum rumen ammonia. Most of this type of research has involved animals fed high-concentrate diets (Satter and Slyter 1974; Mehrez et al. 1977) and the results for roughage based diets may not fit these observations.

However with roughage-based diets, Krebs and Leng (1983) found that the digestibility of cellulose was enhanced with increasing levels of rumen ammonia up to 210 mg/l. Unfortunately they could not ascribe that response to rumen ammonia alone since nitrogen was supplied in a urea/molasses block. To provide more direct data, an experiment has been conducted to determine the effects of increasing concentrations of rumen ammonia on the intake of roughage and the rate of fermentation of that roughage in the rumen.

Materials and Methods

Four rumen fistulated Brahman-cross steers weighing approximately 180 kg were fed ad lib spear grass hay (Heteropogon contortus) with two thirds of the daily ration offered in the morning and one third in the evening. A mineral supplement, complete less nitrogen and sulphur, was sprinkled on top of the feed (40 g/kg of DM). Portable peristaltic pumps (Corbett et al. 1976) were fitted to the animals and a continuous intra-ruminal infusion of sodium sulphate was maintained during the 12 weeks of the experiment. The experiment was divided into 5 periods. Adaptation during the first period was of 3 weeks and subsequently

* Graduate School of Tropical Veterinary Science, James Cook University, Townsville, Qld. 4811.
** CSIRO Division of Tropical Animal Science, Private Mail Bag, Aitkenvale, Qld. 4814.
of 1 week duration between successive periods. During periods 2 to 5, urea and sodium sulphate with an N to S ratio of 10:1 were infused at various concentrations, increased stepwise over time, to give rumen ammonia levels from 5mg/l to 140 mg/l.

Records were kept of feed consumed. Grab samples of faeces were obtained twice daily during the second week of each period and digestibility was determined using acid insoluble ash (Van Keulan and Young 1977). Mean retention time of rumen fluid was estimated from the decline in concentration of chromium (Cr) following intra-ruminal dosing of 70 mg Cr as Cr-EDTA. Nine samples were obtained over the final 24 hours of the period. Rumen fluid for ammonia analysis was taken twice daily during the second week of each period plus when samples were collected for Cr analysis.

A representative sample of the feed was taken prior to commencement and ground to pass a 1.5 mm screen for use as the substrate in the nylon bag study. The substrate dry matter contained 94.0% OM, 0.42% N, 0.06% S and had an in vitro DM digestibility of 42.1%. Nylon bags (250 x 100 mm, 45 µm pore size) containing 4 g substrate were placed in the rumen for 6, 12, 24, 48 and 72 hours. The bags were removed at 1800 hr on the last day of each period and were washed together with a bag not placed in the rumen (To) until no colour was evident in the wash solution. All bags were then dried and weighed. Percent DM disappearance was calculated after correction for loss from the To bag.

Rumen ammonia was determined by auto-analyser technique (Williams and Twine 1967). Chromium was determined by atomic absorption spectroscopy. Dietary nitrogen content (gN/kg feed OM) was calculated by determining total daily N intake from both feed and infusion and dividing by the total daily organic matter intake. Samples of feed and refusals for each run were analysed for DM, OM, N and acid insoluble ash.

RESULTS

Little nylon bag digestion had taken place by 6 hours. After 12, 24, 48 and 72 hours incubation, the minimum ammonia concentrations giving maximum nylon bag digestibility, determined using the "Plateau" model of Mehrez et al. (1977), were 30, 45, 42 and 45 mg/l respectively (Fig. 1). The lower value at 12 hours may reflect inaccuracy of estimates of the small amount of OM fermented. Maximum fermentation was achieved with dietary N:OM ratios of 0.75-0.85 g/100 g with all periods of incubation (Fig. 2). Nylon bag digestibility appeared to be more closely related to dietary N content ($r^2=0.69$) than to rumen ammonia levels ($r^2=0.56$). Nylon bag digestibility was also related to dietary N expressed relatively to DOM intake (Fig. 3, $r^2=0.70$). The minimum percentage of N to DOM from Fig. 3 for the four incubation periods was calculated to be 1.63, 1.47, 1.59 and 1.59 all suggesting that little response in fermentation to N supplementation would be observed with diets in which the ratio of DOM to CP was less than 10:1. It is clear however that at all ammonia levels, fermentation had not reached a plateau after 72 hours (Fig.4).

Although the experimental periods were short, feed intake appeared to increase linearly with dietary N content ($r^2=0.94$) and to a lesser degree with rumen ammonia levels ($r^2=0.84$); feed intake did not plateau even at the highest level of infusion. With increasing feed intake, the retention time of the soluble marker in the rumen declined from 32.1 to 17.3 hours. Digestibility in vivo (Fig. 6) tended to increase in dietary N to a maximum at 0.8-0.9 g N/100g OM and then to decline but the concurrent increase in feed intake ensured that DOM intake rose at all levels of forage nitrogen.
DISCUSSION

The data illustrate conflicting forces in fibre digestion in the ruminant. Nitrogen supplementation undoubtedly enhanced the fermentation of fibre and presumably enhanced the effectiveness of rumination in reducing plant particle size. Hence feed intake increased to such an extent that although the more rapid passage of particles from the rumen depressed in vivo digestibility, DOM intake also rose. This experiment therefore provided data on ammonia levels needed to support
maximum fermentation of the diet but did not cover a sufficient range to indicate the dietary N or rumen ammonia levels needed to support maximum DOM intakes. The possibility that part of the observed effect was due to the infused sulphur rather than ammonia is currently under investigation.

**Rumen** NH3 concentrations were less than 2 mg/l in period 1 when sulphur alone was provided (0.3 g/day) which might indicate the completeness with which available NH₃ was utilized by the microflora. Although there is some debate on the optimum N:S ratio in dry season supplements, it is generally accepted (Kennedy and Siebert 1972) that S should be provided when urea-N is fed. Producers who have access to the rapid field test (Stephenson et al. 1984) should expect a response from cattle grazing dry season speargrass pasture given a urea-sulphur supplement when rumen ammonia fall below 50 mg N/l.

The level of urea infused to give maximum OM fermentation rates within the rumen corresponded to a per capita supplementation rate of 30 g urea/day. Although DOM intakes were still on the increase at the maximum infusion rate of 80 g urea/head/day, recommendations regarding the optimum level of supplementation cannot be determined from this experiment.

**REFERENCES**


