DIGESTION OF HIGH FIBRE ROUGHAGE IN THE RUMEN OF SHEEP

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SUMMARY

The extent of digestion of high fibre spear grass (Heteropogon contortus) hay by sheep was examined to determine the factors which limit its utilization. The mean organic matter (OM) intake (22 g/kg$^{0.75}$/day) and digestibility (39%) were low and all animals were in negative energy and nitrogen balance. Mean retention time in the rumen for the liquid phase marker (Cr-EDTA) was long (17.9 hours) and 71% of OM digestion took place in the rumen. Total volatile fatty acid production rate was low (0.88 moles/day) representing 11.3 moles/kg OM digested in the rumen. Microbial protein synthesis (3.4 g N/day), measured by ^{35}S incorporation into rumen micro-organisms, accounted for all the non-ammonia nitrogen flowing to the abomasum, representing a net increase over that ingested of 2.4 g N/day.

INTRODUCTION

The importance of spear grass (Heteropogon contortus) among the native grasses to the grazing industry in tropical Queensland has been described by Alexander and Carraill (1973). In spear grass dominant areas this species may contribute up to 90% of the annual yield, the majority of which is produced between December and April, following very closely the rainfall pattern (Shaw and Bisset 1955). Thereafter, with the virtual absence of growth during the dry season, plants in an advanced stage of maturity may decline in quality and are unable to sustain live weight of stock (Siebert and Kennedy 1972). This experiment was conducted to provide information on the nutritive value of spear grass roughage, the quantities of nutrients it can provide, and aspects of nitrogen (N) and energy metabolism of sheep on these diets.

MATERIALS AND METHODS

Four Merino wethers aged two years were used. Each animal was fitted with a rumen and an abomasal "T"-shaped cannula and was housed in an individual metabolism crate. The roughage, harvested during the dry season, consisted predominantly (>90%) of spear grass, and was chaffed before feeding. The dry matter (DM) of the hay contained 92.9% organic matter (OM); the composition of the OM was as follows: cell wall constituents - 81%, acid detergent fibre - 56%, lignin - 9.5%, and crude protein - 2.5%. A preliminary prefeeding period of ten days was used. During the following 15-day period, the sheep were offered one twelfth of their daily ration each two hours between 6 am and 6 pm, after which they were offered the remaining portion of their ration as one meal. Digestibility measurements were made during the last ten days of this period. Throughout the experimental period the animals consumed approximately 60% of the daily ration offered.

$NaH^{14}CO_3$ was continuously infused intravenously on day four and intraruminally on day five. of the experimental period. The intravenous and intraruminal infusates contained'l.0 mg unlabelled $NaHCO_3$/ml and the infusion rates were 0.27 ml/min (0.38 µCi/ml) and 0.45 ml/min (0.44 µCi/ml), respectively. On day seven [U-^{14}C] acetate was continuously infused into the rumen with an infusate containing 0.5 µmoles/ml of acetic acid as carrier and was infused at the rate of 0.45 ml/min (0.29 µCi/ml). The infusion of both tracers was maintained for 11 hours and samples taken each 1½ hours after the initial four hours of infusion.

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Infusate containing $Na_2{}^{35}SO_4$ (0.01 mg S; 0.03 μCi/ml) and Cr-EDTA (0.07 mg Cr/ml) was continuously infused intraruminally for five days at the rate of 0.45 ml/min. During the last two days of infusion, samples of the abomasal and rumen digesta were taken three times daily. After cessation of infusion, rumen liquid was sampled every two hours for 12 hours with an additional sample at 24 hours; rumen digesta was also taken every six hours for 48 hours.

Specific radioactivity of blood and rumen fluid CO_2-carbon was determined by the method of Leng and Leonard (1965). Irreversible loss of CO_2-carbon from the blood and rumen CO_2 pools and the contribution of the primary pool to the secondary pool was calculated as described by Nolan et al. (1976). Total heat production for each sheep was estimated from blood CO_2 entry rate using the regression equation established by Corbett et al. (1971). Total VFA concentrations were determined by steam distillation and molar proportions of individual VFA by gas-liquid chromatography. Production rates of total VFA were determined and calculated as described by Weston and Hogan (1968a). Microbial protein flowing from the rumen was estimated by the method of Walker and Nader (1975) while the microbial-N fraction reaching the abomasum was measured by the method described by Hume (1974). Feed offered and refused, abomasal digesta and faeces were analyzed for total N, neutral detergent fibre (NDF) and lignin, while urine N, rumen ammonia and blood urea were also determined. The flow of digesta at the abomasum was calculated using Cr-EDTA and lignin as markers of the liquid and solid phases respectively, as described by Weston and Hogan (1968c). Metabolizable energy intake was calculated from digestible OM intake (DOMI) as described by NRC (1969).

RESULTS

The mean OM intake of the spear grass was very low, being 22 $g/kg^{0.75}$/day. The values for OM intake and digestion are shown in Table 1. Nitrogen digestibility and nitrogen balance were negative (Table 1).

TABLE 1 Means and standard errors (SE) for intake and digestibility of organic matter (OM) and nitrogen (N), and nitrogen balance for four sheep consuming spear grass (Heteropogon contortus) hay

	OM intake (g/d)	OM digest. (%)	N intake (g/d)	N digest. (%)	N balance (g/d)
Mean	282	39.1	0.96	-45.5	-1.90
SE	11	1.6	0.07	12.6	0.14

Irreversible losses of CO_2-carbon from the blood and rumen fluid were 96.6 ± 14.6 and 32.4 ± 3.5 g C/day respectively. The contribution of blood CO_2 to the rumen CO_2 entry rate was 15.4 ± 1.0 g C/day. The mean metabolizable energy intake, which was calculated to be 1.67 ± 0.09 MJ/day, was considerably less than the energy expenditure estimated from CO_2 entry rate (4.16f0.26 MJ/day).

The proportion of OM and NDF digestion occurring in the rumen was 71% and 94% respectively. The mean concentration of total VFA in the rumen fluid of sheep was 42.2 ± 2.15 m-moles/l, consisting of 74 ± 1.3% acetic acid, 20 ± 1.1% propionic acid and 6 ± 0.5% butyric plus longer chain acids. Total VFA production rate was low (0.88 ± 0.04 moles/day) and represented 8.0 moles/kg DOMI.

Mean blood urea-N concentrations were 62.8 ± 15.4 mg N/l while the mean value for rumen fluid ammonia-N was 21.3 ± 7.9 mg N/l. The mean retention time (MRT) for the liquid phase marker (Cr-EDTA) in the rumen was 17.9 hours. The

parameters related with flow of microbial nitrogen from the fore-stomachs are given in Table 2.

TABLE 2 Organic matter (OM), total N, non-ammonia N (NAN), and microbial-N flowing from the fore-stomachs of four sheep consuming spear grass (Heteropogon contortus) hay

	Mean	SE
RUMEN		
Flow of microbial-sulphur (g S/day)	0.27	0.02
Microbial nitrogen : sulphur ratio	12.7	0.46
Flow of microbial-N (g N/day)	3.4	0.25
ABOMASUM		
Flow of OM (g OM/day)	204	18.7
Flow of total N (g N/day)	3.7	0.34
Flow of NAN (g N/day)	3.4	0.10
NAN of microbial origin (%)	76.9	-
Flow of microbial NAN (g N/day)	2.6	0.08

DISCUSSION

The nutritional quality of tropical spear grass pastures during the dry season is generally extremely poor, and beef cattle usually suffer considerable weight loss during this period (Alexander and Carraill 1973). Siebert and Kennedy (1972) working with sheep found digestibility and intake of spear grass to be low. In the present experiment, the digestibility was also very low (39%), and intake so seriously depressed (22 g/kg$^{0.75}$/day) that the sheep were in negative balance for both energy and nitrogen. With such roughage, the main factors affecting intake are likely to be nutrient deficiencies (Hume et al. 1970) and the resistance of the digesta to removal from the reticulo-rumen (Weston and Hogan 1968b). The MRT within the rumen for the liquid digesta phase was quite long (18 hours), compared with that of 9 hours recorded for mature rye-grass hay diets by Weston and Hogan (1968b) indicating the importance of resistance of digesta to removal from the reticulo-rumen in determining the level of intake of high fibre tropical native forages (Thornton and Minson 1972).

Rate of digestion within the rumen was slow as indicated by the low total VFA production rate (<1.0 moles/day). Nevertheless the proportion of DOMI which was degraded by fermentation in the rumen (71%) compares favourably with that for better quality diets, each kg OM digested in the rumen producing 11.3 moles VFA from spear grass and 11.7 moles from fresh rye grass and white clover diets (Walker et al. 1975). While the high fibre (81% NDF) and lignin (10%) contentsof the forage would have inhibited fermentation, also the N level was very low (0.4%). The low dietary N content was reflected in the low rumen fluid ammonia concentrations which were less than half the value of 50 mg NH_3-N/l proposed by Satter and Slyter (1972) as the level at which this metabolite becomes limiting. Rate of digestion and hence intake of these dry season spear grass pastures was probably inhibited by the low rumen ammonia concentrations. Adequate supplementation with non-protein nitrogen should therefore be of benefit, provided cognizance is taken of the concurrent need for sulphur (Kennedy and Siebert 1972).

The mean value found for the microbial N:S ratio' (12.7), while considerably lower than the range of 20-25 suggested by Bird (1973), was similar to the average ratio of 13.1 described by Walker and Nader (1975). The flow of microbial-N from the rumen (3.4 g/day) measured by the method of Walker and Nader (1975) was greater than that measured at the abomasum (2.6 g/day) by the method of Hume

(1974). The former method estimated that all the NAN reaching the abomasum was of microbial origin, supporting the findings of Leibholz (1972) for low quality roughage. However the latter method calculated that only 77% of NAN at the abomasum was microbial-N. This discrepancy could be the consequence of unrepresentative sampling from single cannulae which was also observed by Hume (1974). Because of the difficulties associated with maintaining and sampling from abomasal and duodenal cannulae, it is suggested that where ^{35}S is to be used to measure microbial protein production, the method of rumen dilution may have advantages, especially under grazing conditions.

The total N flowing to the small intestine represented a net increase over that ingested of 2.7 g N/day. This net gain of N is in agreement with the observations of Weston and Hogan (1968b) and Leibholz (1972) on other low N, high fibre diets. Part of this extra N would be derived from salivary urea recycled to the rumen, while the remainder could result from the transfer of other endogenous NAN (MacRae et al. 1977). From the regression equation of Norton et al. (1978) it can be estimated that urea degraded in the rumen contributed 1.3 g N/day, representing 35% of the net gain of N at the abomasum. This net gain is slightly higher than the 23-32% reported for low N herbage by MacRae et al. (1977) as the additional NAN reaching the duodenum that can be accounted for by urea-N recycled to the rumen. A comparison of other tropical native grasses, Mitchell grass and Flinders grass, during the dry season (Norton et al. 1978) would suggest that spear grass is of extremely low nutritive value. This could be due to leaching of the proteins and other plant solubles by winter frosts and dews, which occur in the spear grass regions, in addition to differences in quality between species.

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