
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Comparitive nutrition of deer and goats, goats and sheep

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ABSTRACT

The digestive efficiency of deer, goats and sheep fed on chaffed lucerne hay was compared during summer (S) and winter (W). VFI, rumen pool size and rumen ammonia concentration showed seasonal cycles in red deer, with maximum values in S and minimum values in W, whereas rumen FOR showed lower values in S than in W, especially for particulate matter. Despite an increase in VFI, deer were thus able to maintain DM and fibre digestibility in S, due to simultaneously increasing rumen size and reducing outflow rate. Goats showed higher fibre digestibility relative to sheep, associated with a larger proportion of small particles in rumen digesta. Goats also had the highest rate of rumen ammonia production. Relative to goats and sheep, deer showed very low levels of VFI and rumen pool size in W, emphasising the importance of understanding the factors controlling winter inappetence in red deer, whilst the superior fibre digesting capability of goats suggests they could be most efficiently used to utilise low quality fibrous feeds.

Keywords Deer; goats; sheep; digestive efficiency; summer vs winter

INTRODUCTION

Although some studies have compared the digestive efficiency of goats with sheep (Watson and Norton, 1982; Alam *et al.*, 1985; Antoniou and Hadjipanayiotou, 1985) and others have compared digestion in deer and sheep (Milne *et al.*, 1978; Fennessy *et al.*, 1980), there has not been a study which simultaneously compared digestion in all three species. The first objective of the present study was to compare digestive efficiency in deer, goats and sheep during summer (S) and winter (W), with the same diet being fed in all instances.

Whilst voluntary feed intake (VFI) in red deer is known to follow a seasonal pattern, with maximum values in S and minimum values in W (Kay, 1985; Barry *et al.*, 1990), there is no information about seasonal changes of digestive function in this species. Milne *et al.* (1978) obtained indirect measures of mean retention time (MRT) of the particulate marker ruthenium phenanthroline (Ru P) in the rumen and caecum of sheep and red deer, but there are no measures of MRT or its reciprocal, fractional outflow rate (FOR), using direct sampling from the rumen in red deer. An objective of the present study was to measure seasonal changes (S *vs* W) in VFI, apparent digestibility, rumen pool size and rumen For (water and particulate) and other aspects of digestive function in red deer, goats and sheep fed an identical roughage diet.

MATERIALS AND METHODS

Five hand reared castrate male red deer, seven Angora x N.Z. castrate male feral goats and eight Border Leicester x Romney castrate male sheep were used as experimental animals. All were aged 2´ years when the experiment commenced, and mean weights at that time (SD) were deer 94.8 (5.46) kg, goats 42.5 (4.83) kg and sheep 57.5 (6.58) kg. All were fistulated in the rumen. For a five week period during S (November-December) and W (May-June) the animals were kept indoors in metabolism cages and fed chaffed lucerne hay at hourly intervals from overhead feeders. Intake was *ad libitum*, allowing for a 15% level of feed refusals. After an adaptation period of 12 days, VFI and apparent digestibility were determined over an 8 day period. Rumen fractional outflow rate of Cr EDTA and ruthenium phenanthroline (Ru P) were then determined after a 5 day continuous intra-ruminal infusion of the two markers, using the continuous infusion and total sampling method (Faichney, 1975). Particle size analysis was determined for rumen contents and faeces, using a wet sieving procedure (Evans *et al.*, 1973), with the sieve

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sizes being 4.0, 2.0, 1.0, 0.5 and 0.25 mm (square hole). Particle size as the threshold to passage out of the rumen was established, and apparent FOR for particles below this size calculated on the assumption that there was no further reduction in particle size posterior to the rumen (Poppi *et al.,* 1980). Samples for rumen ammonia concentration were obtained on 6 occasions, using metal probes suspended in the rumen, whilst ammonia irreversible loss (IRL) from the rumen was determined from continuous infusion of 15N ammonium chloride, mixed with the Cr EDTA/Ru P marker solution. IRL measures rumen ammonia production rate, whilst Cr EDTA associates with liquid and Ru P (external) and lignin (internal) are rumen particulate matter markers.

Between feeding periods, all animals were grazed on fresh perennial ryegrass/white clover pasture of high digestibility. Further details are given by Domingue (1989) and Domingue *et al.*, (1991a).

RESULTS

The domestic sheep showed no seasonal variation in VFI, rumen pool size, apparent DM digestibility or rumen FOR (Table 1). Goats showed an increase in VFI (+ 20%) and rumen pool size (+ 27%) from W to S, but this was accompanied by a significant reduction in DM digestibility ($P < 0.01$) and a small but non-significant increase in the rumen FOR of Cr EDTA, Ru P and lignin. Goats digested fibre more efficiently than sheep during W ($P < 0.001$), when VFI was similar for the two species. During S, when VFI was considerably greater for goats than for sheep ($P < 0.05$), there was no difference between the two species in fibre digestibility.

Deer showed a marked increase in VFI (+ 34%) and rumen pool size (+ 51%), from W to S, this being accompanied by no change in apparent DM and fibre digestibility and decreases in rumen FOR, which were of substantial magnitude for lignin and particles passing a 1 mm mesh sieve ($P = 0.16$). Fibre digestibility was consistently higher than for sheep, in both W ($P = 0.13$) and in S ($P = 0.09$). Particles had to be reduced in size sufficient to pass through a 1 mm square sieve, in order to leave the rumen of deer, goats and sheep, since 98% of particles in the faeces were < 1 mm, with there being no differences between the three species. However, rumen digesta of goats contained significantly more particles < 1 mm than that of sheep or deer ($P < 0.05$).

TABLE 1 Voluntary feed intake, apparent digestibility and rumen fractional outflow rate (FOR) in castrate male red deer, goats and sheep fed lucerne chaff during summer (S) and during winter (W).

		Deer	Goats	Sheep	SEM
VFI (g/kg $W^{0.75}$/d)	S	62.5	68.7	52.2	3.20
	W	46.7	57.4	54.8	4.24
Rumen pool size (g/kg $W^{0.75}$)					
	S	289	340	275	17.5
	W	191	268	307	13.4
Digestibility:					
Dry matter (%)	S	56.7	55.9	54.2	0.44
	W	54.7	62.0	55.9	0.78
Fibre	S	44.6	42.6	41.3	0.65
	W	40.1	45.2	36.6	0.80
Rumen FOR (%/h):					
Cr EDTA	S	15.8	10.8	10.4	0.54
	W	16.3	9.6	10.3	0.56
Ru P	S	7.0	7.6	6.9	0.38
	W	7.6	6.8	6.9	0.34
Lignin	S	2.77	3.66	3.32	0.163
	W	3.47	3.47	3.29	0.142
Particles passing 1 mm sieve					
	S*	3.55	3.26	3.47	0.140
	W	4.36	3.30	3.58	0.200
Rumen particle size:					
< 1 mm sieve (% total)	W	67.4	84.9	74.0	1.45

* Calculated as lignin FOR (S) x $\frac{\text{particle FOR (W)}}{\text{lignin FOR (W)}}$

Rumen water FOR, as marked by Cr EDTA, was substantially greater for deer than for sheep and goats, during both W and S ($P < 0.01$). Relative to sheep and goats, deer had a very low VFI and rumen pool size during W ($P < 0.05$).

Rumen ammonia concentration in deer was substantially lower in W than in S ($P < 0.01$) (Table 2), but showed no seasonal trends with sheep and goats. Rumen ammonia IRL, measured in winter, was in the order goats > sheep > deer, with the difference between deer and goats attaining significance ($P < 0.05$).

TABLE 2 Rumen ammonia concentration and kinetics in castrate male red deer, goats and sheep fed lucerne chaff *ad libitum* during summer (S) and during winter (W).

		Deer	Goats	Sheep	SE
N intake (g/kg $W^{0.75}$/d)	S	1.90	1.95	1.43	0.076
	W	1.44	1.65	1.61	0.095
Rumen ammonia:					
Concentration (mg N/l)	S	172	158	181	5.5
	W	110	165	172	6.3
IRL (mg N/g N l/d)	W	535	692	607	35.9

DISCUSSION

The present experiments have confirmed the seasonal pattern of VFI in deer, with a maximum in S and a minimum in W, and in addition shown that this is accompanied by seasonal changes in a range of digestive measurements, including rumen pool size, rumen FOR and rumen ammonia concentration. Increases in VFI during S in deer might be expected to result in increases in rumen FOR and a decrease in apparent digestibility, as occurred with goats. However, deer showed no such reduction in apparent digestibility during S, due to simultaneously increasing rumen size whilst decreasing the outflow rate (FOR), especially of particulate matter. In contrast to the results of Milne *et al.*, (1978), we found greater fibre digestibility in red deer than in sheep, in agreement with the results of Fennessy *et al.*, (1980).

Increases in rumen ammonia concentration can be expected to be related to increases in rumen ammonia IRL (Siddons *et al.*, 1985). Thus, as rumen ammonia concentration increased in deer from W to S, it could be expected that IRL (i.e. ammonia production rate) would also increase in S, thus giving a seasonal cycle in N recycling to the rumen. This is currently under investigation in our laboratory.

In common with other authors, we have obtained greater fibre digestibility in goats than in sheep (Watson and Norton, 1982; Doyle *et al.*, 1984; Howe *et al.*, 1988). Two principal reasons may be involved. Firstly, goats have a larger proportion of rumen particulate matter of smaller particle size (Table 1), and this can be associated with a longer time spent eating than sheep and the eating process being more efficient in goats in reducing particle size (Domingue *et al.*, 1991b). Smaller particle sizes give a larger surface area for microbial attachment and hence the opportunity for enhanced fibre digestion (Cheng *et al.*, 1977; Akin, 1979). Secondly, rumen ammonia IRL tends to be greater in goats than in sheep and deer (Table 2), probably associated with a greater recycling of N into the rumen as saliva (Domingue *et al.*, 1991b). Domingue *et al.* (1990c) also obtained similar results with goats and sheep fed low quality thrashed prairie grass straw. The greater N recycling capacity of goats may be important in maintaining a higher rumen ammonia concentration, and hence encouraging greater fibre digestion, when low quality diets are fed.

The present study has shown the extremely low values for VFI, rumen pool size, rumen ammonia concentration and rumen ammonia production rate in red deer during W relative to the other species used. In the wild state, this may represent an adaptation to feed supply, which will be very low during W at the high N latitudes where red deer evolved. However, under farming conditions, low rates of body growth and VFI of stags during W are a major constraint to efficient venison production from farmed stags (Ataja *et al.*, 1989, 1990). It is therefore important that we obtain a fundamental knowledge of factors controlling winter inappetence in deer, in order to remove a major constraint to efficient venison production.

The present study has also highlighted the superior fibre digestive capacity of the goat, due to its greater efficiency in particle size reduction and better N recycling capacity to the rumen. These findings help explain the increased superiority of goats over sheep as dietary fibre content increases and N content decreases (Alam *et al.*, 1985; Howe *et al.*, 1988), and indicate that for greatest biological efficiency goats could be used in New Zealand to utilise low quality roughages.

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