The efficiency of chewing during eating and ruminating in goats and sheep

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The total amounts of time spent eating and ruminating per 24 h by goats and sheep were determined. The efficiencies of chewing during eating (⟨C.EAT⟩) and chewing during ruminating (⟨C.RUM⟩) on the breakdown of feed particles to below the critical size required to leave the rumen (< 1·0 mm) were investigated. All studies were done with the animals fed on a chaffed lucerne (*Medicago sativa*) hay diet. Goats spent more time eating (+3·1 h; $P < 0·01$), and less time ruminating (−2·2 h; $P < 0·05$) per 24 h, than sheep, when fed hourly at *ad lib.* intake. The efficiency of chewing during eating (⟨C.EAT⟩) in breaking down feed particles to < 1·0 mm was greater in goats (85 %; $P < 0·01$) than sheep (48 %). The process of rumination in sheep served to reduce the feed particles which were > 1·0 mm in the rumen to < 1·0 mm. Sheep tended to be more efficient in this process than goats (59 *v.* 48 %), with the difference not attaining significance ($P > 0·1$). The greater frequency of chews (number of total jaw movements/min) during eating in goats ($P < 0·01$), or during ruminating in sheep ($P < 0·001$), was the major component explaining differences in efficiency between the two species in both the eating and rumination processes. When corrected for the number of chews/min, the differences in ⟨C.RUM⟩ and ⟨C.EAT⟩ were not significant between goats and sheep. During eating goats had greater apparent rates of total salivary secretion ($P < 0·1$), and greater apparent rates of salivary nitrogen secretion ($P < 0·05$) than sheep. The results help explain the greater fibre digestibility and rumen ammonia irreversible loss rates in goats than sheep, when both species were fed on lucerne chaff.

Eating: Ruminating: Chewing: Sheep: Goats

The breakdown of particulate dry matter (DM) in the rumen affects the clearance of digesta from the rumen, and hence voluntary feed intake (Ulyatt *et al.* 1986). Feed particles cannot leave the rumen until they have been reduced to < 1·0 mm, which is the critical threshold size to passage through the reticulo-omasal orifice, for both sheep and goats (Reid *et al.* 1979; Poppi *et al.* 1980; Domingue, 1989).

Two processes affect the breakdown of particulate DM in ruminants (Ulyatt *et al.* 1986), namely: (1) initial chewing during eating, and (2) further chewing during rumination.

Microbial digestion *per se* does not contribute to particle size reduction (Ulyatt, 1983), but assists in weakening plant cell-wall material in the rumen and facilitates particle size breakdown during rumination (Evans *et al.* 1974; Chai *et al.* 1984; Ulyatt *et al.* 1986).

It has been observed that the proportion of small particles (< 1·0 mm) in the rumen digesta of goats was larger than in sheep, when they were fed both on low and medium quality forages (Domingue, 1989; Domingue *et al.* 1991). Domingue (1989) concluded that goats were more efficient 'chewers' than sheep. However, it was not possible to discriminate between effects due to the amount of time spent chewing/24 h, either eating or ruminating in the two species, or between inter-species differences in the efficiencies of

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chewing during eating or ruminating, or both, on the breakdown of feed particles. There is no published information on the efficiencies of chewing during eating and rumination on the breakdown of feed particles in goats. Findings have been reported for sheep (Dulphy *et al.* 1980; Ulyatt *et al.* 1986), and for cattle (Gill *et al.* 1966; Kennedy *et al.* 1986), when fed both on fresh forages and dried feeds.

The objectives of the present study were to determine the total amounts of time spent eating and ruminating/24 h in goats and sheep, when fed on a medium quality forage. One limited study by Geoffroy (1974), indicated that goats spent less time ruminating than sheep, and slightly more time eating than sheep. A further objective of the study was to determine the efficiency of chewing on particle size breakdown by goats and sheep during eating. The rate of eating (g DM/min), number of chews/min spent eating, number of chews/g DM intake (DMI), and the particle size distribution of the boli that had been chewed once (percentage of particles in the DM), were determined. The efficiency of chewing during rumination on particle size breakdown by goats and sheep was also studied. The number of chews/min spent ruminating and the contribution of rumination to breakdown of feed particles (percentage of particles in the DM) were investigated.

EXPERIMENTAL

Diet

Lucerne hay (*Medicago sativa*) was used, containing 903 g organic matter (OM)/kg dry matter (DM), 25·9 g nitrogen/kg DM and of 0·57 DM digestibility as determined in vivo (Domingue, 1989). The animals were allowed free access to a multimineral salt block (50 g; Dominion Salt (NZ) Ltd), placed in the feed bin. The hay was chaffed into 50–80 mm lengths.

Animals

Five Border-Leicester × Romney cross wethers aged 3·5 years and weighing 66·8 (SD 4·39) kg live weight (LW), and five castrated Angora–NZ feral goats, aged 3·5 years and weighing 44·6 (SD 3·08) kg LW, were used. They were all fistulated in the rumen, and fitted with permanent rubber cannulas (i.d. 63 mm). They were housed individually in conventional metabolic crates and kept under continuous fluorescent lighting.

Experimental design

The preliminary period was of 12 d duration (d1–d12), when the animals were fed *ad lib.* with feed offered being 1·15 of the previous day's consumption. The lucerne chaff was placed on belt-feeders which delivered the day's ration in twenty-four feeds, at 1 h intervals. Jaw harnesses were fitted on the animals on day 5 of the preliminary period, and left on for increasing periods of time, until the animals got used to the harnesses. Three experiments were conducted, and the following were investigated: time spent chewing when eating and ruminating/24 h (Expt 1); efficiency of chewing during eating (Expt 2), and efficiency of chewing during ruminating (Expt 3) upon particle breakdown. During days 13–27, the animals were offered 0·90 of the feed offered during days 1–12, i.e. 1·035 of the previously determined voluntary food intake, so that intake was still *ad lib.* but there was little or no diet selection. A small feed residue was hence present in the feed bin at all times, expect for the 1 h period immediately after feeding.

Expt 1. Determination of time spent eating and ruminating/24 h. Four goats and four sheep were taken from those described previously. They were fitted with jaw harnesses, adapted to record automatically the time period spent chewing during eating, rumination and resting. Jaw activity was obtained by sensing the compression of a balloon held under the jaw by the harness, and connected to a pressure transducer (Biocom Type 1010 C),

mounted away from the animals. Records of the jaw activity were made on multi-channel heat sensitive chart paper, with a chart drive of 2·5 mm/min. Recordings were made continuously for four consecutive days (days 15–17) on all animals. Records were made of total jaw movements, referred to as chews; no attempt was made to divide these into prehension and mastication bites.

Expt 2. Efficiency of chewing during eating. This was estimated on one occasion in five goats and five sheep over the period days 19–22. The animals were fitted with jaw harnesses 1 d before the start of the measurements. The rumen of the animals was emptied ('bailed') at 09.00 hours, and the digesta kept warm over a bucket of hot water (70°). The drinking water and salt block were removed. The animals were then offered a 'test-meal' of 200 g DM for the goats and 250 g DM for the sheep, for 30 min. Continuous jaw movements were recorded during the 30-min eating period, with the heat sensitive chart paper travelling at 1 mm/s. This allowed a counting of the actual number of chews/min spent eating.

At the end of the 30-min eating period, any feed residues were removed, weighed, and the dry matter intake (DMI) (g) recorded. The animals were then 'bailed' again, and the total pool of boli present in the rumen, which had been chewed during eating only and swallowed once, was collected through the rumen fistula and weighed. Subsamples were taken for: (1) triplicate determinations of DM by freeze-drying, (2) particle size analysis, (3) total N (relative to DM and OM). The previously-warmed rumen digesta was then returned to the animals.

Expt 3. Efficiency of chewing during rumination. The experiment was carried out over days 25–27 with the same five goats and five sheep, with the measurements being recorded on two goats and two sheep daily. The animals were fitted with the jaw harnesses 1 d before the measurement period. The animals were offered a 'test-meal' at 08.00 hours, for 3 h, 500 g DM for goats and 600 g DM for sheep. At 11.00 hours, the feed refusals from the 'test-meal' were removed, weighed and the DMI (g) determined. Drinking water and the salt block were removed. Jaw movements of rumination only were recorded from 11.00 hours to 19.00 hours. The speed of the heat sensitive chart paper was set at 1 mm/s to allow the counting of actual number of chews/min spent ruminating.

The animals were 'bailed' at 14.00 and 19.00 hours. At each 'bailing', the rumen digesta was weighed, mixed thoroughly, subsampled and returned back to the animal. Subsamples of rumen digesta were taken for: (1) triplicate DM determinations, and (2) particle size analysis for calculation of the efficiency of chewing during rumination in breaking down feed particles in the rumen between 14.00 and 19.00 hours.

Laboratory methods

The feed offered and rumen digesta were analysed for total N by the Kjeldahl method and OM by ashing overnight at 550°. The DM of the boli was determined by freeze-drying for 5 d, until no further loss is weight occurred (FD 57 freeze-dryer; WCG Cuddon (NZ) Ltd).

The particle size distribution of feed and rumen digesta samples was determined by wet sieving, using the apparatus (Turner & Newall Ltd) described by Evans *et al.* (1973). Sieve sizes (length of side of square hole) were 4·0, 2·0, 1·0, 0·5 and 0·25 mm. The samples were washed by recirculation of 1300 ml water, at a flow rate of 4 l/min through the sieves for 5 min. Feed samples were soaked in 100 ml artificial saliva (Baumgardt *et al.* 1962), for 15 min before sieving. Material retained on the sieves was washed onto tared filter paper (Whatman No. 21), in a Buchner funnel, and oven-dried at 100°, for 24 h to determine the dry weight of each particle size fraction. Material not retained on the sieves ($< 0{\cdot}25$ mm particles), was determined by difference from the initial sample dry weight and the sum of recovered particulate DM fractions.

Calculations

Expt 1. Each of the 4 d recording periods was divided into twelve 2 h periods, and the time period spent eating, ruminating and resting counted for each period, per day, and per animal. Mean values of the 4 d were then calculated for each animal, and a 24 h rumination and eating cycle for goats (n 4) and sheep (n 4) determined.

Expt 2. The number of chews/min were counted for each animal for ten periods of 60 s (representing 600 mm on the chart paper). Mean values for the number of chews/min spent eating and the number of chews/g DMI, were then calculated for each goat and sheep.

An index of efficiency of chewing during eating (⟨C.EAT⟩) in reducing particle size to < 1·0 mm was calculated.

$$\langle \text{C.EAT} \rangle = \frac{(\text{g DM} < 1{\cdot}0 \text{ mm in boli} - \text{g DM consumed} < 1{\cdot}0 \text{ mm})}{(\text{g DM of feed consumed} > 1{\cdot}0 \text{ mm}).} \quad (1)$$

⟨C.EAT⟩ was also expressed as (1) divided by the number of chews/g DMI, which gives an index of the efficiency of each chew during eating in reducing particle size.

The apparent salivary secretion (g/g DMI and g/g OM intake (OMI)) was calculated.

Apparent salivary secretion (g/g DMI) =
(Total pool (g) of boli (DM + water) − Feed (g) intake (DM + water))/g DMI. (2)
Apparent salivary secretion (g/g OMI) =
(Total pool (g) of boli (OM + water) − Feed (g) intake (OM + water))/g OMI. (3)

The apparent salivary secretion represents the combined values for saliva secreted during the 30-min eating period, and the balance of water flows into and out of the rumen during the course of the measurement period.

The apparent salivary N secretion rate (mg N/g OMI) was calculated from the difference between total N in the rumen boli and total N in the test meal consumed. The total N concentration in the apparent saliva (mg N/g saliva OM) was also calculated.

Expt 3. The number of chews/min was counted for each animal for fifteen periods of 60 s (three periods of 60 s/h, from 14.00 to 19.00 hours), during the measurement period. Mean values for the number of chews/min during ruminating were then obtained for each animal over this period. The total time spent ruminating (h) was determined for each animal during the 5 h measurement period, and the total number of chews calculated.

The proportion of particles > 1·0 mm in the rumen digesta was determined at 14.00 and at 19.00 hours. An index of efficiency, for chewing during rumination (⟨C.RUM⟩) in breaking down feed particles > 1·0 mm during that period of 5 h (14.00–19.00 hours), was calculated as the reduction in the pool size of particles > 1·0 mm between 14.00 and 19.00 hours as a proportion of the pool size of such particles at 14.00 hours.

The calculation is based on the assumption that feed particles > 1·0 mm cannot leave the rumen (Grenet, 1970; Poppi *et al.* 1980; Domingue *et al.* 1991), for both sheep and goats. Hence, the reduction in the rumen pool size of particles > 1·0 mm during the period of 14.00–19.00 hours was due only to rumination, without any loss of particles > 1·0 mm flowing out of the rumen. ⟨C.RUM⟩ was also divided by the total number of chews during ruminating during the 5 h measurement period, to given an index of the efficiency of each chew during rumination in reducing particle size.

Statistical methods

A complete randomized design was used, with comparisons between goats and sheep being made using one-way analysis of variance. Mean values with their standard error of the difference (SED) are presented.

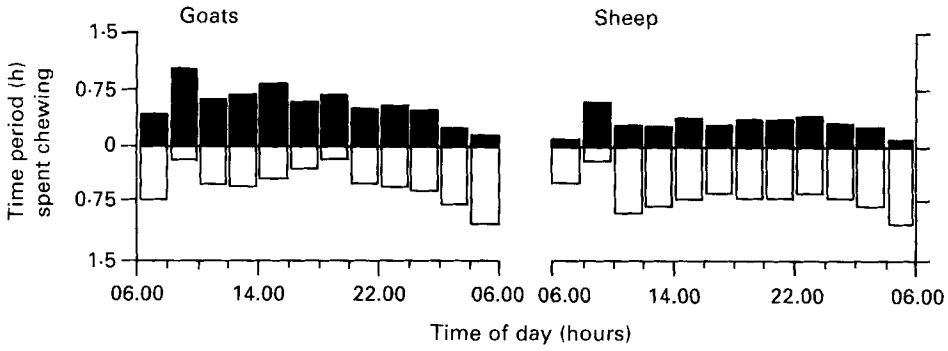

Fig. 1 Expt 1. Time period (h/2 h period) spent chewing during eating (■) and ruminating (□) over a 24 h period, by goats and sheep, fed *ad lib.* on lucerne (*Medicago sativa*) hay. The animals were fed hourly, with the day's ration placed on the automatic feeder at 08.00 hours. For details of procedures, see pp. 356–357.

Table 1. *Expt 1.‡ Time period (h/24 h) spent chewing during eating (EAT) and ruminating (RUM) in goats and sheep, fed* ad lib. *on lucerne* (Medicago sativa) *hay*

(Mean values with their standard error of difference (SED) for four goats and four sheep)

Time	Chewing behaviour	Goats	Sheep	SED	Statistical significance
24 h period:	RUM	6·1	8·3	0·69	*
	EAT	6·8	3·7	0·57	**
	(RUM+EAT)	12·9	12·0	0·37	NS
	RUM:EAT	0·92	2·29	0·276	**
Day: 06.00–18.00 hours	RUM	2·7	3·7	0·35	*
	EAT	4·3	2·0	0·35	***
	(RUM+EAT)	7·0	5·7	0·16	**
Night: 18.00–06.00 hours	RUM	3·5	4·6	0·44	†
	EAT	2·6	1·7	0·33	*
	(RUM+EAT)	6·1	6·3	0·27	NS
Dry matter intake: (g/kg $LW^{0·75}$ per d)		56·2	52·4	3·94	NS
(kg/d)		1·02	1·28	0·044	NS

LW, live weight; NS, not significant ($P > 0·1$).
* $P < 0·05$; ** $P < 0·01$; *** $P < 0·001$; † $P < 0·1$.
‡ For details of procedures, see pp. 356–357.

RESULTS

Expt 1. Time period spent eating and ruminating/24 h

There were no significant differences in voluntary DMI (g/kg $W^{0·75}$ per d), between goats and sheep when fed on lucerne hay. Fig. 1 and Table 1 show that, over a period of 24 h, goats spent 3·1 h longer ($P < 0·01$) chewing during eating than sheep. This comprised 2 h more during the day and 1 h more during the night.

The total amount of time spent ruminating/24 h by goats was lower (2·2 h less; $P < 0·05$) than in sheep, comprising 1 h less during both the day and night periods. There were no differences ($P > 0·1$) between the two species in the total amount of time spent chewing/24 h.

Table 2. *Expt 2.‡ Efficiency of chewing during eating (⟨C.EAT⟩) on the breakdown of feed particles§ by goats and sheep, fed on lucerne* (Medicago sativa) *hay*

(Mean values with their standard error of the difference (SED) for five goats and five sheep)

	Goats	Sheep	SED	Statistical significance
Feeding behaviour:				
Intake rate: (g DM/min)‖	3·71	6·02	1·08	†
(g DM/kg $W^{0·75}$ per min)	0·20	0·24	0·024	NS
No. of chews: min eating‖	154	128	3·7	**
: g DMI	44	21	9·8	†
Particle size distribution (mm) in rumen boli (% dietary DM retained on sieve):				
> 4·0	5·4	19·3	1·90	***
2·0	4·7	7·2	1·06	*
1·0	11·3	12·9	4·32	NS
0·5	15·7	10·3	1·20	**
0·25	24·9	20·1	1·62	*
< 0·25	38·0	30·3	5·46	NS
Total > 1·0	21·4	39·4	6·08	*
Total < 1·0	78·6	60·6	6·08	*
⟨C.EAT⟩	0·85	0·48	0·068	**
⟨C.EAT⟩/chew	0·021	0·024	0·0050	NS
Apparent salivary secretion¶:				
g/g DMI	7·8	5·8	0·97	†
g/g OMI	8·7	6·5	1·08	†
Apparent salivary-N secretion rate (mg/g OMI)	13·0	3·3	3·65	*
N in apparent saliva secretion (mg/g OM)	1·48	0·50	0·42	†

LW, live weight; NS, not significant ($P > 0·1$). DM, dry matter; DMI, DM intake; OM, organic matter; OMI, OM intake.

* $P < 0·05$; ** $P < 0·01$; *** $P < 0·001$; † $P < 0·1$.

‡ For details of procedures, see p. 357.

§ Feed particle size > 1·0 mm for lucerne chaff fed was 95·2%.

‖ Test meal offered for 30 min.

¶ Salivary secretion + net water flow into rumen.

Expt 2. Efficiency of chewing during eating on the breakdown of feed particles

The rate of eating (g DMI/min) was faster ($P = 0·07$) in sheep (+62%), than in goats (Table 2), but when the rate of eating was expressed as g DMI/kg $LW^{0·75}$ per min, the differences between goats and sheep were not significant ($P > 0·1$). The frequency of chewing during eating (number of chews/min) was greater ($P < 0·01$) in goats than in sheep. Hence, the number of chews/g DMI during eating in goats was 106% greater than in sheep, with the difference attaining significance at $P = 0·08$.

The calculated index of efficiency during eating (⟨C.EAT⟩) showed the greater effectiveness of goats (+77%) in reducing the feed particles to below the threshold (1·0 mm sieve) to passage, than sheep ($P < 0·01$). When ⟨C.EAT⟩ was expressed per chew, there was no significant difference between goats and sheep ($P > 0·1$). Table 2 shows that the boli which were chewed during eating only and swallowed once, contained significantly greater percentages (% of dietary DM retained on sieves) of small particles (passing 0·5 and 0·25 mm sieves), and smaller percentages of large particles (retained on 4·0 mm and 2·0 mm sieves) for goats than for sheep.

The calculated apparent salivary secretion (g/g DMI and g/g OMI) was greater during eating in goats than in sheep ($P = 0·08$). The calculated apparent salivary N secretion rate

Table 3. *Expt 3. Efficiency of chewing during ruminating (⟨C.RUM⟩) by goats and sheep, on the breakdown of feed particles > 1·0 mm during a 5 h period (14.00–19.00 hours)*

(Mean values with their standard error of the difference (SED) for five goats and five sheep)

	Goats	Sheep	SED	Statistical significance
Total number of chews (14.00–19.00 hours)	7631	9878	1261	NS
Time period (h) spent ruminating (14.00–19.00 hours)	1·62	1·64	0·216	NS
Number of chews/min ruminating	79	100	2·0	***
⟨C.RUM⟩	0·48	0·59	0·139	NS
⟨C.RUM⟩/chew	0·006	0·006	0·0015	NS

NS, not significant ($P > 0·1$).
*** $P < 0·001$.

(mg N/g OMI) ($P < 0·05$), and the calculated N concentration in apparent saliva (mg N/g OM saliva) ($P = 0·06$), were also greater in goats than in sheep.

Expt 3. Efficiency of chewing during ruminating on the breakdown of feed particles

The number of chews/min spent ruminating was lower ($P < 0·001$) in goats than in sheep (Table 3). Both goats and sheep spent 32–33% of the 5 h measurement period ruminating ($P > 0·1$).

The calculated efficiency of chewing during ruminating (⟨C.RUM⟩), indicated that sheep tended to be more effective (+23%) in breaking down the rumen pool of large particles (> 1·0 mm) to particles < 1·0 mm during ruminating than goats ($P > 0·1$). When corrected for the total number of chews ruminating during the 5 h measurement period, the differences between goats and sheep were not significant ($P > 0·1$).

DISCUSSION

The results of the present experiment showed that goats spent more time eating (+3·1 h) and less time ruminating (−2·2 h)/24 h than sheep, when fed on a chaffed lucerne hay diet. Geoffroy (1974), also reported that goats spent more time eating (+0·67 h/24 h), and less time ruminating (−1·5 h/24 h) than sheep, when fed on chopped ryegrass (*Lolium perenne*) hay, the differences between the two species being smaller than those observed in the present study, especially in the time period spent eating. It is possible that use of once- or twice-daily feeding, as opposed to the hourly feeding used here, would have altered the eating and ruminating times. However, such a practice would have led to a different diet being consumed by the two species, as sheep fed this forage selected a diet higher in N and lower in fibre than the feed on offer, whereas goats showed no evidence of selection (Domingue, 1989). Hence hourly feeding *ad lib.* was used to ensure that the diet consumed was as close as possible for the two species.

The calculated index of efficiency of chewing during eating (⟨C.EAT⟩) indicated that goats were 85% efficient at breaking down large particles to < 1·0 mm during eating, compared with 48% for sheep. Ulyatt *et al.* (1986) reported a mean ⟨C.EAT⟩ index of 43·5% for sheep fed on fresh and dried forages (range: 34·6–51·6%), which is similar to that reported for sheep in the present study but much below that observed for goats.

The greater efficiency of chewing during eating can be due to three main factors (Ulyatt *et al.* 1986): (1) number of chews/min spent eating, (2) the grinding surface area of the teeth

(mm^2/kg $LW^{0.75}$) and (3) the articular surfaces of the skull and jawbones, which determine the forces applied during eating.

When corrected for the number of chews/min spent eating, there were no significant differences ($P > 0.1$) in ⟨C.EAT⟩ between goats and sheep. It is, therefore, concluded that the greater number of chews/min during eating in goats is a major component explaining their greater ⟨C.EAT⟩ values, compared with sheep. Factors 2 and 3 were not measured in the present experiment and are possible components which, together with factor 1, could all have influenced the process of a more efficient particle size reduction during eating in goats. Throughout the present study, no attempts were made to divide total jaw activity (i.e. chews) into prehension and mastication bites. Whilst it is recognized that rate of prehension biting is an important determinant of intake rate under grazing (Black & Kenny, 1984; Penning *et al.* 1984), it would not be so important in the present study where the feed was already harvested and chaffed, and where the objective was to measure differences in particle reduction.

A greater proportion of small particles in the rumen provides a larger surface area of particles which is available for microbial attachment and colonization (Hungate, 1966; Akin, 1976, 1979; Cheng *et al.* 1977; Elliott & Norton, 1985). Thus, the presence of a greater proportion of small particles (< 1·0 mm), in the rumen of goats than sheep for a longer period of time may have contributed to the greater apparent fibre digestibility by goats compared with sheep (Domingue *et al.* 1991).

Because of the longer time period spent chewing and great effectiveness of chewing during eating, it seems that goats do not require to ruminate for as long as sheep. The process of rumination reduces further the size of particles which have not been broken down to < 1·0 mm during eating (Pearce & Moir, 1964; Reid *et al.* 1979; Ulyatt, 1983; Chai *et al.* 1984; Ulyatt *et al.* 1986). Findings in Table 2 indicate that the percentage of particles > 1·0 mm in the boli swallowed after eating was 84% greater for sheep than for goats. Rumination in sheep appears to play a major role in breaking down the feed particles which are > 1·0 mm in the rumen, and is not as important in goats. The tendency for greater efficiency of chewing during rumination (⟨C.RUM⟩) by sheep than goats (59 *v.* 48%), in breaking down the feed particles to < 1·0 mm can be accounted for by the greater number of chews/min during rumination in sheep than in goats. Ulyatt *et al.* (1986) reported that the mean ⟨C.RUM⟩ obtained with sheep fed on fresh forage and dried diets was 53·6% (range 39·0–53·6%), a value close to the one obtained for sheep in the present experiment. The calculations of ⟨C.RUM⟩ have been made on the assumption that particles > 1·0 mm cannot leave the rumen. In practice, particles of this size have a low probability of leaving the rumen, and the small percentage that reach the faeces (< 1·5% total faecal DM) was similar for sheep and goats (Domingue, 1989; Domingue *et al.* 1991).

The apparent rate of both salivary secretion and salivary-N secretion during eating appeared to be greater in goats than in sheep in the present experiment. This, together with the greater amount of time the goats spent eating, implies that goats have a greater N-recycling capacity into the rumen through salivary secretion than sheep, which may contribute to the greater rumen ammonia-N irreversible loss rate (mg N/g N intake per d) observed in goats when fed on the lucerne chaff diet (Domingue, 1989). Seth *et al.* (1976) have also reported greater rates of both parotid salivary secretion (+40%) and total salivary-N secretion in goats than in sheep, while eating a fresh forage diet. The greater salivary secretion rate in goats could also assist in a greater solubilization of the dry diet used in the present study, as the forage is ground between the molars in the presence of saliva. This could be another factor in releasing the cell contents during eating (Kay, 1966; Ulyatt, 1983), and explain a greater apparent fibre digestibility by goats compared with sheep.

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