ADAPTATION OF THE RUMEN BAG DIGESTIBILITY TECHNIQUE FOR USE IN GOATS

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Summary

Problems with maintaining service and equipment in some developing countries suggest that the rumen bag technique may be more appropriate for the determination of plant dry matter digestibility. The technique has been adapted for use in goats in the 16-25 kg liveweight range. Reliable results were obtained for animals maintained under shelter in cages and fed on a mixed legume/grass diet. The results showed that up to 7 bags containing dried and ground (2 mm screen) plant samples (1-3 g) could be satisfactorily used in each goat. The digestibility of the legumes studied did not increase with incubation times over 48 hours, but there was an increase in the digestibility of grasses. However an incubation time of 48 hours was adapted for both legumes and grasses as it allowed more efficient work scheduling for large numbers of samples while still giving acceptable comparisons between species. Losses of material from the bags during a 6 hour soaking in water were 2-9% as fine solids and 14-21% in solution. In the method finally adapted the disappearance was measured for plant samples that were placed in Dacron mesh bags (7 × 14 cm, 44 micron) and 6 bags suspended in the rumen of each sheep for 48 hours.

(Key Words: Forage, Nutritive Value, Digestibility, Rumen Bag, Goat)

Introduction

Over the years there have been many developments in the methodology of assessing forage nutritive value. Most attention has been paid to the development of methods which require no or few animals and small sample size because of the cost associated with maintaining the large number of animals required for feeding trials and the large amount of test forages. However, the *in vitro* techniques require precise control of laboratory procedures and equipment that frequently cannot be operated or maintained in the facilities available in developing countries. Consequently, attention has been focussed on the artificial fibre bag technique initiated by Quin et al. 1938 (cited by Weakley et al., 1983). Both the rate and extent of degradability of the feedstuff in the rumen can be estimated using bags made of dacron.

Since the initial development of the technique, the method has gained acceptance as a means of measuring fibre and dry matter digestion in the rumen. In the past few years the technique has also been used for measuring nitrogen disappearance from feed and protein sources, primarily as a tool for ranking their resistance to ruminal protein degradation.

Estimates of *in vivo* ruminal protein degradability using this technique have been reported by Ørskov and McDonald (1979), Stern and Satter (1979), Stern et al. (1980). When appropriate factors are accounted for the method can be used for quantitative estimates (Ørskov et al., 1980).

In assessing the results of rumen bag digestibility measurements, Ørskov et al. (1980) pointed out three important limitations. The first is that the sample must be confined within the bag; secondly, the particles should be able to leave the rumen bag once broken down to a suitable particle size and, thirdly, what is actually measured is the breakdown of material to a size small enough

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to leave the bag and not necessarily a complete degradation to simple chemical compounds.

Many studies have considered the effect of diet on the results obtained in rumen bag digestibility measurements. Factors influencing the determinations of in-situ fibre digestion in the rumen have been reviewed extensively by Weakley et al. (1983). The effect of bag pore size, sample weight and bag surface area have been studied e.g. Uden et al. (1974), Mehrez and Ørskov (1977), Playne et al. (1978).

It has been suggested that 30 to 50 rumen bags can be inserted into the rumen of cattle or buffaloes (liveweight 300 to 500 kg), and 6 bags are often used with sheep having a body weight of around 40 kg (Perdock, *pers. comm.*).

In studies with sheep, Mehrez and Ørskov (1977) found only very small differences in DM disappearance when different numbers of bags were used, but also found a reduction in degradability when sample size was increased for a given bag size. In cattle, a sample size of 2 g with bags measuring 12.5 cm by 9 cm was used by Vario and Huber (1984).

Ørskov et al. (1980) showed that the incubation time depends on the type of material used. Generally, concentrates require 12-36 hours, good quality forages 24-60 hours and poor quality roughages 48-72 hours.

Increasing attention is being given to forage quality measurements in the developing world but often reliable facilities are not available to utilize the published methodologies. In many countries goats are the only small ruminants available. Goats often have a lower liveweight than sheep and no published data is available in the use of rumen bags in goats.

The studies reported here were undertaken to examine the effects of number of bags, sample size, incubation time and fineness of grinding of dried samples on the rumen bag (RB) digestibility of tropical forages in an effort to adapt the method for use in remote areas.

Materials and Methods

Management of animals

Local goats, weighing 16-25 kg and fitted with rumen fistula, were used. An animal house was constructed from bamboo and measured 4 × 7 m. It had open sides and a thatched roof to provide protection from sun and rain. The individual cages measured 0.6 × 1.2 m and were elevated one metre above the ground. Each cage was fitted with a container for feed and one for water. A salt lick was also provided.

Internal parasites were controlled by drenching at six weekly intervals. External parasites were controlled by dipping the animals when necessary. The area around the rumen fistulas was kept clean at all times in order to prevent infection.

The diet for the goats consisted of 70% dried corn stover which could be obtained from local farmers, and 30% of mixed tree legume leaves which were available on the research station. The latter was a mixture of dried leaves of *Leucaena leucocephala*, *Gliricidia* sp., *Sesbania grandiflora*, and *Calliandra calothyrsus*. The components were crushed and hammer milled to pass through a 3-4 cm screen. This basal diet was fed *ad lib.* daily from 09:00 A.M. to 16:00 P.M. Water was always available and both feed and water containers were cleaned daily.

Rumen bags

Rumen bags 7 cm wide and 14 cm deep, were made from Dacron mesh (44 micron). After tying the bags, an effective surface area of approximately 150 cm^2 remained.

Rumen bags were dried overnight in an oven at 65°C, placed into a desiccator and then weighed. A dried, ground (< 2 mm) plant sample of a given weight and a glass marble of a known weight were placed into the bag. The bag was securely tied and a short length of string left attached to the top of the bag. The required number of bags were then inserted into the rumen and held suspended by the strings which were then attached to the cannula. The glass marble was necessary to fully immerse the rumen bag in the rumen fluid. After a given time the bags were removed from the rumen, thoroughly washed, squeezed for several minutes under running water and then dried in an oven for 24 hours at 65°C, placed into a desiccator to cool and weighed. The percentage disappearance was then calculated. After each use the bags were turned inside out, the residue removed and the bags washed in a detergent solution for at least two hours. They were then rinsed with clean water and placed into a 4% chromic acid solution for 24 h in an

oven at 65℃. Bags were then washed in clean water and dried for further use.

Experiment 1. Effect of number of bags per goat

Experimental

Based on the relative liveweight of the different ruminants it was estimated that about 4 rumen bags would be appropriate for the size of the goats available. A preliminary trial showed that there were no differences in the amount of material digested when using three to five bags per goat. However, there are often large numbers of samples to be processed and it would be advantageous if more bags could be used per animal. Consequently, an experiment was conducted using 5, 6 or 7 bags per goat. Five, six or seven bags each containing 2 g of either *B. decumbens* or *M. atropurpureum*, which had been dried at 80℃ for 24 hours and ground to pass a 2 mm sieve, were placed into the rumen of each goat and were incubated for 48 hours. The experimental design is shown in table 1.

Where 5 bags were used, 3 contained legumes and 2 contained grass. Where 6 bags were used, 3 contained legumes and 3 contained grass. Where 7 bags were used, 3 contained legumes and 4 contained grass.

TABLE 1. DESIGN OF THE RUMEN BAG NUMBER EXPERIMENT

Goat	Run		
	1	2	3
	(No. of bags)		
A	5	7	6
B	6	5	7
C	7	6	5

Results and Discussion

There was no significant difference in dry matter disappearance when using 5, 6 or 7 bags per animal (table 2). It was concluded that up to 7 bags per goat could safely be used but as 6 bags per goat suited our studies no attempt was made to try higher numbers of bags.

The results of this trial are similar to those obtained by Mehrez and Ørskov (1977) who found only very small differences in DM disappearance when different numbers of bags were used.

TABLE 2. DM DISAPPEARANCE (%) USING 5, 6 OR 7 BAGS PER ANIMAL

Species	Number of bags			Sig.
	5	6	7	
B. decumbens	57.6	58.7	57.9	N.S.
M. atropurpureum	61.3	61.5	62.5	N.S.

Experiment 2. Effect of sample size per bag

Experimental

Often only small amounts of herbage are available, particularly in the early stage of screening trials. An experiment was therefore conducted investigating the minimum sample size necessary to obtain reliable results.

A range of sample weights (0.5, 1, 2, 2.5, 3, 4, 5, 6 and 7 g) were tested using three goats. A wide range of sample weights were used in each goat but the complete range of sample weights were not used in all goats. Six bags per goat containing a mixture of sample weights of ground *L. leucocephala* were incubated for 24 hours.

Results and Discussion

Although there was a trend to decreasing digestibility with increasing sample size in goat 3 there was no significant goat × sample size interaction (figure 1). Examination of the data

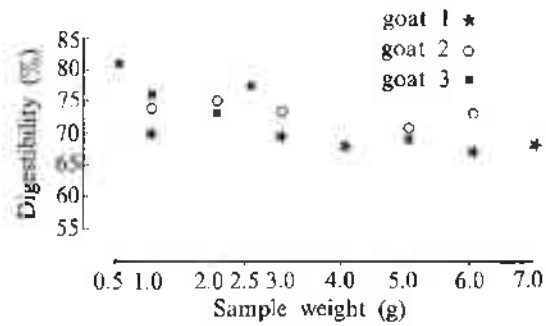

Figure 1. Effect of sample size on DM disappearance.

suggested that samples in the range of 1 to 3 g per bag would provide repeatable results.

Experiment 3. Effect of incubation time

Experimental

The aim of this experiment was to determine a common incubation time for use in experiments where contrasting materials are included. A common incubation time is often necessary to allow concurrent measurement of grass and legume samples and because of limitations in electricity supply and the availability of labour.

Six bags per goat, each containing about 2 g, were incubated for 12, 24, 48 and 72 hours using two goats (table 3). There were two bags of *Arachis* sp., two bags of *Imperata cylindrica*, one bag of *B. decumbens* and one bag of *M. atropurpureum*.

Results and Discussion

The amount digested increased with increasing incubation time for both grasses and legumes. While legumes had reached a maximum after 48 hours, there was still an increase in the amount digested between 48 and 72 hours of incubation for grasses (table 3). The increase recorded between 48 and 72 hours for *B. decumbens* was not significant because of the high standard deviation however the difference for *I. cylindrica* was significant. Often it is required to complete the analyses within restricted working hours and because of limitations on the time available it was decided that a standardized incubation time of 48 hours would be used for both grasses and legumes. For comparative purposes this appears an acceptable compromise.

TABLE 3. EFFECT OF INCUBATION TIME ON RUMEN BAG DIGESTIBILITY (%)

Species	Incubation time (h)			
	12	24	48	72
Arachis sp.	67.8(3.2)[1]	71.6(0.9)	74.9(0.4)	74.8(2.2)
M. atropurpureum	47.6(2.3)	55.4(8.8)	62.3(1.0)	63.5(0.2)
B. decumbens	35.6(3.5)	46.6(4.6)	55.7(8.4)	64.7(0.7)
I. cylindrica	22.5(2.2)	31.0(3.1)	40.2(0.2)	45.6(0.7)

[1] *Standard deviation in parenthesis.*

Experiment 4. Water soluble component and fine material in samples

Experimental

Often plant grinders are not well maintained and plant samples ground in them posess a wide range of particle sizes. This situation posed two questions:

i) how much fine material escapes from the rumen bags, and;

ii) the degree of water solubility of the samples.

Two standard materials, *B. decumbens* and *M. atropurpureum*, and a red clover *Trifolium pratense* sample (used in rumen bag trials at the University of New England) were used. The latter was included since it was a much coarser sample (> 2 mm) than the other tropical forage materials and provided a good source for comparison.

Six bags of each of the three materials were used; sample weight was approximately 2 g. Each bag was soaked for one hour in 250 ml water. Bags were shaken every 15 minutes during this period. The bags were then removed, squeezed, and dried overnight in an oven at 65°C. Next morning they were placed in a desiccator for 30 minutes and the dry weight recorded. The bags were then soaked for a further five hours, and treated as described above. Following the second drying, the bags were then incubated in the rumen (six bags per goat) for 48 hours, washed, dried and total disappearance recorded. The material from the one and five hour treatments was filtered to separate fine material from the soluble fraction. The filter paper plus fine material was dried, the filtrate evaporated to dryness, and the weight of the fractions determined.

Results and Discussion

Total disappearance was similar for *B. decum-*

lens and *M. atropurpureum*, but was approximately 15% higher than that for Red Clover (Table 4). The total disappearance of 76.9% of the Red Clover recorded in this study is similar to that recorded for this material in studies at the University of New England (Perdok *pers. comm.*).

Of the total disappearance approximately 3% was fine material for *B. decumbens* and *M. atropurpureum* and 8% for Red Clover. A further 14-21% of the total losses were soluble. At least 75% of the soluble material had left the bag after 1 hour, and between 50% to 75% of the fine material had escaped after 1 hour. Fears that *B. decumbens* and *M. atropurpureum* were ground too finely for rumen bag work can be dismissed and this finding agrees with other workers. For example, Lawrey (1969) found no difference in dry matter losses with forages ground to pass 4, 3, or 2 mm screen sizes, although massive losses of materials through the pores of the bag occurred with the use of a 1 mm screen.

TABLE 4. SOLUBILITY AND DISAPPEARANCE OF FINE MATERIAL AFTER 1 OR 6 HOURS IN WATER, AND TOTAL DISAPPEARANCE AFTER A FURTHER 48 H INCUBATION IN THE RUMEN

Species	Total disappearance (%)	Fine material (%)		Soluble material (%)	
	6 + 48 h	1 h	6 h[1]	1 h	6 h[1]
B. decumbens	60.1 (1.0)[2]	1.2 (0.4)	2.4 (0.5)	10.7 (0.5)	14.0 (1.6)
M. atropurpureum	62.1 (1.1)	2.6 (0.4)	3.8 (0.6)	16.0 (2.7)	20.9 (4.4)
Red Clover	76.9 (1.2)	6.2 (1.2)	8.6 (1.2)	16.2 (2.3)	19.6 (2.2)

[1] Total of 1 + 5 h soaking.
[2] Standard deviation in parenthesis.

Recommendations for use of rumen bags in goats

Dacron bags (7 × 14 cm in size; 44 micron) with an effective surface area of approximately 150 cm^2.

Plant material dried and ground to pass through a 2 mm sieve.

Sample size per bag 1.3 g.

– Six bags per goat.

– A common incubation time of 48 hours for both grasses and legumes.

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