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THE MEASUREMENT OF SHEEP DIET USING SMALL GRAZING ENCLOSURES

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ABSTRACT

A method for obtaining quantitative diet information for sheep is described. It requires no elaborate equipment or procedures. Dietary intake is measured as the daily difference in available forage in a heavily-grazed enclosure; the forage is measured using the Adelaide technique. This procedure gives data with smooth curves suitable for use in preference models and indices, and a new "Area" index was developed to summarize the data from these experiments. The advantages of the method are that it does not require elaborate equipment or techniques, dietary intake is averaged over all of the sheep and the whole of each grazing period, and the sheep appear to graze normally. Its principal disadvantage is the error associated with each intake value, which is twice that of the associated forage values, but ways of ameliorating this are discussed.

Introduction

It is important to know what the grazing animal eats, both from an animal nutrition and from a pasture management point of view. This supposedly basic information is often imperfectly known. For example Leigh and Mulham (1967) when studying the diet of sheep in semi-arid pastures of the Riverine Plain, found that *Calocephalus sonderi* averaged 15% of the diet even though it was "generally regarded as a worthless weed", and that pig face (*Disphyma australe*), held by some to be quite palatable, was only lightly grazed.

There are basically three ways of studying diet. The animal is watched as it grazes, or the pasture is watched as it is grazed, or one inspects the material that has actually been swallowed. The bulk of information in the literature comes from the first two methods and ranges from anecdotal to quite rigorous observations. To date however, decisive information has come from the last procedure, of which there are three variants, namely the study of taxonomically - identifiable residues in dung, inspection of gut contents of grazing animals, and the use of oesophageal fistulation.

We wished to quantify sheep diet in relation to available forage in the arid chenopod shrublands of South Australia without being dependent on veterinary facilities. We developed a new method to do this which is free of such dependence. The information we gained on the diet of sheep in arid chenopod shrubland using this method will be reported elsewhere. In this paper the method is described and illustrated with a set of data collected at Middleback Station, Whyalla, S.A. in November 1972. A new preference index for summarizing this data is proposed. The strengths and weaknesses of the method are discussed, particularly in comparison with the use of oesophageal fistulated sheep.

Philosophy of the method

Forage weight of individual shrubs can be measured with an accuracy of 10% or better using the Adelaide technique (Andrew *et al.* 1979). This is sufficiently precise to enable dietary intake to be measured as the difference in available forage before and after a grazing period, providing this difference is sufficiently large. Our method involves stocking an enclosure with enough sheep to eat most of the forage in a week, and simultaneously measuring the forage on a daily basis. The relative error of the total forage will be much less than that for individual shrubs, as it is the sum of many values, each with a random error. Vegetative growth is assumed to be negligible over this time. Thus intake is calculated daily as the forage difference. Since the decline in available forage will be more rapid for a preferred species a preference index can be calculated based on the area beneath the forage *vs* time curve. When scaled to lie in the range 0-1 (0 for an uneaten species, 1 for a species eaten completely in the first day), this is called the 'Area' index.

The method thus requires three important criteria. First, the enclosure must be not so large as to prevent the total forage from being estimated with sufficient accuracy. Second, the stocking rate must be sufficiently high so that the daily decrease in available forage (*i.e.* intake) can be discerned from the errors of measurement. Third, the enclosure must be sufficiently large to allow the expression of normal grazing behaviour (with the obvious exception that ranging behaviour is necessarily restricted).

Field procedure

An enclosure of 0.1 ha with an adjacent holding pen was erected in chenopod shrubland. Drinking water was provided and six 3-year-old ewes were put in the pen. While they were acclimatizing, permanent quadrats were laid out in the enclosure. Forage was measured in them using the 'Adelaide' technique for shrubs and modifications of this for the grasses and forbs.

The sheep were then introduced into the enclosure. At 24 hour intervals, coinciding with their natural resting period, they were herded into the holding pen, and the weight of forage in the enclosure was measured. This took up to three hours, after which the sheep were returned to the enclosure. This routine was continued for one week. Litter fall was measured in small quadrats so that it could be included as a correction factor. The amounts recorded were generally trivial.

Results

The time-course of total forage and total intake, and the relation between them (Figure 1), show smooth curves with errors not atypical for such ecological measurements. The first two criteria were clearly met *viz*, forage was measured sufficiently accurately and intake was discernible as forage difference. The third criterion also applied. The grazing and resting behaviour appeared to be normal, and sheep tracks were cut radiating from the water trough throughout the enclosure akin to the pattern in station paddocks (Lange 1969).

Intake per head, before it declined, was 1.5 kg day^{-1} which is in the range of values expected. The individual species data are plotted in Figure 2 with the exception of *Maireana pyramidata* and *Enchylaena tomentosa* (present in small quantities and not eaten till the last day) and *Rhagodia spinescens* (not eaten at all). The individual species show a slightly erratic but still regular behaviour. For example the bluebush (*Maireana sedifolia*) forage as measured on day three was slightly more than that of the preceeding day. Such discrepancies are inevitable given that forage values have some error and this is doubled when intake is calculated by difference. This is exacerbated in cases such as bluebush with a low intake relative to the weight of forage on offer. Nevertheless, it is clear that the sheep acted as generalist feeders taking some of all the available species with the exception of *Rhagodia spinescens*. *Bassia* and *Atriplex vesicaria* comprised the bulk of the diet.

Discussion

The main problem with the method is the doubling of the error when the intake values are calculated. There are two ways of alleviating this problem apart from reducing the error of the forage estimates as much as possible. The first is to develop formulae for preference indices or models which use the forage values directly and not the calculated intake values. The second is to smooth the curves of forage decline over time in those cases where the decline is not regular and interpolate adjusted forage and intake values from them. Such a smoothed curve is shown in Figure 2 for bluebush. An example of the first approach is a dietary preference index

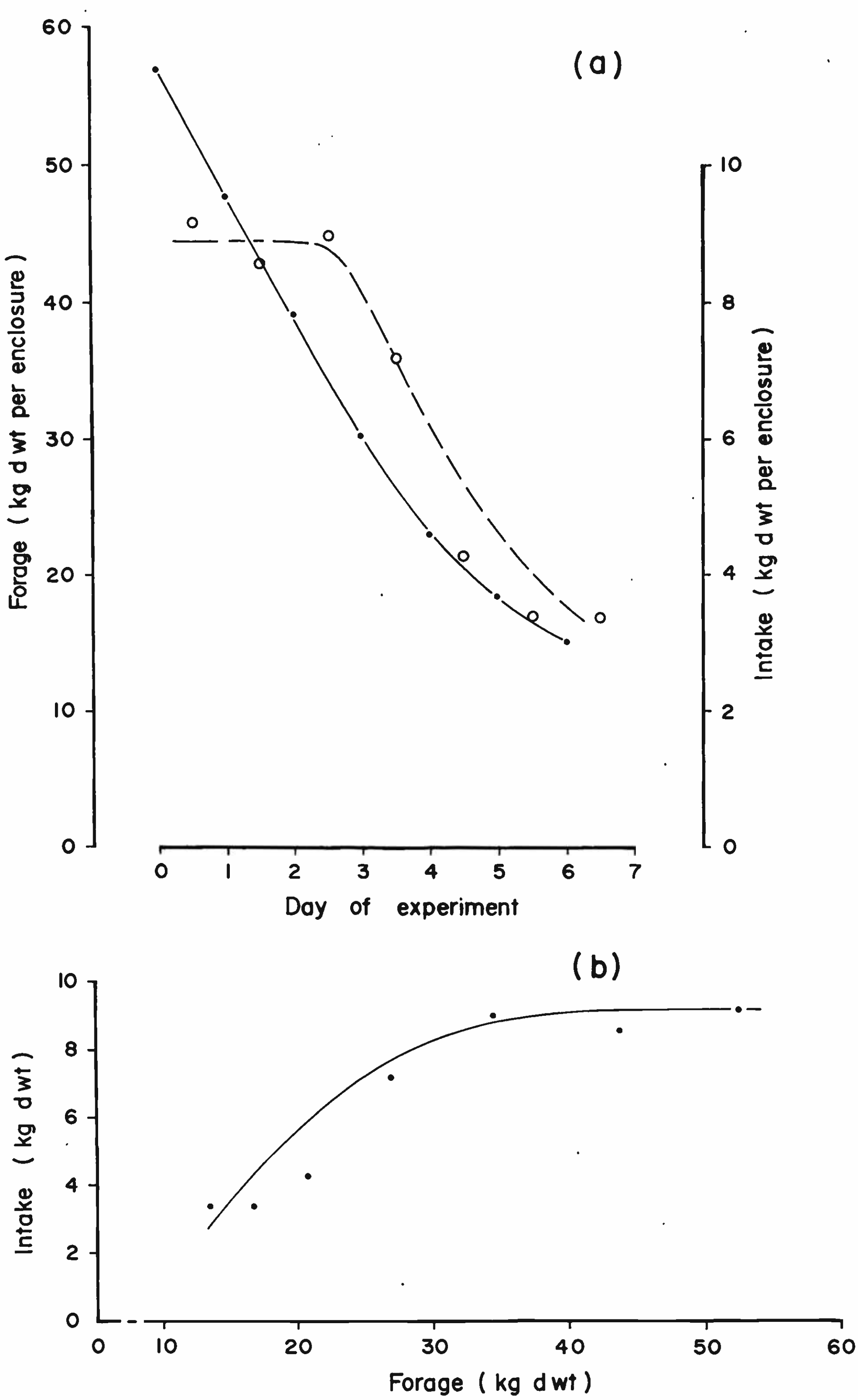

Figure 1. (a) The change in total forage on offer in the enclosure (.) and total intake (o) over the duration of the experiment; and (b) the relation between total intake and total forage on offer.

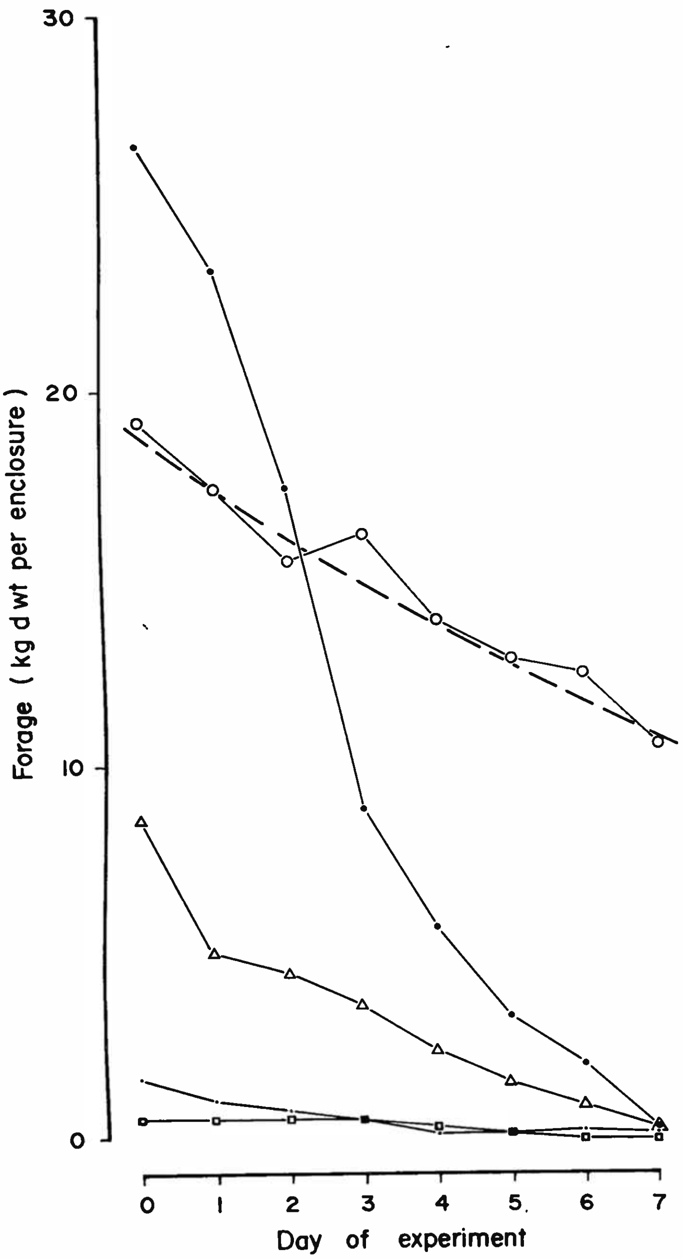

Figure 2. The decline in forage of individual taxa over the course of the experiment. *Bassia* spp (•); *Atriplex vesicaria* (▵); *Maireana sedifolia* (o); *M. turbinata* (◻); grasses (.). The smoothed curve for bluebush (*M. sedifolia*) is shown by the dotted line.

(the 'Area' index) developed by us to analyse these grazing experiment data. The usual indices of dietary preference *e.g.* Van Dyne and Heady (1965) and Ivlev (1961) relate the proportion of a food in the diet to its relative availability. These are calculated for each grazing period using the (smoothed) forage and intake information. The values of the Area index and of the Ivlev index (Table 1) show that the grasses were the most preferred although they did not contribute the bulk of the diet, and some species like *Maireana turbinata* became preferred only when other more palatable species had disappeared. These results accord with experience elsewhere (*e.g.* Leigh and Mulham 1966a).

Total intake, too, can be studied and the totality of our data together with those from the Riverine Plain (Leigh and Mulham 1966a,b; Robards, Leigh and Mulham 1967) suggests that the shape of the intake *vs* forage curve is quite characteristic. Intake per head is approximately constant at high levels of forage availability and it declines well before the sheep appear to have difficulty in finding forage. The causes of the decline were subsequently examined and the results will be discussed elsewhere.

It is of interest to compare diet data obtained using both forage decline and oesophageal fistulated sheep simultaneously. The Riverine plain data permit this comparison and the results are given in Table 2. Clearly there are considerable discrepancies between the two methods especially for the first day's grazing where the rank orders of intake differ - the grasses ranking higher in the fistula samples and the chenopods and clover ranking higher in forage decline. These differences are undoubtably due to a number of factors - loss by trampling in the denser Riverine vegetation and errors associated with forage measurement for forage decline, and for oesophageal fistualtion, the short sampling time of 30 to 50 minutes, the use of fasted sheep, the use of only three of the six sheep in the light of high individual diet variability, and the possibility that the sheep may select a 'softer' diet on account of the fistula. These factors highlight the caution that is necessary when interpreting any such dietary data.

Our procedure for studying diet has several advantages but only a few drawbacks. No special equipment or facilities are required; a single person trained at forage measurement can handle the work load, but obviously more people will get the forage measured more quickly or more accurately by enabling more intensive quadratting. We found this procedure an excellent teaching tool for acquainting final-year botany undergraduates with the

Table 1. Preference index values for all species.

	Area Index[1]	Ivlev Index[2] For Day Number:						
		0-1	1-2	2-3	3-4	4-5	5-6	6-7
Grasses	0.82	0.45	0.32	0.27	0.68	-1.00	-1.00	-1.00
Atriplex vesicaria	0.74	0.50	-0.18	-0.23	0.28	0.36	0.35	0.69
Bassia spp	0.72	-0.14	0.22	0.35	0.32	0.42	0.63	0.70
Maireana turbinata	0.47	-1.00	-1.00	-1.00	0.38	0.65	0.79	-
M. sedifolia	0.27	-0.31	-0.41	-0.61	-0.53	-0.49	-0.50	-0.37
M. pyramidata	0.08	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	0.83
Enchylaena tomentosa	0.08	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	0.83
Rhagodia spinescens	0.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
Total	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[1] Area Index $= 1 - \left[\dfrac{\left(\sum_{i=0}^{n-1} \left(\dfrac{F_{i+1}}{F_0}\right) + \frac{1}{2}\left(\dfrac{F_i - F_{i+1}}{F_0}\right)^2 \right) - \frac{1}{2}}{(n-1) - \frac{1}{2}} \right]$; max preferred = 1, min preferred = 0

where F_i = forage measured on day i

[2] Ivlev Index = (D - F)/(D + F) where D = % of species in diet
F = % of species available as forage;
max preferred = +1
min preferred = -1

Table 2. Comparison of diet determined by two methods from the same experiment - forage difference and oesophageal fistulation (OF). Data is from Table 3 of Leigh and Mulham (1966a).

% DIET:

	Day 1		Day 2	
	Forage Difference Day 1-2	OF Day 1	Forage Difference Day 2-3	OF Day 2
Danthonia caespitosa	1.8	13.2	0.2	-
Hordeum leporinum	1.1	35.0	0.8	6.0
Hedypnois cretica) *Hypochaeris* spp)	0.6	0.5	0.1	1.5
Medicago polymorpha	70.9	27.0	23.4	31.0
Medicago burrs	-	2.5	-	3.0
Atriplex vesicaria	13.6	1.0	57.1	36.0
* *Kochia aphylla*	3.0	-	3.3	3.0
K. pentagona	5.3	-	1.1	-
K. excavata	3.0	-	1.1	-
Nitraria schoberi	0.8	-	0.5	-
Other species	0.0	20.5	12.5	19.5
TOTAL	100.1	99.7	100.1	100.0

* Now *Maireana* spp.

practicalities of field experimentation. The intake values are obtained over a full 24-hour period, unlike that obtained using oesophageal fistulated sheep. Furthermore, the diet is the average of all the sheep thus avoiding the problem of individual variability encountered when measuring the intake of only a few of them. In fact, given the man-power, it would be feasible to increase the number of sheep used by increasing the enclosure size proportionately so as to obtain a better average diet. Another advantage is that sheep grazing behaviour appears to be normal. The main disadvantages are that the diet is derived from a restricted area; that the forage available at any time is that which has not been eaten previously (thus the amount available, and probably its palatability and digestibility, steadily declines during the experiment); and that the intake values have attendant error problems, although these can be partly overcome. Rain could be a problem by making the forage measurement more difficult, but no rain fell during any of our experiments.

Conclusions

We have developed a method for obtaining useful quantitative information on sheep diet which has no dependence on elaborate techniques or facilities, and which does not require fistulated animals. Our method has a number of other advantages, and there are ways of ameliorating its main drawback which is the error associated with the intake values.

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