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Estimation of the pasture horisons grazed by cattle, sheep and goats during single and mixed grazing

A.M. NICOL AND H.A. COLLINS

Department of Animal Science, Lincoln University.

ABSTRACT

Detailed sward measurements made before and after grazing can detect the changes in mass and composition of vertical sward horizons which result from grazing. When animal species are grazed in mixtures, it is impossible, by this method to relate such sward changes to any one particular species.

We estimated the quantitative importance of different sward horizons to the diet of cattle (CA), sheep (SA) and goats (GA) grazing alone or in a mixture; cattle with sheep (CS), sheep with cattle (SC) and cattle with goats (CG), goats with cattle (GC) in a progressive defoliation of ryegrass/white clover pasture. A least squares optimisation routine estimated the contribution of 5, 40mm sward horizons, each containing 6 botanical components to oesphageal extrusa (OE), containing the same 6 components, from each of the treatments.

The results suggest that the diet of CA was more equally derived from horizons above 40mm than was that of SA which was concentrated in the 80- 120mm horizon. GA was intermediate. The contribution of the upper sward horizons to the CS diet was greater than for CA and SC moved lower down the sward horizons than SA. The mixing of goats and cattle had less effect on the relative contribution of the sward horizons to the diet selected than mixing sheep and cattle.

Keywords Grazing, sward horizons, diet selection, cattle, sheep, goats

INTRODUCTION

A good understanding of grazing behaviour is needed before best use can be made of various grazing species in integrated grazing systems. Changes in the mass and composition of vertical sward horizons which result from grazing can be obtained by detailed sward measurements made before and after grazing. With such horizon data it is possible to realistically compare the composition of the diet consumed with the pasture grazed and conclusions may be drawn about discrimination by grazing animals between components in the sward within the grazed horizons (Milne *et al.*, 1982; L'Huillier *et al.*, 1984). When animal species are grazed together in mixtures, however, it is impossible, (from pre- and post-sward sampling) to relate sward changes to any one particular specie.

This paper describes the results of a mathematical approach we took to assess the quantitative importance of different sward horizons to the diet and intake of cattle, sheep and goats grazing alone or in mixtures. At comparing the composition of each horizon with a concommitant oesphageal extrusa an estimate of the relative contribution make by each horizon to the diet was made by an optimisation procedure. The extent of discrimination by animals when grazed alone or together for sward components was inferred from the results.

METHODS

Experiment

The data used were from an experiment in which castrated male cattle (12 months old, 300 kg liveweight, designated CA), sheep (3 months, 25 kg, SA) and goats (14 months, 26 kg, GA) grazed alone or in mixtures (1:1 based on $W^{0.75}$) of cattle with sheep (CS) sheep with cattle (SC) cattle with goats (CG) and goats with cattle (GC) in a progressive defoliation (4400 to 1550 kg DM/ha) of a ryegrass/white clover sward over 20 days in summer. Full details of the experimental protocol have been given elsewhere (Collins, 1989).

TABLE 1 Initial and mean botanical composition of a ryegrass/white clover sward grazed by cattle, sheep and goats alone or in mixtures over 20 days.

	proportion of each component					
	dead material	grass stem	grass leaf	grass seedhead	clover leaf	clover flower
Initial sward	0.073	0.136	0.152	0.393	0.226	0.019
(SEM)	0.001	0.016	0.029	0.059	0.049	0.007
Mean over grazing period						
CA	0.116	0.229	0.169	0.303	0.161	0.022
SA	0.142	0.214	0.173	0.221	0.212	0.037
GA	0.146	0.309	0.125	0.322	0.092	0.049
CS + SC	0.163	0.290	0.124	0.294	0.116	0.013
CG + GC	0.153	0.198	0.111	0.213	0.305	0.034

Sward samples (25 of 250 mm^2) were taken on each alternate day from all treatments. Samples were cut from the base upwards into 4 horizons each 40mm in depth with the fifth horizon containing all material above 160mm. Material was bulked by horizon within treatment. Oesphageal extrusa (OE) samples were obtained daily from 6 oesphageal fistulates of each species assigned in equal numbers to the experimental treatments. Sward and OE samples were frozen, freeze dried and subsequently dissected into 6 botanical components (dead material, grass stem, grass leaf, grass seedhead, clover leaf and petiole and clover flower).

Analysis

The basis of the analysis was an iterative least squares optimisation (NAG, 1987) of the proportionate contribution of the 5 sward horizons (defined as the individual mass of the 6 botanical components) sampled on any one day, to each OE composition (same 6 botanical components) on that day. Implicit in this approach is the simplistic but necessary initial assumption that the grazing animal may select the horizon(s) in which to graze but not discriminate between components within that horizon. A "predicted" OE composition was then calculated from the "optimal" horizon proportions and the mass of each component in each horizon. Actual (A) and predicted (P) OE compositional data were compared within treatments by a simple one way analysis of variance for each component.

RESULTS AND DISCUSSION

The initial botanical composition of the sward and mean values for the composition of the sward and the OE samples (meaned over days) for each treatment are given in Tables 1 and 3 respectively. Individual data (by day and sward horizons) for OE and sward composition constitute the data set used in the optimisation.

The optimal proportion (mean across days) of each sward horizon (best match to the OE composition) are shown in Figure 1 for each treatment. Also shown is the mean residual variance after optimisation and the mean number of iterations required to reach the solution. These results suggest that the composition of the OE of CA best matched a relatively equal proportion of all horizons above 40 mm in contrast to that of SA which was heavily concentrated (0.52) in the 80-120 mm horizon. The horizon proportions predicted for GA were intermediate.

Mixing cattle and sheep increased the apparent use by cattle (CS *cf* CA) of the upper 2 horizons ($p<0.05$ for the >160mm horizon) while the diet of sheep (SC) matched a wider mix of horizons than sheep grazing alone (SA). Mixing of cattle and goats had little impact on the apparent horizon contribution to the diet of cattle

TABLE 2 The proportion of sward horizons predicted to contribute to the diet (OE composition) and organic matter intake (OM composition) by cattle, sheep and goats grazed alone or in mixtures.

Treatment		0-40	40-80	Horizon 80-120 Proportion of each horizon	120-160	>160mm
CA	diet	0.087	0.163	0.300	0.241	0.209
	intake	0.087	0.173	0.309	0.219	0.218
SA	diet	0.117	0.109	0.522	0.119	0.131
	intake	0.044	0.109	0.694	0.078	0.074
GA	diet	0.013	0.309	0.428	0.092	0.164
	intake	0.006	0.181	0.548	0.039	0.225
CS	diet	0.058	0.116	0.319	0.253	0.272
	intake	0.052	0.069	0.333	0.267	0.278
SC	diet	0.088	0.313	0.338	0.156	0.105
	intake	0.039	0.278	0.460	0.182	0.041
CG	diet	0.022	0.134	0.320	0.253	0.272
	intake	0.028	0.162	0.376	0.183	0.250
GC	diet	0.058	0.089	0.350	0.234	0.268
	intake	0.022	0.031	0.428	0.265	0.253

	CA	SA	GA	CS	SC	CG	GC
Residual variance	183.8	393.9	576.7	82.9	775.2	111.7	446.0
Number of iterations	3.7	3.9	4.2	4.0	4.6	3.4	3.8

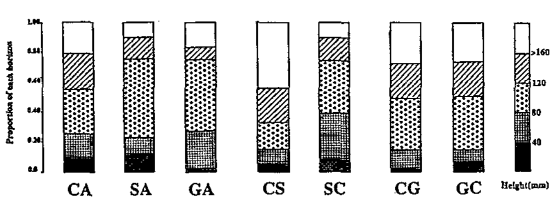

FIG 1 The proportionate contribution of 5 sward horizons to the diet of cattle, sheep and goats grazed alone or in mixtures.

(CG *cf* CA) although the diet of goats with cattle (GC) was predicted to originate from higher in the sward than for goats alone (GA).

The above approach does not account for changes in organic matter intake with time. However, by weighing the individual daily predicted horizon use for each treatment by the OM intake for each day (from Collins, 1989) the mean predicted contribution of each horizon to mean OM intake was computed and is compared with the horizon contributions to mean diet composition in Table 2. The effect of treatment on the predicted horizon use was greater for intake than for diet composition.

Table 3 compared the "predicted" OE composition based on the horizon proportions for each treatment with the actual OE composition and shows the mean absolute deviation (A-P). In most cases there is a close relationship between the actual and expected OE botanical composition, suggesting that if account is taken of the horizons grazed there may be relatively little discrimination within the horizon, a similar conclusion to that of Milne *et al.*, (1982) and L'Hullier *et al.*, (1984). Thus many of the observed differences between treatments in OE composition (e.g. CA *vs* SA for grass seedhead or CA *vs* CS for clover leaf) could be explained by differences in the contribution of different horizons to the diet.

However, some A-P comparisons of individual botanical components do show a significant difference, implying discrimination within horizons for, or against, those components. These differences were both positive e.g. GA for clover, SC for clover, supporting the observations of others for sheep (Curll, 1982, Clark *et al.*, 1982; Milne *et al.*, 1982) but not commonly reported for goats (Clark *et al.*, 1982, Radcliffe *et al.*, 1982, Russel *et al.*, 1983). GA displayed negative discrimination for dead material in agreement with other work. The only consistent differences across treatments were positive discrimination for clover and a small negative discrimination against dead material.

Cattle showed, on average, less discrimination between components than sheep or goats. When grazed with cattle, sheep (SC) apparently discriminated between sward components to a greater degree than SA suggesting that they made use of their scope to do so although this was not the case for GC compared to GA. The unexplained variance from the optimisation (Figure 1) correlated closely with the mean A-P suggesting that the former may be a useful indicator of discrimination.

Without validation of the approach described in this paper, the interpretation of the results is somewhat speculative. However, the results show that cattle, sheep and goats favour differing horizons during their progressive defoliation of a ryegrass/white clover sward. The results also illustrate that the grazing strategy of sheep allows them, when mixed with cattle to not only change the importance of various horizons to their diet, thus "pushing" cattle further up the sward, but to discriminate to a greater extent between components in a horizon. Less is known about the grazing behaviour of goats, but in this study they appear to show quite strong discrimination between some sward components but still maintain a mixed diet.

Use of an optimisation technique to give a 'best estimate' of the distribution of grazing between sward

TABLE 3 The actual and predicted proportional contribution of 6 sward components to the diet of cattle, sheep and goats grazed alone or in mixtures.

Treatment		Proportion of each component						
		dead material	grass stem	grass leaf	grass seedhead	clover leaf & petiole	clover flower	Mean absolute deviation (A-P)
CA	actual	0.132	0.246	0.140	0.166	0.292	0.025	0.018
	predicted	0.120	0.281	0.156	0.162	0.246	0.034	
SA	actual	0.101	0.220	0.184	0.084	0.391	0.019	0.040
	predicted	0.135	0.250	0.197	0.063	0.292	0.052*	
GA	actual	0.064	0.235	0.129	0.152	0.398	0.021	0.086
	predicted	0.156	0.359	0.164	0.159	0.156***	0.001*	
CS	actual	0.093	0.289	0.127	0.317	0.160	0.012	0.014
	predicted	0.120	0.287	0.143	0.306	0.133	0.010	
SC	actual	0.130	0.175	0.152	0.034	0.490	0.018	0.095
	predicted	0.213	0.341**	0.162	0.056	0.209***	0.016	
CG	actual	0.096	0.273	0.122	0.134	0.360	0.014	0.020
	predicted	0.109	0.231	0.137	0.117	0.366	0.039**	
GC	actual	0.055	0.169	0.084	0.149	0.518	0.024	0.061
	predicted	0.137	0.209	0.132	0.116	0.368	0.037	
Ave. difference								
	actual	0.097	0.230	0.135	0.149	0.369	0.021	
	predicted	0.142	0.282	0.156	0.142	0.250	0.006	

Actual and predicted proportion of that component significantly different at $P<0.05$ (*), $P<0.01$ (**) and $P<0.001$ (***).

horizons identified plausible and consistent species/ treatment differences and has potential in grazing behaviour studies. In this experiment many of the differences in diet composition between cattle, sheep and goats grazed alone or together could be explained by choice of grazing horizon. Discrimination by the grazing animal for or against components within horizons was of less importance in influencing diet composition.

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