An evaluation of Bana, Greengold and Pennaris. II. Partial digestion

T.D. de Bruyn* and W.A. van Niekerk
Department of Animal & Wildlife Sciences, University of Pretoria, Pretoria, 0002

The objective was to study the partial digestion by sheep of the 500-mm regrowth of three *Pennisetum* selections (Bana, Greengold and Pennaris) over three seasons (autumn, spring and summer). There were no differences ($p > 0.05$) between selections in the quality of the material or intake. Rumen variables did not differ ($p > 0.05$) between treatments, apart from the lower ($p < 0.01$) rumen ammonia levels of Pennaris. Digesta flow was correlated with OM intake, and did not differ ($p > 0.05$) between selections but was lower in autumn ($p < 0.01$) owing to lower intake. OM and fibre digestion occurred mainly in the rumen, whereas N digestion occurred in the small intestine. OM digestibility was high (*ca.* 70%) for all treatments. Seasonal differences were manifested as the lower digestion of fibre in the rumen in spring, perhaps as a result of the higher digesta flow, and the lower OM digestibility in summer than in autumn. Seasonal differences were more pronounced than selection differences. There were no significant differences in partial digestion between these selections.

Die doel van die studie was om die gedeeltelike vertering van die 500 mm-hergroei van drie *Pennisetum* seleksies (Bana, Groengoud en Pennaris) deur skape oor drie seisoene te bestudeer, nl. herfs, lente en somer. Daar was geen verskille ($p > 0.05$) tussen seleksies in die kwalitatiewe of kwantitatiewe inname nie. Rumenveranderlikes het ook nie tussen behandelings verskil nie ($p > 0.05$), behalwe vir laer ammoniakwaardes vir Pennaris. Digestavloei was gekorreleer met OM-inname en het nie tussen seleksies verskil nie ($p>0.05$), maar was laer gedurende herfs ($p < 0.01$) as gevolg van laer innames. OM- en veselvertering het hoofsaaklik in die rumen plaasgevind, terwyl N-vertering in die kleinderm plaasgevind het. OM-verteerbaarheid was hoog (± 70%) by alle behandelings. Seisoensverskille het gemanifesteer in die laer rumenale veselvertering gedurende die lente ($p < 0.01$), moontlik as gevolg van hoër digestavloei en laer OM-verteerbaarheid gedurende die somer en lente. Seisoensverskille was meer betekenisvol as verskille tussen seleksies. Daar was dus geen betekenisvolle verskille in gedeeltelike vertering tussen seleksies nie.

Keywords: *Pennisetum;* sheep; season; OM, N and cellulose partial digestion

*To whom correspondence should be addressed at: Department of Livestock & Pasture Science, University of Fort Hare, Alice, 5700

Introduction

This study formed part of an evaluation of three *Pennisetum* selections, Bana grass (Bana), Greengold and Pennaris as forage for sheep (De Bruyn *et al.*, 1998). These selections became very popular in the 1980s but few scientific results are available on their nutritive value or digestion patterns. The extent of organic matter (OM) fermentation in the rumen strongly influences both the quantities of volatile fatty acids (VFAs) produced in the digestive tract and the amount of protein that passes from the stomach for digestion in the small intestine. Changes in fermentation patterns

could, therefore, substantially affect either the total supply of energy and amino acids to the animal, or the balance between them (Hogan *et al.*, 1989). According to Egan *et al.* (1985), amino acid absorption in the small intestine is often the limiting nutrient with grazing animals.

To investigate these variables, use was made of markers to partition digestion within the gastro-intestinal tract, including the mathematical reconstitution of digesta, which gives a clear understanding of the amounts and proportions of a particular nutrient that are absorbed (Faichney, 1975). The objective was to study the partial digestion of nutrients in Bana grass, Greengold and Pennaris as it varied seasonally.

Materials and methods

The *Pennisetum* selections were established on the Hatfield Experimental Farm of the University of Pretoria as described by De Bruyn *et al.* (1998). In that study, intake by sheep and pasture variables were determined at 300-mm and 800-mm regrowth. In this study the partial digestion by sheep of an intermediate 500-mm regrowth height was repeated over three seasons, namely autumn (April 1991), spring (October 1991) and summer (February 1992).

Twelve multi-fistulated (rumen, abomasum and terminal ileum) Merino-type wethers were kept in metabolic crates and samples were collected for a four-day period in each season. Four animals were randomly allocated to each selection treatment. The average live mass of the animals in autumn was 46.5 kg, in spring 52.5 kg and in summer 62.5 kg. Prior to the trials the animals were drenched against internal parasites and placed in a spare paddock for 10 days to allow for adaptation. The animals were then fitted with faecal collection bags and placed individually in the metabolic cages.

During the four day evaluation period the animals were fed freshly cut forage (*ad lib.*) five times daily at 4-h intervals in feed bins with free access to water. Orts were removed every morning.

Chromium (Cr)-EDTA was used as a fluid phase marker (Faichney, 1975) and ytterbium (Yb) acetate as the particulate phase marker (Siddons *et al.*, 1985). Chromium-EDTA was prepared according to Morgan *et al.* (1976). Ytterbium-acetate was dissolved in de-ionised water so that 10 ml of the solution would contain 100 mg Yb. A peristaltic pump was used to infuse 220 mg Cr and 90 mg Yb per day into the rumen via polyethylene tubing inserted through the rumen fistula. Animals were infused for four days to obtain steady state conditions (Faichney, 1975) and continued for the four days of sampling.

Sampling

On the first day sampling occurred at 06:00 and 18:00; on the second day, at 09:00 and 21:00; on the third day at 12:00 and 24:00 and on the fourth day at 15:00 and 03:00. At each of these occasions ruminal, abomasal and ileal samples were drawn and preserved. Total faeces voided daily was collected and frozen. Samples of the fresh feed and the residues were cut into ± 10 cm pieces with a guillotine and frozen. The daily samples were pooled for each animal over the four days.

Analytical procedures

Feed and faecal subsamples were analysed for DM (A.O.A.C., 1990) and ashed to determine OM and the remainder dried at 60°C for further analysis. Abomasal and ileal samples were freeze-dried after a subsample was centrifuged to obtain a supernatant. All dried samples were milled through a 1-mm screen before analysis. The N content of samples was determined by the Kjeldahl method (A.O.A.C., 1990). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to Van Soest *et al.* (1967). Cellulose was calculated as the

difference between ADF and ADL.

Dry samples containing markers were prepared by wet digestion, and marker concentrations in supernatant samples were measured directly by atomic absorption spectrophotometry. The ammonia concentration in the rumen, abomasum and ileum samples were determined on a Technicon Autoanalyzer in the supernatant of the respective fluids after centrifusion. Rumen VFA concentration was determined by gas chromatography. Non-ammonia nitrogen (NAN) was calculated as total N flow minus NH_3-N flow and represents the true protein (mostly microbial protein) in the small intestine.

The data were analysed separately for each season and selection together with their interactions, using a two-way analysis of variance procedure. Results are reported as means with their standard errors. Values with common letters on the same horizontal line do not differ significantly at the 5% significance level. Owing to limited space and because of practical considerations, no replications were possible.

Results and discussion

The influence of season and selection on the chemical composition of freshly cut pasture is presented in Table 1.

Except for N being higher in autumn ($p \leq 0.04$; $n = 9$), there were no significant differences in the chemical composition between seasons or selections, but the forages were of high quality.

In Table 2 rumen variables of the sheep as influenced by season and selection are presented.

In summer the rumen pH and the rumen ammonia concentration were significantly lower ($p \leq 0.01$, $n = 36$) compared to autumn and spring while VFA concentrations did not differ significantly between seasons. The biological significance of the lower pH values is probably negligible. The rumen pH and VFA values were of the order reported for pasture-fed animals (Akin, 1981) while ammonia levels relative to N content were within the range for forages predicted by Meissner *et al.* (1993). The lower ammonia levels in summer could be ascribed to the lower N content of the forages (Table 1), since Meissner *et al.* (1993) found that the N content of forages accounted for 81% of the variation in rumen ammonia levels. Pennaris had significantly lower rumen ammonia concentrations ($p \leq 0.01$, $n = 36$) than Bana, but neither differed significantly from Greengold. There

Table 1 The chemical composition of the selections as influenced by season and selection

	Autumn	Spring	Summer
DM (%)	17.8 ± 1.72	18.8 ± 0.24	18.4 ± 1.21
OM (%)	82.5 ± 0.49	82.1 ± 0.35	83.1 ± 0.49
N (%)	3.0 ± 0.21^{b}	2.7 ± 0.15^{ab}	2.0 ± 0.10^{a}
Cellulose (%)	26.1 ± 2.33	27.3 ± 1.37	30.8 ± 0.25
	Bana	Greengold	Pennaris
DM (%)	17.9 ± 1.39	18.4 ± 1.44	18.7 ± 0.73
OM (%)	82.4 ± 0.53	83.2 ± 0.44	82.1 ± 0.26
N (%)	2.7 ± 0.34	2.5 ± 0.18	2.5 ± 0.44
Cellulose (%)	26.8 ± 2.17	29.5 ± 1.32	27.8 ± 2.25

[ab] Values in rows bearing different superscript letters are significantly different ($p < 0.05$).

Table 2 Rumen variables of sheep as influenced by season and selection

	Autumn	Spring	Summer
pH	6.4 ± 0.03[b]	6.4 ± 0.03[b]	6.3 ± 0.01[a]
Rumen NH_3 (mg/100 ml)	28.2 ± 2.19[b]	23.9 ± 1.7[ab]	19.1 ± 1.3[a]
VFA conc. (mmol/100 ml)	17.9 ± 0.53	18.5 ± 0.88	20.7 ± 0.7
	Bana	Greengold	Pennaris
pH	6.3 ± 0.02	6.4 ± 0.02	6.4 ± 0.03
Rumen NH_3 (mg/100 ml)	27.7 ± 2.45[b]	24.2 ± 1.0[ab]	19.4 ± 1.8[a]
VFA conc. (mmol/100 ml)	20.7 ± 0.87	18.5 ± 0.51	18.0 ± 0.7

[ab] Values in rows bearing different superscript letters are significantly different ($p < 0.05$).

were no other significant differences in rumen variables between selections.

Although ammonia levels seemed to reflect the N content of the forages, the differences in ammonia levels observed were proportionally greater than differences in N content. This indicated possible differences in the degradability or solubility of plant protein between selections. Pennaris ammonia levels were mostly influenced by N content and N intake; 93% of the variation being explained by these two factors. Bana and Greengold ammonia levels were influenced to a smaller extent by these two variables.

In Table 3 the intake, digesta flow (Td) and partial digestion of OM as influenced by season, across selections, is presented.

There were no differences ($p > 0.05$) in OM intake between seasons, though the lowest values were measured in autumn. Relative to the metabolic livemass of the animals the lowest values were measured in summer, the highest in spring and autumn intermediate ($p \leq 0.01$; $n = 36$) which could be ascribed to the higher fibre content of material in summer (Table 1).

Digesta flow was lower in autumn ($p < 0.01$; $n = 36$) compared to spring and summer and reflected OM intake trends. Relative to OM intake, values were slightly lower in this study compared to those reported for other subtropical pastures (Meissner *et al.*, 1991).

In autumn higher proportions of OM were digested in the rumen compared to spring ($p = 0.09$;

Table 3 Organic matter intake and partial digestion by sheep as influenced by season

	Autumn	Spring	Summer
OMI (g/d)	737 ± 45.2	907 ± 45.5	878 ± 44.1
DOMI (g/kg $W^{0.75}$/d)	28.6 ± 1.3[ab]	33.1 ± 1.56[b]	27.0 ± 1.28[a]
Td flow at abomasum (l/d)	15.1 ± 0.44[a]	19.4 ± 0.71[b]	18.5 ± 0.57[b]
at ileum (l/d)	4.9 ± 0.24[a]	6.1 ± 0.41[b]	6.0 ± 0.31[b]
OM disapp. in rumen (% of OMI)	50.9 ± 1.74[b]	43.1 ± 1.92[a]	45.7 ± 1.41[ab]
in small intest. (% of OMI)	13.3 ± 0.85	16.4 ± 0.88	13.5 ± 1.03
% disapp. in total tract	72.1 ± 0.74[b]	69.7 ± 1.06[ab]	66.6 ± 0.74[a]

[abc] Values in rows bearing different superscript letters are significantly different ($p < 0.05$)

$n = 36$). There were no differences in OM digested in the small intestine ($p > 0.05$). The reason for the higher total tract digestion in autumn ($p < 0.01$; $n = 36$) was probably the lower flow rates in autumn which led to increased exposure of the digesta to digestive processes (Egan *et al.*, 1985). In Table 4 the intake and partial digestion of OM as influenced by selection, across seasons, is presented.

There were no differences ($p > 0.05$) in intake or digestion between selections when compared across seasons probably because there were no significant differences in chemical composition between selections (Table 1).

With high quality forages the site of OM digestion is shifted more into the lower digestive tract when compared to forages of lower digestibility (Faichney *et al.*, 1977). In this study values for OM digested in the forestomach (rumen) relative to total OM digested ranged between 62–68% whereas values for subtropical pastures of lower quality ranged from 68–76% (Meissner *et al.*, 1991). The values for OM digestion in the rumen relative to OM intake (44–51% see Tables 3 and 4) were comparable to values reported for *Lolium multiflorum* (Du Preez *et al.*, 1992), confirming the high quality of these pastures.

In Table 5 the results of the partial digestion of N as influenced by season and selection are presented. Since the microbial protein yield and degradability and solubility of forage protein was not

Table 4 Organic matter intake and partial digestion by sheep as influenced by selection

	Bana	Greengold	Pennaris
OMI (g/d)	835 ± 67.9	861 ± 41.9	826 ± 33.7
DOMI (g/kg $W^{0.75}$/d)	30.3 ± 1.77	30.3 ± 1.86	28.1 ± 0.85
Td flow at abomasum (l/d)	17.9 ± 1.06	18.2 ± 0.68	16.7 ± 0.52
Td flow at ileum (l/d)	5.8 ± 0.47	5.9 ± 0.36	5.3 ± 0.16
OM disapp. in rumen (% of OMI)	44.3 ± 1.17	49.2 ± 1.84	46.1 ± 2.38
in small intest. (% of OMI)	15.7 ± 0.96	13.3 ± 0.94	14.2 ± 1.01
% OM disapp. in total tract	69.5 ± 0.83	70.3 ± 1.07	68.7 ± 1.26

Table 5 Partial digestion of N in the small intestines as influenced by season and selection.

	Autumn	Spring	Summer
N intake (g/d)	28.0 ± 1.60^{ab}	30.9 ± 1.99^{b}	21.9 ± 1.07^{a}
N disapp. (% of N intake)	76.1 ± 1.30	72.1 ± 1.61	75.8 ± 1.46
NAN disapp. (% of N intake)	65.6 ± 2.19	64.6 ± 2.31	72.3 ± 1.56
% N disapp. in total tract	79.6 ± 1.52	76.1 ± 1.42	82.0 ± 1.71
	Bana	Greengold	Pennaris
N intake (g/d)	27.8 ± 2.14	27.1 ± 1.80	25.9 ± 1.85
N disapp. (% of N intake)	74.1 ± 1.30	75.2 ± 1.33	74.7 ± 1.95
NAN disapp. (% of N intake)	66.8 ± 2.05	65.7 ± 2.87	69.9 ± 1.57
% N disapp. in total tract	79.6 ± 1.39	80.6 ± 1.86	77.6 ± 1.75

^{abc} Values in rows bearing different superscript letters are significantly different ($p < 0.05$)

determined, the disappearance of N in the forestomachs can not be presented, and N disappearance is only presented for the small intestine.

The lower N intake in summer compared to spring ($p < 0.01$; $n = 36$), probably resulted from the lower N content (Table 1) and OMI (Table 3) in that season. There were no other differences in N digestion between seasons or selections despite the differences in rumen ammonia levels (Table 2).

N was digested in the small intestine as NAN or was absorbed across the rumen wall in the form of ammonia (Ørskov, 1982). NAN disappearance in this study was comparable to values reported for those obtained on subtropical pastures (Meissner et *al.*, 1991) but lower than for *L. multiflorum* (Du Preez *et al.*, 1992).

Meissner *et al.* (1993) predicted that NAN disappearance as a proportion of N intake in subtropical grasses should be in the order of 70%. In this study values varied between 66–72%, which supports that conclusion.

A high correlation was found between N intake and NAN disappearance ($r = 88\%$). This would indicate little variation between seasons and selections in the digestibility of protein in the lower digestive tract. Meissner *et al.* (1993) predicted a linear relationship between N intake and NAN flow to the small intestine ($r^2 = 0.96$ for subtropical grasses), as well as a high correlation between NAN flow to the small intestine and NAN disappearance in the small intestine ($r^2 = 0.99$). Those findings are supported by the results of this study. Meissner *et al.* (1993) also concluded that NAN disappearance proportional to NAN flow should be relatively consistent, and should not deviate appreciably from a value of 75%. That finding was supported in this study since values varied between 72% and 78%.

As expected, cellulose was digested mainly in the rumen. Cellulose intake was lower in autumn than in the other seasons ($p < 0.01$; $n = 36$). There were no significant differences in cellulose digestion between seasons or selections (Table 6).

Table 6 Partial digestion of cellulose as influenced by season and selection

	Autumn	Spring	Summer
Cellulose intake (g/d)	214 ± 15.1[a]	327 ± 14.8[b]	342 ± 20.1[b]
Cellulose disapp. in rumen (% of cell. intake)	64.4 ± 1.14	62.9 ± 1.51	63.0 ± 1.18
total tract disapp. (%)	71.0 ± 0.81	73.5 ± 1.20	71.4 ± 1.00
	Bana	Greengold	Pennaris
Cellulose intake (g/d)	296 ± 32.7	293 ± 16.9	295 ± 19.6
Cell. disapp. in rumen (% of cell. intake)	63.1 ± 1.24	64.4 ± 1.11	62.8 ± 1.48
total tract disapp. (%)	70.7 ± 0.98	73.8 ± 1.12	71.4 ± 0.85

[abc] Values in rows bearing different superscript letters are significantly different ($p < 0.05$)

Conclusions

In this study there were no significant differences in OM intake across season or selection. This is in contrast to the intake trial (see De Bruyn *et al.*, 1998) where significantly lower estimates of intake were obtained for autumn, and the highest in spring. The trends were similar though since intake in autumn tended to be lower. Intake of Pennaris, however, tended to be higher in the intake trial.

Digestion patterns were also not different between selections, but seasonal differences did occur which could be ascribed to differences in the absorption of nutrients (notably OM and N), along

with other external factors (leaf:stem ratios, DM content of material, etc.). Intake was, therefore, probably influenced by a number of internal and environmental factors.

The selections do have value as grazing for high producing animals provided bypass proteins are supplemented. There were, then, no marked differences between the three selections while seasonal differences were of greater significance than selection differences.

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