Nutrient selection by cattle, goats and sheep on natural Karoo pasture. 2. Nitrogen

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The nitrogen (N) content of material selected by cattle, Boer goats, Dorper and Merino sheep on natural Karoo pasture was investigated. A pronounced seasonal variation in the N content of selected material was found. No correspondence was recorded between the N content of oesophageal extrusa and hand-sampled material. Cattle selected material with a lower ($P < 0,01$) N content (1,28 ± 0,28%) than Boer goats and sheep, with Boer goats (1,60 ± 0,35%) lower ($P < 0,05$) than sheep. The difference between Dorper (1,88 ± 0,35%) and Merino sheep (1,87 ± 0,37%) was not significant. Close correlations between the small stock species ($r = 0,81-0,89$) indicates a similarity in the seasonal N selection pattern of small stock on Karoo veld. Lower correlations between cattle and small stock ($r = 0,43-0,61$) shows that the N selection pattern of cattle deviates from that of small stock. A small but significant ($P < 0,01$) difference in extrusa N content between dry female (1,72 ± 0,44) and castrated male (1,65 ± 0,43) animals was recorded. Notwithstanding, high correlations ($r = 0,87-0,95$) suggest that N selection of dry females can be predicted from castrated males and vice versa. A highly significant difference ($P < 0,01$) in the N content of selected material was determined between years. An intraclass (animal species) correlation of $r = 0,95$ between years indicated a correspondence in the seasonal N selection pattern. A difference ($P < 0,01$) was recorded in N content of extrusa pooled for the first and last 2 days of the 4-day sampling period. This difference (4,2% units or 0,07% N) was however small. The N content of selected material is discussed together with its digestibility. It is concluded that small stock selected material with a higher nutritive value than cattle on Karoo veld.
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Die stikstofinhoud (N) van materiaal deur beeste, boerbokke, Dorper- en Merinoskape op Karooveld geselekteer, is ondersoek. 'n Duidelike seisoenale variasie in die N-inhoud van geselekteerde materiaal is geïllustreer. Geen ooreenkoms is gevind in die N-inhoud van materiaal met slukdermgefistelleerde diere versamel en dié van monsters met die hand versamel nie. Beeste het materiaal met 'n laer ($P < 0,01$) N-inhoud (1,28 ± 0,28%) as boerbokke en skape geselekteer, met boerbokke (1,60 ± 0,35%) laer as skape. Dié verskil tussen Dorper- (1,88 ± 0,35%) en Merinoskape (1,87 ± 0,37%) was nie betekenisvol nie. Noue verwantskappe ($r = 0,81-0,89$) tussen die kleinveesoorte dui op 'n ooreenkoms in hulle seisoenale N-seleksiepatrone. Die laer korrelasies ($r = 0,43-0,61$) tussen kleinvee en beeste toon dat die N-seleksiepatroon van beeste afwyk. Die N-inhoud van materiaal deur droë vroulike (1,72 ± 0,44%) en gekastreerde manlike diere (1,65 ± 0,43%) geselekteer, het verskil ($P < 0,01$). Dié verskil (4,2% of 0,07% N) was egter heelwat kleiner as die standaardafwykings van die gemiddeldes. Nietemin dui hoë korrelasies tussen geslagte ($r = 0,87-0,95$) op die moontlikheid dat N-seleksie van droë vroulike diere voorspel kan word vanaf gekastreerde manlike diere en omgekeerd. 'n Betekenisvolle ($P < 0,01$) verskil in die N-inhoud van die geselekteerde materiaal is tussen jare vasgestel. 'n Intraklas (diersoorte)-korrelasie van $r = 0,95$ tussen jare dui op 'n ooreenkoms in die seisoenale N-seleksiepatrone tussen jare. 'n Verskil ($P < 0,01$) in N-inhoud van geselekteerde materiaal wat vir die eerste en laaste 2 dae van die 4-dae-monsterperiode saamgevoeg is, is aangeteken. Dié verskil (4,2% of 0,7% N) was egter klein. Die N-inhoud en verteerbaarheid van geselekteerde materiaal is gesamentlik bespreek. Daar is tot 'n gevolgtrekking gekom dat kleinvee materiaal met 'n hoër voedingswaarde geselekteer het as beeste op Karooveld.
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Introduction

Many natural pasture plants in the Karoo Region have been examined for nutritional value from chemical analysis of samples collected by hand (Botha, 1938; Steenkamp, 1967; Louw, Steenkamp & Steenkamp, 1968a,b,c; Louw, 1969; Steenkamp & Hayward, 1979). Kennedy (1962) concluded that these samples were not representative of the material selected by free-grazing animals, a view supported by McDonald (1968). Furthermore, Dudzinski & Arnold (1973); Langlands & Sanson (1976); Wilson (1977); and Greatz & Wilson (1980) established that differences exist between cattle, sheep and goats in their grazing preferences and consequently nutrient consumption on pasture. It follows, therefore, that the application of data obtained by hand sampling is doubtful in compiling for example, supplementary feeding strategies. The present experiment, of which the first part has already been published (Zeeman, Marais & Coetsee, 1983), was undertaken to study seasonal variation in the nutrient content of material selected by cattle, goats and sheep grazing together on natural Karoo pasture and to compare it to hand-sampled material.

Material and Methods

A detailed description of experimental materials and methods used in this study was given by Zeeman, *et al.* (1983). Oesophageally fistulated Afrikaner heifers and oxen, Boer-goat castrates, Dorper ewes and wethers (four each) and Merino ewes and wethers (five each) were used in this investigation. Extrusa samples were collected at 6-week intervals starting in May 1976 through to the termination of the experiment in October 1977. These samples, which included saliva, were freeze-dried individually and then pooled on a mass basis for the first and last 2 days of the 4-day sampling period. The nitrogen content of extrusa and material collected by hand was determined by Macro-Kjeldahl procedure (AOAC, 1980).

A one-way experimental layout was followed with repeated observations on the same experimental units (animals). A factorial model was used for analysis of variance, and covariance (Dixon & Brown, 1979) was applied to test for differences within sampling times.

Results

The average N content of material selected at different times by the different animal types is illustrated in Figure 1.

According to Figure 1, a pronounced seasonal variation in the N content of selected material occurred. A prominent peak value was recorded for February 1976 with lesser ones

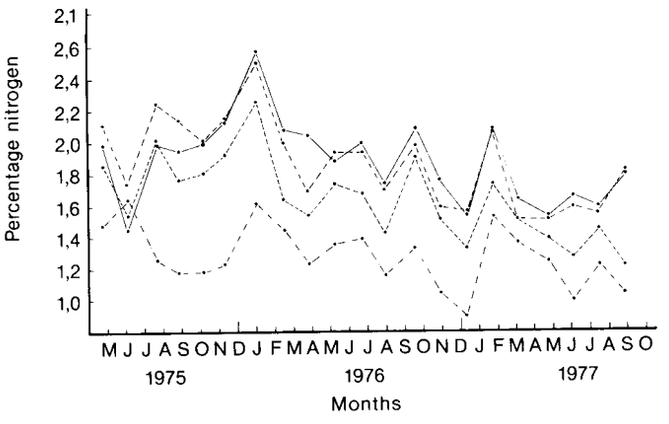

Figure 1 Percentage nitrogen in material selected by cattle (– · · –), Boer goats (– – –), Dorper (——) and Merino sheep (– · –) on natural Karoo pasture

for August 1975, October 1976 and February 1977. The peaks in February (1976 and 1977) coincided with peak rainfall periods while August 1975 and October 1976 were months when the maximum daily temperature exceeded 20 °C after the winter period.

A descending-wheelpoint survey (Roux, 1963) showed that 33 Karoo bush, 19 grass and 23 ephemeral species occurred on the experimental plot used for sampling. Of these 30 Karoo bush, 17 grass and 12 ephemerals produced sufficient material for analysis. The average N content (%) of the main plant communities and their relative composition expressed as a percentage of the total plant species on the plot is given in Table 1 (sampling dates coincide with dates in Figure 1).

Large variations were found as demonstrated by the standard deviations and ranges between maximum and minimum values (Table 1). In addition, it is clear from Table 1 that Karoo bush and grass were the most important species on the experimental plot and that ephemerals made a small contribution to available plant material.

A highly significant difference ($P < 0,01$) in extrusa N content between animal species (F = 190,92; DF = 3; DF error = 1229) was recorded. On average cattle selected material with less N (1,28 ± 0,28%) than Boer goats and sheep ($P < 0,01$). Boer goats also selected material with a lower ($P < 0,05$) N content (1,60 ± 0,46%) than sheep but, the difference between Dorper (1,88 ± 0,35%) and Merino (1,87 ± 0,37%) sheep was not significant ($P > 0,05$). Close correlations between Dorper sheep, Merino sheep and Boer goats (Table 2), suggest a correspondence in the N selection pattern of small stock. The lower correlations between sheep and cattle shows that the N selection pattern of cattle differs from that of small stock. This tendency is also illustrated in Figure 1.

The difference in the N content of material selected by dry females (1,72 ± 0,44%) and castrated males (1,65 ± 0,43%) was significant ($P < 0,01$) (F = 13,83; DF = 1; DF error = 1056). Comparisons within animal types disclosed that material selected by cattle, Dorper and Merino sheep contained 1,30 ± 0,19 and 1,26 ± 0,20; 1,97 ± 0,25 and 1,80 ± 0,27; and 1,88 ± 0,27 and 1,87 ± 0,28% N respectively for the dry female and castrated male animals.

The difference between sexes was significant ($P < 0,05$) only for Dorper sheep. An analysis within sampling time showed that dry females did not consistently select material with a higher N content. This inconsistency was confirmed by a significant animal species × sex interaction ($P < 0,01$) (F = 6,12; DF = 2; DF error = 1056). However, the inconsistency was not large enough to prevent the highly significant correlations between sexes within animal species (Table 2).

Pooled averages for percentage N in selected material for 1975, 1976 and 1977 were 1,80 ± 0,45^a, 1,76 ± 0,43^a and 150 ± 0,39^b respectively (a > b at $P < 0,05$) (F = 94,4**; DF = 2; DF error = 1252). An intraclass (animal species) correlation of r = 0,95 was calculated between years. Furthermore, a significant interaction ($P < 0,01$) (F = 6,09; DF = 6) between years and animal species was obtained. Although the interaction shows an inconsistency in the N selection pattern, the intraclass correlation suggests a correspondence between years. This correspondence is also illustrated in Figure 1.

The N content of extrusa pooled for the first (1,73 ± 0,45%) and last (1,66 ± 0,43%) 2 days of the 4-day sampling period differed significantly ($P < 0,01$) (F = 12,79; DF = 1; DF error = 1229). This difference amounts to 4,2% (0,07% N), which is lower than the variance within the first and last 2 days. Furthermore, an analysis within sampling time showed that this difference was not consistent. The N content of extrusa for the last 2 days tended to be higher than the first two on an increase in N content and lower on the decrease in N content (as shown in Figure 1). The differences recorded, however, were small and were not substantiated with a test between averages.

Discussion

Seasonal variation is a characteristic of natural Karoo pasture (Roux, Vorster, Zeeman & Wentzel, 1981). This observation is confirmed by the distinct seasonal variation in extrusa N content illustrated in Figure 1. Moreover, peaks in N content coincided with peak values recorded for the digestibility of organic matter (DOM) (Zeeman *et al.*, 1983). Further confirmation of this variation was the significant differences ($P < 0,05$) in the extrusa N and DOM content between years and the significant interactions between animal species ×

Table 1 The average nitrogen content of material sampled by hand and relative composition (RC) of the main plant communities on the experimental plot

Sample date (1976)	Karoo bush					Grass					Ephemerals ('opslag')				
	N (%)				RC	N (%)				RC	N (%)				RC
	Mean ± SD		Max	Min	(%)	Mean ± SD		Max	Min	(%)	Mean ± SD		Max	Min	(%)
January	1,15 ± 0,33		1,98	0,73	49	0,96 ± 0,19		1,22	0,65	48	1,97 ± 0,53		2,58	1,64	3
April	1,01 ± 0,24		1,60	0,42	42	0,74 ± 0,23		1,16	0,20	55	1,35 ± 0,43		1,72	0,85	3
July	0,94 ± 0,24		1,47	0,65	53	0,65 ± 0,11		0,83	0,29	45	1,59 ± 0,43		1,85	1,33	2
November	0,89 ± 0,30		1,48	0,52	57	0,86 ± 0,25		1,28	0,60	40	1,28 ± 0,25		1,45	1,10	2

Table 2 Correlations and regression equations between sexes and animal types for % nitrogen in selected material

Relationship between		[a]Correlation	[b]Regression equation		
(*X*)	(*Y*)	coeff (*r*)	*b*	*a*	*S*
Oxen	heifers	0,87	0,2274	0,8474	0,100
Dorper wethers	Dorper ewes	0,92	0,4234	0,8554	0,103
Merino wethers	Merino ewes	0,95	0,1853	0,9071	0,089
Merino sheep	Dorper sheep	0,86	0,3473	0,8205	0,136
Merino sheep	Boer goats	0,89	0,0644	0,8433	0,126
Merino sheep	cattle	0,51	0,6037	0,3612	0,176
Dorper sheep	Boer goats	0,81	0,1130	0,8124	0,158
Dorper sheep	cattle	0,43	0,6735	0,3219	0,185
Boer goats	cattle	0,61	0,5258	0,4589	0,162

[a]r = 0,433 at the 5%, and 0,549 at the 1% level of significance.
[b]Regression equation in the form $Y = b + aX$.

years. In addition, correlations calculated between extrusa N and DOM content within animal species were not significant. These inconsistancies in N and DOM selection patterns can be ascribed to the complex botanical composition of the plants on the experimental plot and to a seasonally related preference for different plant species by the different animal species (Botha, 1981). On the other hand, the intraclass (animal species) correlation between years of r = 0,95 (r = 0,88 for DOM) shows a strong correspondence to the seasonal pattern of extrusa N (and DOM) content, in spite of a decreasing trend over the experimental period. This suggests a similarity in the nutrient selection patterns between subsequent years. The similarity between years can be ascribed to a recurrence in climatic patterns. In excess of 50% of the total rainfall occurred during January, February and March of 1976 and 1977 and the average maximum temperature exceeded 20 °C in September of 1975, 1976 and 1977. The comparison between selection patterns (Figure 1) and climate parameters suggest that a combination of precipitation, soil moisture reserves and temperature-influenced seasonal nutrient selection patterns.

Although the average N content of material sampled by hand (Table 1) corresponds to values reported by Steenkamp & Hayward (1979), it differs substantially from the N content of selected material (Figure 1). Ephemerals contained more N than Karoobush and grass (Table 1). Its proportional contribution to the selected diet (Botha, 1981), however, was not large enough to raise the N content of hand-sampled material to levels comparable to extrusa N contents. A similar finding for DOM was reported by Zeeman, *et al.* (1983). This confirms well-documented findings (Engels, 1983) that results obtained with hand-sampled material not only underestimates the nutritive value of natural pastures but, deviates considerably from values obtained with grazing animals. In addition, this anomaly seems to be more pronounced on pastures with a divergent botanical composition.

The fact that sheep selected material with a higher N content than cattle accords with the findings of Thetford, Pieper & Nelson (1971) and Langlands & Sanson (1976). Sheep also selected material with a higher DOM content (Zeeman, *et al.*, 1983). Furthermore, the magnitude of differences in N and DOM between sheep and cattle in this study are comparable to those reported by Thetford, *et al.* (1971) and Langlands & Sanson (1976). Consequently, it seems that differences in the grazing method (Arnold & Dudzinski, 1978) between sheep and cattle may be responsible for the differences in the selection of N and DOM. Aucamp (1981) found that in the Valley Bushveld (Veld type no. 26 of Acocks, 1975) goats selected material with a higher N content than Dorper sheep. He ascribed this to the preference of browse by goats. The absences of browse could be responsible for the lower N content of material selected by goats in this study, which was conducted on a short-shrub veld. Furthermore, Botha, Blom, Sykes & Barnhoorn (1983) found a high dietary overlap between goats and sheep in a study conducted together with this investigation. The Dorper and Merino sheep selected material with a similar N (and DOM) content. This is in agreement with Langlands (1969) who found no differences in nutrient selection between breeds of sheep. Moreover, the high correlations between the Boer goats, Dorper and Merino sheep (Table 2) imply a similarity in their N selection patterns. This, together with DOM, suggests a similarity in their dietary preferences and grazing methods on the veld type used in this study. In contrast, the lower correlations between cattle and the small stock species (Table 2) suggest a dissimilarity in dietary preference which is also illustrated in Figure 1.

The difference ($P < 0,01$) in N content of material selected by dry female and castrated male animals is not in agreement with the results of Langlands (1969). He reported no differences between sexes. A similar finding for DOM was reported by Zeeman, *et al.* (1983). Further analysis showed, however, that the difference in N selected was only significant ($P < 0,05$) for Dorper sheep. The differences recorded for DOM between sexes within animal species were not significant ($P > 0,05$). Furthermore, Langlands (1969) observed that dry females did not consistently select material with a higher N and DOM content. Although Zeeman, *et al.* (1983) reported no interaction for DOM, an animal species × sex interaction was recorded for N. This confirms the inconsistency observed by Langlands (1969). The inconsistencies were, however, small and regression equations to predict the relationship of N (and DOM) selection between dry female and castrated male animals were obtained (Table 2).

Although significant ($P < 0,01$) the difference in extrusa N content pooled for the first and last 2 days of the sampling period was small and inconsistent. Langlands (1967) observed differences between the diet selected on different days in some cases but recorded no evidence of a progressive change. The complex botanical composition of plants on the experimental plot may be responsible for this result.

It is evident that small stock selected material with a N (and DOM) content which qualitatively exceeded maintenance requirements for most of the experimental period. Cattle, however, selected material with a much lower N and DOM content. The grazing method of small stock, especially sheep, is consequently better adapted than that of cattle to qualitatively utilize False Upper Karoo Veld or veld with a similar shrub and grass content.

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