Relationships between climatic factors and the diet selected by ruminants on Karoo veld

P.J.L. Zeeman* and A.J. Fourie

Dohne Agricultural Research Station, Stutterheim, 4930 Republic of South Africa

*To whom correspondence should be addressed

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Diet selection and intake by cattle, goats and sheep was related to climatic factors by principal-component analysis. Digestibility of selected material and digestible organic matter intake per metabolic size (DOMI/kg $W^{0,75}$) were significantly correlated to a principal component combining rainfall, and minimum and maximum temperature which described 49,3% of climate-factor variation. The selection pattern of cattle was more closely related to this principal component than the pattern in goats and sheep. This was ascribed to a more precise diet selection ability by small stock.

Die dieëtseleksie en inname van beeste, bokke en skape is deur middel van hoofkomponentanalise met klimaatsfaktore in verband gebring. Verteerbaarheid van organiese materiaal en inname van verteerbare organiese materiaal per metaboliese grootte was betekenisvol gekorreleer met 'n hoofkomponent wat reënval, minimum en maksimum temperatuur gekombineer het en 49,31% van die variasie in klimaatsfaktore beskryf het. Die seleksiepatroon van beeste was nouer gekorreleer met dié hoofkomponent as dié van skape en bokke. Dit is aan 'n meer presiese seleksie deur kleinvee toegeskryf.

Keywords: Climate, diet selection, ruminants, Karoo veld

According to Corbett (1982) all components of a grazing system interact and all must be considered if a real understanding of the system is to be achieved.

De Waal, Engels & Van der Merwe (1980) concluded that the seasonal trend in crude protein and digestible organic matter (DOM) selected by free-grazing sheep on natural pasture corresponded closely with rainfall. However, Zeeman (unpublished results) was unable to obtain close correlations between climate (rainfall and minimum temperature *per se*), DOM, nitrogen (N) selected, and intake of cattle, goats and sheep grazing natural Karoo pasture. The ecological nature of pasture utilization, where a climatic factor cannot solely account for the variation in nutrients selected, could be responsible for this apparent anomaly. Dudzinski & Arnold (1973) stated that principal-component analysis appears to be useful for interpretation of results where plant × animal interactions are involved. The work reported here was consequently undertaken to elucidate interactions between climate and the diet selected by cattle, goats and sheep on Karoo veld.

The experiment was conducted on False Upper Karoo Veld (Veld type 36 of Acocks 1975). Oesophageally fistulated Afrikander cattle (8), Boer goats (4), and Merino sheep (10) were used to collect samples on four consecutive days at 6-week intervals from May 1975 to October 1977. The experimental procedure was described by Zeeman, Marais & Coetsee (1983). DOM was determined *in vitro* and N by macro-Kjeldahl. Dry-matter intake (DMI) and DOM intake per metabolic size (DOMI/kg $W^{0,75}$) was calculated from faecal excretion measured with Cr_2O_3 as external indicator according to Engels, Malan & Baard (1974). Eight intact animals of each species were used.

Climatic data was supplied by the SIRI division Agrometeorology, Middelburg, Cape. Rainfall was taken as the total rainfall (mm) for the 6 weeks preceding a sampling period while for minimum temperature, maximum temperature (°C), sunshine ($h.d^{-1}$), and wind ($km.d^{-1}$) a daily average over the 4-day sampling period was used. A regression on principal-component analysis (BMDP/4R) was used with the climatic parameters as independent variables and DMI, DOMI/kg $W^{0,75}$, % DOM, and % N as dependent variables.

The results of the principal-component analysis are given in Table 1.

The principal-component analysis of the five climate variables showed that the first three principal components accounted for 92,1% of the total variation in climate (Table 1).

The first principal component (PCl) accounted for 49,3% of the total variation (Table 1) and was characterized by positive coefficients for rainfall, minimum- and maximum temperature and negative, but low, coefficients for sunshine and wind. It contrasts between rain and temperature on the one hand, and sunshine and wind on the other. Hence, it represents a measure of 'humidness' denoting a condition favourable for plant growth.

The second principal component (PC2) was responsible for 27,4% of total variation. It had positive eigen vectors for sunshine, maximum temperature and wind with a lower positive value for minimum temperature and a low negative value for rainfall (Table 1). It described a condition that is dry with long sunshine hours and high temperatures or 'aridity'.

The third principal component (PC3) (14,2% of total variation) was high and negative for wind with a negative coefficient for minimum temperature and positive for sunshine. This component (Table 1) differentiates between wind (−), minimum temperature (−), and sunshine (+) which suggests a 'windless' condition with long sunshine hours.

Correlations between DMI, DOMI/kg $W^{0,75}$, and N for the different animal species and the first three principal components for climate are given in Table 2.

The DMI's of the three ruminant species were not significantly correlated to the principal components ($P < 0,05$) (Table 2). DMI by cattle, however, is of interest in that the correlation was higher than for goats and sheep and that it was negatively correlated to PC3. This suggests that wind had an influence on DMI by cattle.

The correlations between PCl and DOMI/kg $W^{0,75}$, were highly significant ($P < 0,01$) for cattle and significant ($P < 0,05$) for goats and sheep (Table 2). This shows that 'humidness' which combines rainfall and temperature had an effect on DOMI/kg $W^{0,75}$ by ruminants grazing veld. Furthermore, the correlations obtained for the % DOM of material selected by the experimental animals and PCl were closer

Table 1 Climatic factors reduced by principal-component analysis to orthogonal predicting variables (eigen vectors)

	Principal components (PC)				
	1	2	3	4	5
Eigen values	2,47	1,37	0,77	0,36	0,04
Cumulative proportion of total variance (%)	49,31	76,75	92,07	99,26	100,00
Eigen vectors					
Rainfall	0,53	−0,22	0,07	0,81	0,08
Minimum temperature	0,54	0,31	−0,43	−0,16	−0,64
Maximum temperature	0,47	0,54	0,11	−0,24	0,64
Sunshine	−0,24	0,65	0,55	0,32	−0,34
Wind	−0,38	0,38	−0,71	0,39	0,23

Table 2 Summary of regression analysis of DMI, DOMI/kg $W^{0,75}$, DOM, and N of cattle, goats and sheep on climate principal components

Dependent variables and animal species	Correlations between principal components and dependent variables			Multiple correlation coefficient (R)	F value for regression
	1 'Humidness'	2 'Aridity'	3 'Windless'		
DMI					
Cattle			$-0,41^a$	$0,17^a$	$3,92^a$
Goats	$0,21^a$			$0,05^a$	$0,89^a$
Sheep	$0,35^a$			$0,12^a$	$2,60^a$
DOMI/kg $W^{0,75}$					
Cattle	$0,65^c$			$0,42^a$	$13,54^c$
Goats	$0,49^b$			$0,24^a$	$6,07^b$
Sheep	$0,45^b$			$0,20^a$	$4,72^b$
DOM					
Cattle	$0,84^c$			$0,71^c$	$45,38^c$
Goats	$0,64^c$			$0,41^a$	$12,92^c$
Sheep	$0,63^c$			$0,40^a$	$12,44^c$
N					
Cattle		$-0,45^b$		$0,21^a$	$4,89^b$
Goats	$0,31^a$			$0,10^a$	$2,08^a$
Sheep	$0,31^a$			$0,10^a$	$2,08^a$

[a]Not significant ($P > 0,05$); [b]$P < 0,05$; [c]$P < 0,01$.

($P < 0{,}01$) than for DOMI/kg $W^{0,75}$ and % DOM for cattle was higher than the correlations recorded for goats and sheep. This shows a more direct influence of the PC1 on the DOM selection pattern of cattle. Additionally, the difference between cattle and small stock could be ascribed to the better ability of small stock to more precise diet selection than cattle (Dudzinski & Arnold, 1973).

The N content of material selected by goats and sheep was not significantly ($P > 0{,}05$) correlated to PC1 and for cattle it was negatively correlated to PC2 ('aridity') (Table 2). This differs from DOM possibly because of a divergence in the N and DOM selection patterns. It seems therefore that N selected was less subject to climatic factors than DOM.

Diet selection represents an interplay between climate, available plant material and grazing animals of which the plants are an important component. Dudzinski & Arnold (1973) reported a close correspondence between factors pertaining to pasture plants (greenness, total bulk, etc.) and selective preferences by sheep and cattle. Furthermore, climate is a determinant of plant production and quality, and affects diet selection through available plant material. This effect, however, is through a combination of climatic factors rather than single factors.

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