

PRELIMINARY RESULTS OF *in vitro* DIGESTION OF SOME PLANTS UTILIZED BY KALAHARI UNGULATES

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Abstract — Five species of ungulates are compared with respect to digestibility and energy production of some plants found in their diet. Blue wildebeest prefer *Stipagrostis obtusa* which is well digested and produces little methane in autumn. However, *Schmidtia kalahariensis* is a better source of energy for wildebeest during the winter. *Stipagrostis obtusa* is also well digested by gemsbok, but is not a good energy source for eland. The relationship between volatile fatty acid energy gain and methane energy lost is typical for each ungulate species. Only during spring was a correlation found between the percentage digestibility and percentage protein in the plants and then only for eland and springbok.

Introduction

It must be more of a challenge to make a living as an antelope in the subdesert Kalahari than in the subtropical eastern Transvaal lowveld, one is inclined to think. By means of adaptation through natural selection over numerous generations the ecological balance for ungulates is no more delicate for those in the subdesert than those in the subtropics. The desert's dramatic response to rainfall is well known and here the chain of life is more strictly regulated by available water which through vegetative growth in particular governs the welfare of the desert animals.

Herbivore-vegetation relationships have been studied from various angles in the Kalahari in the past. Bothma & Mills (1977) studied the relationship between ungulate abundance and rainfall in the Nossob River valley, an unusual approach made possible by the rapid and pronounced vegetative response to rainfall. They found gemsbok (*Oryx gazella*), red hartebeest (*Alcelaphus buselaphus*) and springbok (*Antidorcas marsupialis*) to reach peak abundance in the valley during the summer rainy season. The blue wildebeest (*Connochaetes taurinus*) did just the opposite and moved out of the valley into the sandveld during the rainy season and concentrated in the valley during the dry season. Eloff (1959a, 1959b, 1961, 1962, 1966) gives detailed accounts on the abundance, distribution, migration and habits of the ungulates in the Kalahari Gemsbok National Park, aspects which are all regulated by two closely linked factors: rainfall and vegetation. Leistner (1959) re-

ports specifically on the influence of the vegetation on the distribution of ungulates in this national park.

Work on the feeding behaviour of ungulates in the Kalahari (De Beer 1980) led to a study of the extent of digestion of the various plants.

Methods

Plant samples of various dietary components utilized by the gemsbok, red hartebeest, blue wildebeest, eland and springbok, were collected from mid-1979 to the middle of 1980. The plants were collected in an area south-west of the Auob River and north of the river in line with Driefendaspan, Vaalpan and Rooiputs. Plants were collected from camps (10 × 15 m) randomly distributed in the area. Fractions utilized were identified by comparing plants within and outside the camps.

Plant samples were collected from within the camps on a monthly basis. During this period the feeding habits of the ungulates in the area were studied. The plant samples used in the *in vitro* experiments were chosen according to plants utilized by the animals. Plant samples collected from February to April were combined to form one sample of each species, as were the plants collected from October to January. The samples were dried in a forced-draught oven to a constant mass at 60 °C and ground to 2 mm.

In vitro digestion experiments were done in the late summer, April 1981, and in October 1981 when grazing conditions were limited. A field laboratory was installed near Kamqua in the Auob River. The animals culled were brought to the laboratory within 20 minutes. Rumen fluid was strained through a double layer of cheesecloth and kept at 39 °C until used in *in vitro* experiments as described by Boomker & Van Hoven (1983). Gas and volatile fatty acid (VFA) production were monitored during the 20 hour incubation in the field. Controls containing only rumen fluid and buffer were used in all experiments. Control values were subtracted from all experimental values to allow comparisons between animals to be made.

Gas samples were taken using glass syringes and stored in 10 cm³ evacuated glass tubes (Bide 1978). Sampling and analytical procedures for gas and VFA determination are described by Van Hoven (1980), Van Hoven & Boomker (1981) and Boomker (1983). *In vitro* dry matter disappearance (IVDMD) was established using the method of Tilley & Terry (1963). •

Results

Some of the plants used, with their local names, are listed in Table 1. Plants found in the diet of each animal are discussed here. The percentage IVDMD appears in column A. Results of the April (autumn) and October (spring) *in vitro* experiments are listed separately to facilitate comparisons. Protein content of the substrates used is also listed. The total amount of gas produced during the 20 hour incubation appears in column B.

Figs 1a to e illustrate the relationship between energy yields in terms of volatile fatty acids (VFA) produced, and energy lost, in the form of methane, by the ungulates studied.

Using the Pearson moment method, the only correlation found between the per-

centage digestibility and percentage protein content of the substrate was in spring in the eland ($r = 0,89$) and the springbok ($r = 0,74$). In the autumn only a very slight correlation between these variables was found in the springbok ($r = 0,55$).

Significant regression equations were:

$$Y = 1,68X - 94,2 \text{ (eland)}$$

$$Y = 2,1X - 118,1 \text{ (springbok) where}$$

Y is the percentage protein present and

X is the digestibility of the substrate.

Discussion

Blue wildebeest in the plains area were found to prefer *Stipagrostis obtusa*, but also utilized *S. uniplumis* and *S. ciliata*. *Stipagrostis obtusa* was utilized throughout the year. During the spring experiment it was found that 59% of the plant substrate (*S. obtusa*) was utilized while in autumn 60% was utilized. However the energy produced from the substrate digested in spring was 1 263 kJ and in autumn 2 321 kJ. More methane was also produced in spring. Thus it would appear that although *Stipagrostis obtusa* is well utilized and digested throughout the year, VFA energy yield is greatest during the autumn and the greatest energy loss (methane) occurred during spring. *Schmidtia kalahariensis* was preferred during the winter and was also found to have a higher VFA energy production in autumn than in spring. The amount of energy produced in autumn (3 248 kJ) by *Schmidtia kalahariensis* is greater than that produced by *Stipagrostis obtusa* and could be an indication of why *Schmidtia kalahariensis* is preferred in winter. *Eragrostis lehmanniana* is also well utilized and the digestibility and VFA energy pattern follows that of *Stipagrostis obtusa* in wildebeest.

Gemsbok utilize *Stipagrostis obtusa* and *E. lehmanniana* through the year. *E. lehmanniana* is preferred when the gemsbok graze in the dune area. *Schmidtia kalahariensis* is only used by gemsbok when young and again when it is dead and dry. *Stipagrostis obtusa* was digested by gemsbok at a lower level than by wildebeest (51–57%) but produced more VFA energy in autumn (3 043 kJ). *E. lehmanniana* had a 62% digestibility in autumn by gemsbok and produced 3 004 kJ of VFA energy. In spring the digestibility was 54% and produced 2 468 kJ VFA energy. *E. lehmanniana* is especially well utilized during autumn and winter when the gemsbok move into the dune area. This agrees with the higher production of energy from *E. lehmanniana* at this time of the year. Gemsbok usually were found in association with eland.

Eland utilized *E. lehmanniana* well. The digestibility of this plant for eland was 62% both during spring and autumn. During autumn a very high VFA energy value (4 050 kJ) was recorded while methane loss was not high. *Stipagrostis obtusa* was also well digested by eland but did not produce much energy (1 636 kJ in spring and 1 900 kJ in autumn).

Springbok were found to utilize *Stipagrostis obtusa* throughout the year, with a slight decrease in the winter months. This plant was digested well in spring when a large amount of VFA energy (2 557 kJ) was produced. In autumn, even though the *in vitro* digestibility of *Stipagrostis obtusa* was 58% only 603 kJ VFA energy was produced. Springbok were found to utilize grasses 33% of the total time, bushes

and trees 35%, and forbs, herbs and creepers 30%. Leaves from *Acacia haematoxylon* were eaten throughout the year and the pods from June. The pods had a digestibility of 60% in spring, but produced very little VFA energy (682 kJ). *Kohautia* is an important plant in the diet of the springbok and has a digestibility of 64–65%. In spring this plant produced 2 215 kJ energy, while in autumn the VFA energy was considerably more (6 091 kJ). During October and November *Cassia italica* and *Acacia erioloba* leaves were also eaten by the springbok.

Stipagrostis uniplumis is utilized by gemsbok and wildebeest especially when *S. obtusa* is not present. This grass has a digestibility of 55% by gemsbok and 61% by wildebeest during autumn and an average of 2 500 kJ VFA energy.

Volatile fatty acids (VFA) are the single most important source of metabolic energy for ruminants. This energy yield depends on the VFA concentration, composition, production and rate of passage of food through the digestive tract. All values given here relate to the amount of substrate digested in 20 hours in the *in vitro* system where only 2 g substrate was available.

When looking at the whole system in the animal Allo, Oh, Longhurst & Connolly (1973) found that the rumen VFA yields were 54–80% of basal metabolic requirement for sheep and 21–44% for deer. Whitelaw, Hildegaard-Jensen, Reid & Kay (1970) found the rumen VFA energy yield in a heifer to be 36,5% of digestible energy and 43,4% of metabolic energy. Annison & Armstrong (1970) postulate a possible 60–80% metabolizable energy as rumen VFA energy. If the energy produced by VFA from each plant was extrapolated to the animal system the range of energy would be 30–70% of the basal metabolic requirement of each animal, which agrees with the results of Allo *et al.* (1973).

During the process of digestion some of the potential metabolic energy is lost through methane production. Selection and utilization of diet is thus from a nutritional point of view successful if more VFA can be produced and less methane.

Carbon dioxide in the presence of hydrogen is reduced to methane. If hydrogen is in short supply less methane will be formed. An increase in VFA in the rumen causes a drop in pH, which decreases methanogenesis. This results in a negative concentration between the percentage methane in rumen gas and the rumen VFA concentration (Boomker 1981).

Blaxter & Clapperton (1965) found that sheep produce 30 ℓ methane per day when compared to 514 ℓ by cattle. Investigating African buffalo (*Syncerus caffer*) Van Hoven (1980) calculated 318 ℓ of methane was produced per day while Boomker (1981) found grey duiker (*Sylvicapra grimmia*) produced 11,23 ℓ methane per day in summer and 8,52 ℓ in winter. These are total amounts produced from rumen contents.

If one examines the various substrates as sole dietary components for gemsbok, *Stipagrostis obtusa* would produce only 26 ℓ of methane during one day. This is far less than the 154 ℓ found by Blaxter & Clapperton (1965) for cattle. However, for wildebeest the value is even less, a mere 1–3 ℓ methane produced from a rumen (29 kg) full of *S. obtusa*. This would be the ideal situation if all the plants produced as little methane. However, in wildebeest the more energy produced as VFA the more seems to be lost as methane.

Table 1

A. The in vitro digestibilities of food components of five Kalahari ungulates by the animal's own rumen fluid and protein values of these diets. B. Digestion of substrates in terms of gas produced during 20 hours

	A.										B.				
	% IVDMD										Gas produced (ml)				
	Eland	Gembok	Blue wildebeest	Hartebeest	Springbok	% Protein	Eland	Gembok	Blue wildebeest	Hartebeest	Springbok				
1. <i>Asthenatherum glaucum</i> (leaves) (Ghagras)	58	55	63	62	60	5.4	82	78	74	68	66				
) Autumn															
) Spring	58	55	45	56	61	5.3	69	67	51	51	59				
2. <i>Stipagrostis ciliata</i> (leaves) (Langbeenboesmangras)	59	57	62	62	60	10.4	80	79	78	62	69				
) Autumn															
) Spring	60	50	60	57	59	5.4	63	59	43	57	58				
3. <i>Stipagrostis obtusa</i> (leaves) (Kortbeenboesmangras)	61	57	60	57	58	9.2	79	76	74	64	59				
) Autumn															
) Spring	60	51	59	58	60	6.6	58	55	43	52	57				
4. <i>Stipagrostis uniplumis</i> (leaves) (Blinkblaagras)	57	55	61	64	61	7.3	74	73	72	73	66				
) Autumn															
) Spring	60	54	58	61	61	6.6	61	63	44	62					
5. <i>Eragrostis lehmanniana</i> (leaves) (Kniekiesgras)	62	62	66	62	62	11.1	89	84	81	76	71				
) Autumn															
) Spring	62	54	61	62	62	9.9	68	66	43	70	67				
6. <i>Schmidia kalahariensis</i> (leaves) (Suurgas)	71	65	63	38	57	12.8	97	82	74	28	64				
) Autumn															
) Spring	63	56	64	62	62	9.6	71	68	54	64	71				
11. <i>Setaria verticillata</i>	53	53	52	40		17.4	68	61	48	36					
) Autumn															
13. <i>Brachiaria glomerata</i> (Soetgras)	66	59	53	43		10.4	96	78	59	45					
) Autumn															
20. <i>Monechma australe</i> (Perdebos)	68	63	66	66	66	16.9	107	96	104	80	120				
) Autumn															
28. <i>Kohautia</i> sp.	66		55	58	65	17.6	92	53	60	81	82				
) Autumn															
) Spring	62	51				12.8	76	53		51					
29. <i>Cassia italica</i> (Swartstorm)	61	59	60	57		27.6	79	80	65	49					
) Autumn															
30. <i>Boscia albitrunca</i> (leaves) (Witgatboom)	69	59	53	63	64	19.6	97	77	58	62	82				
) Autumn															
) Spring	65	54	56	60		19.6	78	58	38	46					
31. <i>Acacia haematoxylon</i> (leaves) (Vaalkameel) (pods)	65	57	58	58	60	16.3	83	75	65	61	56				
) Autumn															
) Spring	66	48	50	48	60	15.8	57	45	24	41	68				
32. <i>Antelope cubus</i>	71	65	63	63	63	18.6	91	84	64	60	68				
) Autumn															
) Spring	64	55	62	66	65	18.6	70	41	48	61	76				

The VFA energy yield of each dietary component was related to the methane energy lost during the 20 hour incubation. A definite pattern for each Kalahari ungulate emerges (Figs 1a-e). Gemsbok and springbok produce much less methane than the red hartebeest on the same diets tested *in vitro*. No definite pattern emerges from the tests done using eland.

The energy relationship is a complex one, where *in vitro* tests give an indication of what occurs in each ungulate. More data are needed on rate of passage, percentage diet selected and rumen fill before animal energy balances can be estimated.

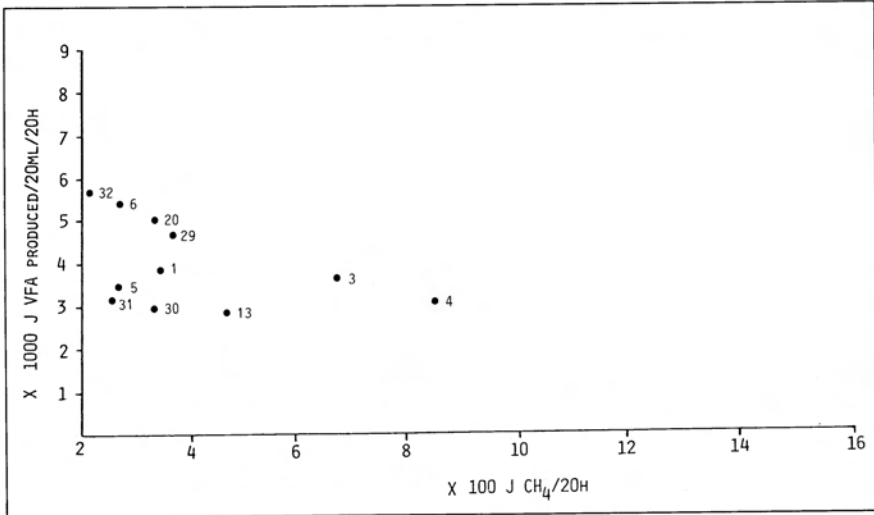


Fig. 1a. Gemsbok, relationship between energy lost and energy produced. Numbers as in Table 1.

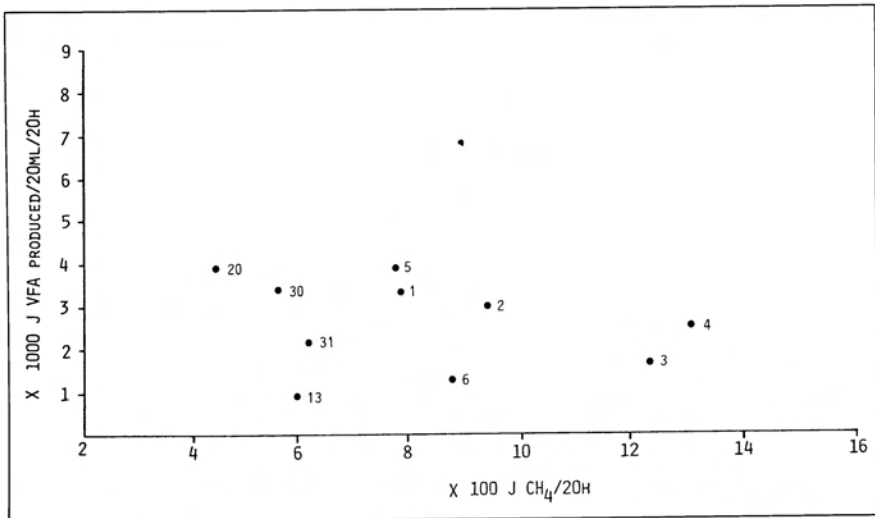


Fig. 1b. Eland, relationship between energy lost and energy produced. Numbers as in Table 1.

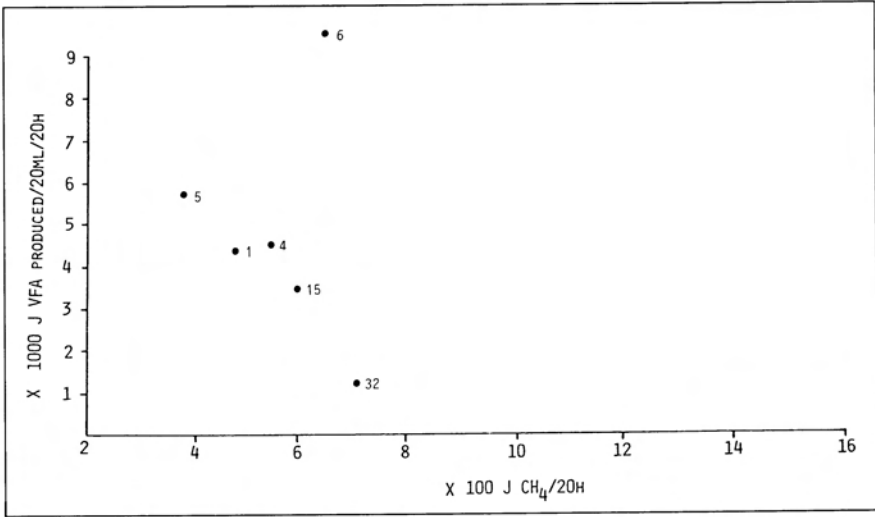


Fig. 1c. Springbok, relationship between energy lost and energy produced. Numbers as in Table 1.

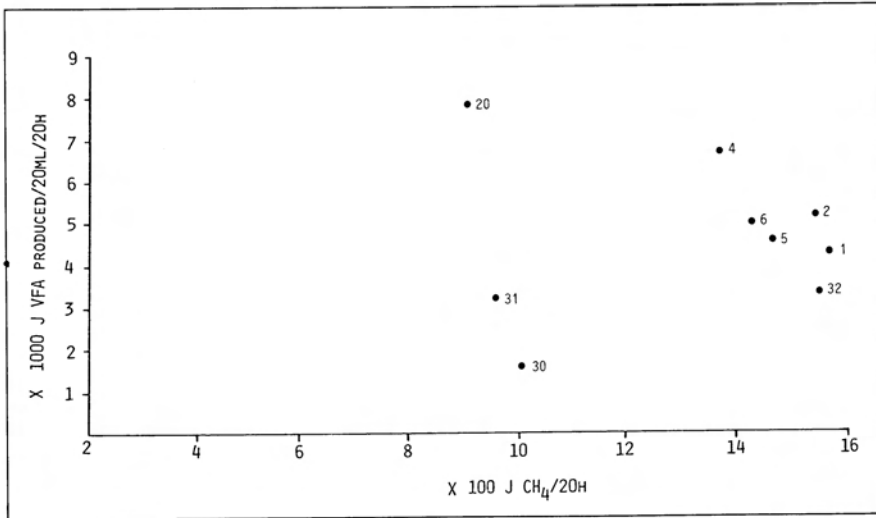


Fig. 1d. Red hartebeest, relationship between energy lost and energy produced. Numbers as in Table 1.

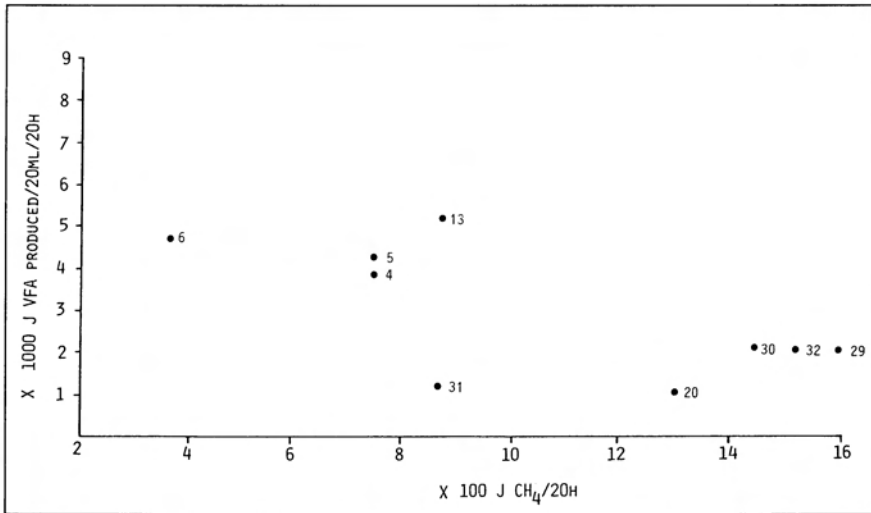


Fig. 1e. Blue wildebeest, relationship between energy lost and energy produced. Numbers as in Table 1.

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