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SUPPLEMENTING SHEEP WITH PROTEIN AND PHOSPHORUS ON NATIVE PASTURE OF THE CENTRAL ORANGE FREE STATE. 1. DIET COMPOSITION, DIGESTIBILITY AND RUMEN AMMONIA CONCENTRATION*

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H.O. de Waal, E.A.N. Engels and F.J. van der Merwe(1)
Agricultural Research Institute, Glen 9360

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(Sleutelwoorde: *Aanvullende voeding, dieetsamestelling en verteerbaarheid, NH_3-konsentrasie)*

OPSOMMING: AANVULLING VAN PROTEÏEN EN FOSFOR AAN SKAPE OP NATUURLIKE WEIDING VAN DIE SENTRALE ORANJE-VRYSTAAT. 1. DIEETSAMESTELLING, VERTEERBAARHEID EN RUMENAMMONIAKKONSENTRASIE

Die invloed van proteïen-en fosforaanvulling aan Dorper- en Merinohamels op veldweiding is oor 'n periode van een jaar ondersoek. Beide aanvullings is op 2 maniere voorsien, naamlik, as 'n lek óf as 'n daaglikse toediening via rumenkannules. Sommige van die waargenome verskille in dieetsamestelling, verteerbaarheid en rumen-NH_3-konsentrasie tussen die verskillende behandelings en rasse was statisties betekenisvol ($P \leqslant 0,05$). Geen definitiewe tendens ten gunste van enige behandeling kon egter waargeneem word nie. Dieetsamestelling, verteerbaarheid en rumen-NH_3-konsentrasie het 'n seisoenspatroon getoon waarin reënval 'n oorheersende rol gespeel het.

SUMMARY:

The influence of supplementary protein and phosphorus to Dorper and Merino wethers on native pasture was investigated over a period of one year. The supplements were provided by 2 different methods namely as a lick or at a constant daily level via rumen cannulae. Some of the observed differences in diet composition, digestibility and rumen NH_3 concentration between the different treatements and breeds, were statistically significant ($P \leqslant 0,05$). No definite trend due to any of the treatments could be found. Diet composition, digestibility and rumen NH_3 concentration followed a seasonal trend in which rainfall played a dominant part.

The native pasture of South Africa, consisting mainly of grass, is generally regarded to be deficient in both protein and phosphorus (Theiler, 1932; Du Toit, Louw & Malan, 1940). Since this early pioneering research the practice of supplementing grazing ruminants with various mineral and rumen stimulating licks has become an integral part of livestock production in South Africa (Bisschop, 1964; Coetzee, 1969; Louw, 1969, 1978, 1979).

Very little information is available regarding the influence of supplementary feeding on the composition and digestibility of the diet selected by sheep and also on rumen NH_3 concentration. Results in this regard pertaining to free grazing sheep are virtually non-existent. Both diet composition and digestibility are important factors in the evaluation of the nutritive value of any feed. Therefore it was decided to obtain more quantitative information on native pastures in this regard.

Procedure

The experiment was conducted at the Agricultural Research Institute, Glen. A 3 camp rotational grazing system with a stocking rate of one sheep per ha was used. A total of 9 camps were used in order to accommodate the 3 experimental flocks. The trial lasted from June 1977 to May 1978. A botanical survey using the wheelpoint method (Tidmarsh & Havenga, 1955), was carried out halfway through the trial. *Themeda triandra, Eragrostis chloromelas* and *Cymbopogon plurinodis* were the dominant grasses, comprixing 61,8% of the basal plant cover.

Two types of supplements were used, namely:

(i) a Protein supplement (Fish meal 50%, Salt 30%, Dicalciumphosphate 15% and Molasses meal 5%) and

(ii) a Salt/Phosphate supplement (Salt 50%, Dicalciumphosphate 45% and Molasses meal 5%).

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(1) Dept. of Animal Science, Faculty of Agriculture, University of Stellenbosch 7600.

Table 1

The experimental design with the number of sheep per breed and per treatment

Treatment / Breed	Group 1	Group 2	Group 3	Group 4	Number of sheep per breed
	Salt/Phosphate supplement *ad lib.*	Protein supplement *ad lib.*	Salt/Phosphate supplement per RF	Protein supplement per RF	
Dorper	5 Intact (Control)	5 Intact	5 RF	5 RF	20
Merino	5 Intact (Control)	5 Intact	5 RF	5 RF	20
Dorper	3 OF (Control)	3 OF	3 OF + RF	3 OF + RF	12
Merino	3 OF (Control)	3 OF	3 OF + RF	3 OF + RF	12
Number of sheep per treatment	16	16	16	16	Total number of sheep = 64

OF – *oesophageal fistulae*
RF – *rumen fistulae*
Intact – *no fistulae*

Young Dorper and Merino wethers were used as experimental animals. The experimental design (fully randomized) with the number of sheep per breed and per treatment is presented in Table 1.

The sporadic and inconsistent consumption of supplements by sheep is often suggested as cause for the poor response by sheep to supplementary feeding. Therefore the different supplements were administered by 2 different methods, namely:

(i) as a lick in Treatments 1 and 2, and

(ii) as a constant daily dose via rumen cannuale in Treatments 3 and 4 (30,4 g Salt/Phosphate and 61,3 g Protein supplement respectively).

Due to practical considerations the sheep in Treatments 1 and 2 were run as separate flocks, while those in Treatments 3 and 4 were combined as a third flock. The 3 flocks were rotated between the available camps on a weekly basis to eliminate any effects due to differences in basal plant cover.

The oesophageally fistulated sheep (designated OF in Table 1) were used for the collection of samples from the pasture on a monthly basis. The sampling was done on 3 successive days during each month and each OF sheep was given the opportunity to sample each of the camps used a specific time. Sampling took place after a fasting period of 4 hours in order to minimize the possibility of regurgitation during sampling. Any samples showing excessive quantities of saliva or contaminated with regurgitated material were discarded. Drinking water was always available during the fasting periods.

The samples of each OF sheep for the 3 days were pooled, freeze dried, ground through a Wiley mill with 1mm screen and then analysed.

Digestibility of organic matter (OM) of the native pasture was predicted as described by Engels & Malan (1978). The crude protein content of the pasture was expressed on an ash-free (OM) basis.

During each month rumen fluid was sampled at 08h30 on 2 non-successive days from all sheep fitted with rumen fistulae (designated RF in Table 1). The rumen fluid was aspirated from the rumen via the RF by means of a stomach tube connected to a flexible plastic container. An aliquot of 60 to 70 ml rumen fluid was then acidified with 1 ml of concentrated H_2SO_4 in small plastic bottles and stored at a temperature of $-15^{\circ}C$. The sampling of rumen fluid took place over the period

Table 2

The average daily intake of phosphorus (P) and crude protein via the respective supplements

Average daily intake of supplements, P and crude protein

Month		Treatment 1 Salt/Phosphate supplement *ad lib.*		Treatment 2 Protein supplement *ad lib.*		
		Supplement	P	Supplement	P	Crude protein
		g	g	g	g	g
June	'77	10,2	0,86	21,2	0,94	6,03
July	'77	12,3	1,04	28,2	1,25	8,02
August	'77	14,6	1,23	24,6	1,09	7,00
September	'77	9,3	0,78	19,6	0,87	5,57
October	'77	7,7	0,65	12,6	0,56	3,58
November	'77	8,5	0,72	14,1	0,63	4,01
December	'77	8,8	0,74	12,7	0,57	3,61
January	'78	6,2	0,52	10,7	0,48	3,04
February	'78	7,0	0,59	10,4	0,46	2,96
March	'78	7,8	0,66	9,5	0,42	2,70
April	'78	6,8	0,57	9,1	0,40	2,59
May	'78	4,9	0,41	6,5	0,29	1,85

that OF samples were collected. Prior to analysis these samples were thawed, centrifuged and the 2 samples from each sheep pooled. Rumen ammonia (NH_3) was determined according to the method of distillation over MgO (Kemmink, 1964) as described by Van Niekerk (1965) and expressed as mg NH_3 / 100 ml rumen fluid.

The voluntary consumption of the 2 supplements by the sheep in Treatments 1 and 2 was recorded on a monthly basis.

Results

The average monthly precipitation for the experimental period and also for the period 1960 to 1975, are presented in Fig. 1.

From Fig. 1 it is evident that from January 1978, the rainfall pattern was in accordance with the long term average. However, a higher than normal precipitation was recorded in September 1977 while the early summer (November 1977) could be considered as relatively dry.

The average daily intake of phosphorus (P) and protein via the respective supplements, is presented in Table 2.

The results in Table 2 indicate that the voluntary daily intake of the 2 supplements by the sheep was rather low

The highest daily intake of the supplements was recorded during August 1977 for Treatment 1 and during July 1977 for Treatment 2. The initial differences in daily intake between the 2 treatments were more than 100% during June/July 1977 and less than 33% during May 1978.

The sheep in Treatments 3 and 4 received 2,57 and 2,73 g P per day respectively via the RF. In addition, the sheep in Treatment 4 received 17,4 g crude protein daily from the protein supplement.

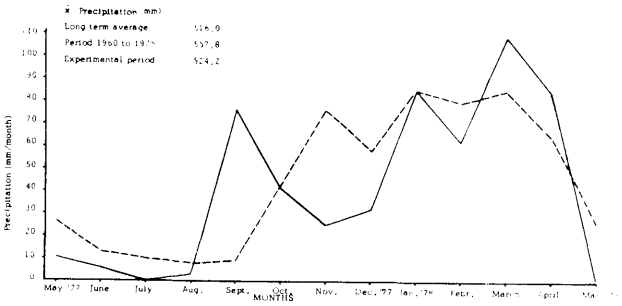

Fig. 1 The monthly precipitation for the experimental period (—) and also for the period 1960 to 1975 ( )

Table 3

The crude protein content and digestibility of OM of samples collected by oesophageally fistulated (OF) sheep during the different months of the experimental period

Crude protein content and digestibility of OM

Month	June	July	Aug.	1977 Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	1978 March	April	May
* Crude protein %	8,4	7,9	11,1	12,1	14,8	11,5	10,3	12,3	12,7	13,1	12,0	11,9
Digestibility of OM%	54,0	57,2	60,7	63,0	65,9	61,5	61,9	64,4	64,0	65,0	60,0	58,3

* Crude protein content expressed on an ash-free basis

Table 4

The average monthly rumen ammonia (NH_3) concentration of the sheep in Treatments 3 and 4

Average rumen NH_3 concentration (mg NH_3 / 100 ml rumen fluid)

Treatment	Breed	1977 June	July	Aug.	Sept.	Oct.	Nov.	1977 Dec.	1978 Jan.	Feb.	March	April	1978 May	Treatment average ± SE
		mg	mg	mg	mg	mg	mg	mg	mg	mg	mg	mg	mg	mg
3		a	ac											
Salt/Phosphate	D	4,79	2,14	3,65	8,32	5,56	2,18	6,11	7,48	7,13	6,80	9,77	7,36	5,94 ± 0,495
supplement		ab	bc											
per RF	M	7,26	5,78	3,47	9,44	5,63	2,62	6,37	8,20	7,36	6,72	8,88	8,20	6,66 ± 0,495
4		ab	ac											
Protein	D	6,07	2,84	4,05	8,95	7,99	3,11	8,15	9,22	10,08	9,08	12,22	10,12	7,66 ± 0,493
supplement		b	b											
per RF	M	8,43	6,32	4,40	11,13	7,43	2,72	7,87	6,70	8,47	8,79	12,10	8,59	7,75 ± 0,493

a, b, c: Averages in a column with the same superscript do not differ significantly ($P \leqslant 0,05$)

D – Dorpers
M – Merinos
RF – rumen fistulae

The differences in diet selection between treatments as reflected in crude protein content and digestibility of OM of the OF samples were significant in 2 isolated cases only. Since these significant differences could by no means be attributed to treatment or breed, the data of all sheep were pooled on a monthly basis. The pooled data are presented in Table 3.

The 2 isolated cases where differences with regard to diet selection were significant occurred in May 1978 when the sheep in Treatment 1 selected plant material with a significantly ($P \leqslant 0,05$) higher crude protein content than those in Treatment 3. In June 1977 the sheep in Treatment 3 selected plant material with a significantly ($P \leqslant 0,05$) lower digestibility of OM than those in Treatment 4.

The average monthly rumen NH_3 concentrations of the sheep in Treatments 3 and 4 are presented in Table 4.

From the results in Table 4 it is evident that the differences between breeds and treatments reached significance ($P \leqslant 0,05$) during June and July 1977 only. The average rumen NH_3 concentration for the experimental period in Treatment 3 was lower than in Treatment 4 for both breeds. However, these differences were statistically non-significant ($P \leqslant 0,05$). A definite seasonal trend in rumen NH_3 concentration seems to be evident from the results in Table 4. This trend could be linked directly to the crude protein content of the pasture in response to rainfall.

Discussion

According to Blaxter (1964) the nutritive value of a feed depends largely on chemical composition, digestibility of the ingested nutrients and the voluntary intake of the feed by the animal. Therefore the rate of animal production is a function of the digestible nutrient intake. Due to the importance of both chemical composition and digestibility in total nutritive value, an effort was made in this study to obtain information in this regard. Furthermore the investigation was aimed at the quantification of any effect of supplementary protein and phosphorus on the selective grazing behaviour of sheep as reflected in crude protein content and OM digestibility of OF collected samples. At the same time the rumen NH_3 concentration was studied in order to obtain some indication of what is to be expected under grazing conditions.

The results of the present study showed that breed differences regarding selective grazing behaviour, as reflected in crude protein content and digestibility of OM in OF collected samples, did not occur. This is in agreement with the results of Langlands (1969) and Engels, Malan & Baard (1974). In addition, the results of the present study indicate that the grazing behaviour of sheep was not effected by the different methods and levels of protein and phosphorus supplementation. The crude protein content of the OF collected samples varied between 7,9 and 14,8%. The digestibility of OM ranged from 54,0 to 65,9%. This is in sharp contrast with the results of Du Toit *et al.* (1940) and Louw (1969) for native pastures in South Africa in general and Swart, Van Schalkwyk, Hugo & Venter (1963), for Glen in the central Orange Free State in particular. It is however in agreement with the results published by Engels, Van Schalkwyk & Hugo (1969), Engels (1972) and Engels & Malan (1978). This discrepancy originates from the differences in techniques used for sampling of the pastures for analysis. Engels & Malan (1978) concluded that chemical analysis based on samples collected manually, can by no means serve as an indication of the nutritive value of mixed native pastures.

A definite seasonal trend in crude protein content and digestibility of OM is evident (Table 3). This seasonal trend corresponded very closely with the rainfall (Fig. 1). Peaks in rainfall were almost invariably reflected in subsequent rises in both crude protein content and digestibility of OM. The sharp increase in crude protein content and digestibility of OM in August 1977 was a result of early spring growth with the OF sheep expressing their preference for green material. The influence of the seasonal summer drought during November and December 1977 was clearly reflected in the decrease in the digestibility of OM and crude protein content (Table 3). It may be concluded that the influence of season as a result of rainfall was the most important factor governing the growth of the native pasture in this study. Consequently this allowed the grazing sheep to select a diet of relatively good quality.

According to the results of recent studies, a rumen NH_3 concentration of between 3 and 6,5 mg NH_3 -N per 100 ml rumen fluid provides conditions for optimum microbial activity (Miller, 1973; Satter & Roffler, 1975; Barry & Johnstone, 1976). In conventional studies of this kind rumen fluid is sampled at fixed intervals after feeding. In the present study rumen fluid was sampled monthly on 2 non- successive days prior to the administration of the daily supplement per rumen cannula at 08h30. Obviously at this time the sheep had had the opportunity to graze until the rumen fluid was sampled. Therefore, the samples taken in the present study could be regarded as representative of a phase during or just after feeding. On the other hand, Arnold & Dudzinski (1978) regard the feed intake of grazing animals as a continuous process, for all practical purposes. Furthermore the main objective in this study regarding rumen NH_3 concentration was to establish seasonal trends and the extent to which these, if any, were influenced by supplementary protein. Therefore, the results of the present study could be considered as a reflection of the long term effect of the 2 different treatments (Treatments 3 and 4) on the activity of the microbial population, together with the short term effect of the nitrogen content of the diet. The rumen NH_3 concentration followed a definite

seasonal trend in which crude protein content of the diet played a prominent role. However, the increase in crude protein content and rumen NH_3 concentration did not occur simultaneously. The increase in NH_3 concentration did not occur simultaneously. The increase in NH_3 concentration usually occurred the month after a major rise in crude protein content took place. This may be a reflection of the fact that the rumen population needs a period of adaptation after any major change in diet composition. Consequently an immediate response in NH_3 concentration, as a result of an increase in crude protein content, was not expected. A definite conclusion is not possible since this delay in response to a higher crude protein content was partly due to the long (one month) period between sampling. The sampling procedure used in this study, where OF samples and rumen fluid samples were collected monthly within a period of 5 days, could also have had an influence. This means that the increase in rumen NH_3 concentration could have occurred well before the rise observed in the present study.

Although ignoring the possible diurnal variation in rumen NH_3 concentration, the results of the present study give some indication of the seasonal trend to be expected under grazing conditions. Arnold & Dudzinski (1978) consider the feed intake of grazing animals as a continuous process and therefore a smaller diurnal variation in rumen NH_3 concentration could be expected. This aspect is being investigated at present.

The results of the present study regarding the rumen NH_3 concentration indicate that a nitrogen containing supplement will not necessarily have a stimulating effect on the activity of the microbial population under grazing conditions. In spite of the limitations of the sampling procedure used in the present study, the observed rumen NH_3 concentrations were almost consistently in excess of the lower limit (3 mg NH_3 -N per 100 ml rumen fluid) put forward for optimal microbial synthesis. Therefore, the protein intake of the sheep in Treatment 2 via a lick could hardly have had a stimulating effect on microbial activity.

The results of the present study point to a lack of response in grazing behaviour by non-reproducing grazing sheep to differential supplementation of protein and phosphorus on mixed native pastures of the central Orange Free State. The real advantage of any economical supplementary feeding strategy must be reflected in a positive animal response. This response can only be mediated by an increase in digestible nutrient intake. This aspect will be dealt with in a future paper.

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