Phosphorus supplementation of Karakul sheep grazing natural pasture

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The phosphorus (P) status of adult Karakul ewes grazing natural pasture was determined by measuring the P content of blood, saliva, faecal, and bone samples. The ewes were divided into four groups of 20 ewes each, *viz.* ewes supplemented with P^+ and P^- which lambed during May and October. All lambs born were slaughtered. The nutritive value (% CP and DOM) of the natural pasture of P^- and P^+ groups was similar. The average daily intake of supplement (g/sheep) by the P^- and P^+ groups was 4,9 ± 2,8 and 5,6 ± 2,8 g (P = 0,01) respectively. The latter figure implied an average daily P intake of 0,5 g. Average saliva P concentration for the P^- and P^+ groups was 43,7 ± 17,3 and 45,2 ± 19,2 mg/100 ml ($P > 0,5$) respectively. Blood and faecal P concentrations were variable in contrast to bone P concentration. Average rib-bone P concentration of the two P groups varied between 140 and 157 mg/cm^3 fresh bone. Blood, saliva, faecal, and bone concentration did not indicate a negative P status. Furthermore, P supplementation had no effect on reproduction. Phosphate supplementation to Karakul sheep grazing natural pasture in the Gordonia district appears to be unnecessary.
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Die fosfor (P)-status van volwasse Karakoelooie op natuurlike weiding is bepaal in terme van die P-inhoud van bloed, speeksel, mis en ribbeenmonsters. Die ooie is in vier groepe van 20 ooie elk verdeel, naamlik ooie wat P^-- en P^+-byvoeding (lek) ontvang het wat gedurende Mei en Oktober gelam het. Alle lammers wat gebore is, is geslag. Die voedingswaarde (% RP en VOM) van die natuurlike weiding van die P^-- en P^+-groepe was gelyksoortig. Die gemiddelde daaglikse lekinname (g/skaap) by die P^-- en P^+-groepe was 4,9 ± 2,8 en 6,6 ± 2,8 g (P = 0,01) respektiewelik. Laasgenoemde beteken 'n gemiddelde P-inname van 0,5 g per dag. Gemiddelde P-konsentrasie van speeksel vir die P^-- en P^+-groepe was 43,7 ± 17,3 en 45,2 ± 19,2 mg/100 ml ($P > 0,5$) respektiewelik. Bloed en mis P-konsentrasies was veranderlik in teenstelling met die been P-konsentrasie. Die gemiddelde ribbeen P-konsentrasie van die twee P-groepe het gevarieer tussen 140 en 157 mg/cm^3 vars been. Bloed, speeksel, mis en ribbeen P-konsentrasie het nie 'n negatiewe P-status aangetoon nie, terwyl P-byvoeding ook nie 'n invloed op reproduksie gehad het nie. Dit kom voor asof fosfaatbyvoeding aan Karakoelskape op natuurlike weiding in die Gordonia distrik onnodig is.
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Introduction

A scarcity of biological evidence for the necessity and profitability of phosphorus (P) supplementation to sheep, coupled to rising production costs makes this practice of doubtful value on natural pasture. Surveys done by Theiler (1920, 1931) and Du Toit, Louw & Malan (1940) on natural grazing in South Africa revealed a widespread seasonal P deficiency. Despite this, a P deficiency could not be demonstrated in sheep as was the case for cattle.

The dramatic, widely publicized advantages brought about by P supplementation to cattle resulted in the practice being commonly applied in the sheep industry. Most of these recommendations were based on chemical composition of hand-collected herbage samples. The superior nutritive value of herbage selected by grazing sheep on natural pasture compared to samples collected by hand (Engels, 1972; Faure, Minnaar & Burger, 1983), showed those early recommendations to be invalid. This raises the question whether P supplementation to grazing sheep is justified. Consequently, this experiment was undertaken to study the influence of P supplementation on reproduction performance and P status of Karakul sheep grazing Kalahari sand veld.

Material and Methods

The experiment was conducted on Kalahari sand veld (Acocks, 1975 veld type 32, Orange River Broken Veld), at the Karakul Research Station near Upington (21°15′E, 28°25′S). Randomly selected, approximately 3-year old, parous, Karakul ewes were blocked for age into four groups of 20 each. A lick containing 45% dicalcium phosphate, 45% salt, and 10% molasses powder (Calorie 3000, Natal Cane By-products) was supplied to two groups (P^+) while the remaining two groups (P^-) received a salt lick (90% salt and 10% molasses). For the determination of the chemical composition and dry matter intake of herbage selected by sheep on natural pasture, three ewes with oesophageal fistulas were added to each P group and eight wethers to the P^+ group respectively. Half the ewes (except ewes with fistulas) in the P^+ and P^- groups were mated in December and the other half in April. The experiment started in January 1980 and ended in June 1983.

The animals were dosed with a broad spectrum anthelmintic at the onset of, and also after winter. A narrow spectrum anthelmintic remedy was administered 2 – 3 weeks after the first summer rains. The ewes in the P^+ and P^- groups grazed in adjacent 45 ha camps with four camps per group (3,5 ha/SSU). The ewes were rotated monthly. The unfasted bodymass and lick intake of the animals were determined every 14 days. The mean of two successive 14-day bodymass determinations gave the monthly value. Ewes were group mated (three rams per 20 ewes) during December after oestrous synchronization (60 mg MAP intravaginal sponges, Upjohn and 300 IU PMSG subcutaneously with sponge withdrawal) and during April at natural oestrus. All the lambs born were slaughtered within 36 hours of birth.

The nutritive value of the natural pasture (CP content and digestibility) was determined in camps grazed by both P groups, while intake (crude protein and digestible organic matter) was determined only in camps grazed by the P^+ group. Monthly samples were collected as well as saliva samples from fistulated ewes. Methods used in determining the nutritive value of the natural pasture have been described by Faure, *et al.* (1983).

Blood, faecal, and rib-bone samples were collected the week before the mating and lambing period started from 20 ewes each lambing season, 10 each from the P^- and P^+ group. The same 20 ewes were used throughout the experimental period. Free-flowing jugular blood samples were taken into heparinized syringes (± 100 IU/ 10 ml blood), centrifuged, plasma aspirated and frozen until assayed. Inorganic phosphate of blood samples and saliva samples was determined as soon as possible after sampling by the photometric micromethod of Kallner (1975). Rectal faecal samples were collected over a 3 – 4-day period and frozen after sampling.

The faecal specimens were dried at 100°C for 24 hours, finely milled and stored in airtight containers. Rib-bone biopsies were performed as described by Little (1972) on both sides of the sheep. Ribs in the same position for all the animals were sampled each lambing season. Biopsies were performed on a new set of ribs during each successive sampling. Phosphorus in bone and faecal samples was determined by the method of Hanson (1950). Bone phosphorus concentration was expressed in mg/cm^3 fresh bone (Benzie, Boyne, Dalgarno, Duckworth & Hill, 1959).

The average P concentrations of all the faecal, blood, and rib-bone samples collected during the experimental period were tested among subgroups and years for differences to indicate effects of gestation, lambing season, and P supplementation according to Student's *t* test (Spiegel, 1961).

Results and Discussion

Nutritive value of supplemented camps

The average CP and digestibility percentage of the grazing in the P^- and P^+ camps over the experimental period was 8,5 ± 4,6; 8,4 ± 4,4% ($P > 0,4$) and 63,8 ± 3,2; 63,1 ± 3,5% respectively ($n = 42$; $P > 0,4$). High positive correlations for percentage CP (0,93) and digestibility (0,76) were found between the pasture samples of the P^- and P^+ camps. Therefore, the P^+ and P^- camps were of similar nutritive value in terms of CP and DOM.

The average CP and DOM intake (g/W kg) by non-pregnant sheep in the P^+ camps over the experimental period was 1,4 ± 0,8 and 10,3 ± 1,9 g ($n = 42$) respectively. When these results (Figure 1) are compared with a daily intake of 1,8 g CP (NRC, 1975) and 13,1 g DOM/W kg (Engels, 1972) for non-pregnant sheep, it is evident that both CP and DOM intake were insufficient during most of the experimental period. These results could also be extrapolated to the P^- group as no clear evidence existed whether phosphate supplementation improve dry matter intake or digestibility of feed consumed by sheep (Playne, 1969; Ozanne, Purser, Howes & Southey, 1976).

In sheep the absorption of P from a high-protein diet is enhanced by energy intake (Myburgh & Du Toit, 1970;

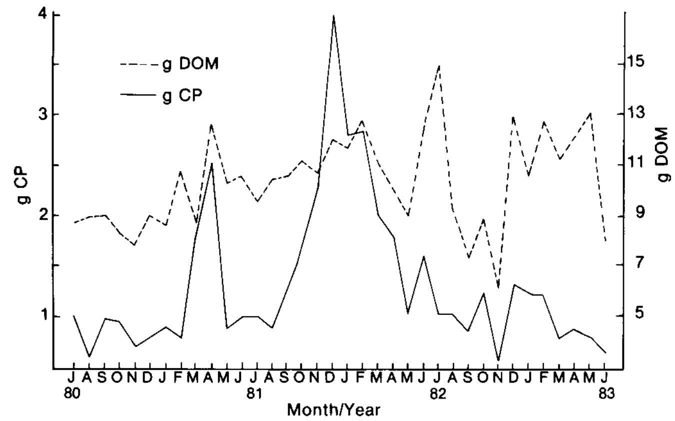

Figure 1 Daily intake of CP and DOM (g/W kg) by sheep supplemented with P^+

Leibholz, 1974; and McMeniman & Little, 1974). The importance of protein intake for P absorption from the diet was demonstrated with sheep (Myburgh & Du Toit, 1970) and cattle (Siebert, Newman, Hart & Michell, 1975). However, CP and DOM intakes (Figure 1) in this experiment indicate a negative rather than a positive influence of diet on P absorption by non-pregnant ewes.

Bodymass

The average bodymass of ewes at the start of the experiment in the P^+ and P^- groups which lambed during May and October respectively was 45,7 ± 5,7; 42,1 ± 5,5 kg ($n = 20$; $P = 0,05$) and 45,8 ± 5,4; 42,2 ± 6,0 kg ($n = 20$; $P = 0,05$). For the experimental period it was 46,6 ± 2,0; 46,2 ± 2,5 kg ($n = 42$; $P = 0,5$) and 48,1 ± 3,3; 45,9 ± 3,0 kg ($n = 34$; $P = 0,01$). These results show a higher bodymass for the ewes in the P^+ groups lambing in October. Because of an initial significant difference in bodymass between P^+ and P^- groups of ewes lambing in October and May, no definite conclusion could be made whether P supplementation had a positive effect on bodymass. No consistent tendency in bodymass existed between seasons. Results show mass increases during gestation followed by a subsequent post-partum drop.

Supplement intake

The average lick intake (g/sheep/day) during the experimental period for the P^- and P^+ groups was 4,9 ± 2,8 g and 6,6 ± 2,8 g ($n = 42$; $P = 0,01$) respectively. The latter implied an average daily phosphorus intake of 0,5 g during this period. Lick intake of the two P groups was closely related ($r = 0,56$) and showed a tendency to increase during the lambing seasons (May and October), with the lick intake of the P^+ groups nearly always higher than that of the P^- group. Lick intake showed no correlation with bodymass or percentage CP and digestibility.

Phosphorus status

The average monthly saliva P concentration showed a high positive correlation ($r = 0,63$) between the P^- and P^+ group (Figure 2) during the experimental period with averages of 43,73 ± 17,33 and 45,18 ± 19,20 mg/100 ml ($n = 41$; $P > 0,5$) respectively. No consistent tendency in the monthly saliva P concentration was detectable. According to Clark (1953) saliva P concentration decreases with insufficient P in the diet. As saliva P concentrations were similar to normal values of between 41 and 98 mg/100 ml reported by Clark (1953) and since there was a high positive correlation between

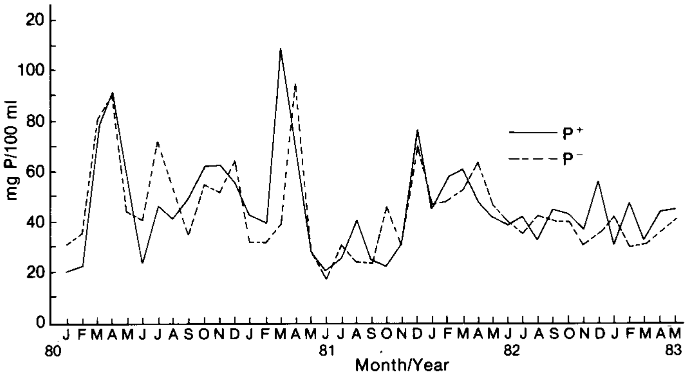

Figure 2 Average monthly saliva phosphorus (P) concentration of non-pregnant ewes ($n = 3$) with and without phosphate supplementation during the experimental period

the saliva P concentrations of the P^+ and P^- groups there was no P deficiency in the diet during this study.

When comparing the saliva P concentration (Figure 2) with the nutritive value of the pasture, percentage CP and digestibility, a positive correlation ($r = 0,53$) was found between percentage CP and saliva P concentration in both P groups.

The average P concentrations of faecal, blood, and rib-bone samples collected in the P^- and P^+ groups a week before the mating and lambing period started are presented in Tables 1 and 2.

There was a general decrease in P concentration in samples collected before mating when compared to that of samples collected before lambing. This was the case for blood, plasma, and faecal samples of pregnant and non-pregnant ewes. However, there was no decrease in the bone P status. This is in accordance with findings that blood and faecal P concentrations (Wise, Ordoveza & Barrick, 1963; Cohen, 1974) increase or decrease in relation to the level of P intake (Belonje & Van der Berg, 1980). Blood P concentration is also influenced as a result of excitement (Gartner, Ryley & Beattie, 1965) and through mobilization of skeletal P (Cohen 1974). Blood and faecal P concentrations are therefore not reliable indicators of P status.

The normal concentration range of blood inorganic P is 4 – 8 mg/100 ml with higher values not uncommon. Under conditions of an insufficient P intake, concentrations may drop as low as 1 – 2 mg/100 ml.

The average rib-bone P concentration of both P groups varied between 140 and 157 mg/cm^3 fresh bone. Rib-bone P concentration (Tables 1 and 2) of pregnant and non-pregnant ewes showed a general contradictory increase or decrease during the gestational period respectively in the May and October lambing group of both P^- and P^+ groups. Because the same tendency existed for pregnant and non-pregnant ewes in both supplemented groups this could only be explained in terms of nutrition during the gestation period. The average rib-bone P concentrations of pregnant and non-pregnant ewes in both lambing seasons and supplemented groups (Tables 1 and 2) agree with values found by Engels (1981) with pregnant Dorper ewes grazing natural pasture. The average rib-bone P concentration of pregnant Dorper ewes was 136,25 mg/cm^3. It is also evident that P supplementation had no influence on the P concentration of samples collected in the P^+ group.

No significant differences were found in the average P concentrations of blood, bone, and faecal samples and in bone specific gravity values between subgroups and years or between pregnant and non-pregnant ewes that indicated a negative P status in either group.

Reproductive efficiency

Lambing percentage and percentage ewes lambed in the May and October lambing seasons of the P^- and P^+ groups during the experiment are given in Table 3.

It is evident that no tendency in reproductive performance across lambing seasons was found. The total average percentage ewes lambed and lambs born in the P^- and P^+ groups was 86,1; 93,9% and 80,2; 83,0% respectively ($P > 0,2$). However, the general tendency in the percentage ewes lambed and lambs born in the May and October lambing groups

Table 1 Phosphorus (P) content (mean ± SD) of blood, faecal, and bone samples collected from the groups lambing in October during the experimental period

Group	Reproductive state	n	Plasma P, (mg/100 ml)		Faecal P, (%)		Bone P, (mg/cm^3)	
			A	B	A	B	A	B
P^-	Pregnant	28	4,06 ± 0,82	2,69 ± 1,22	0,30 ± 0,08	0,20 ± 0,03	149,5 ± 10,1	140,3 ± 15,1
	Non-pregnant	2	3,91 ± 0,97	0,89 ± 0,97	0,37 ± 0,02	0,18 ± 0,06	150,0 ± 15,4	146,4 ± 1,3
P^+	Pregnant	24	3,90 ± 0,99	3,03 ± 0,68	0,33 ± 0,09	0,24 ± 0,09	157,2 ± 11,5	146,3 ± 12,2
	Non-pregnant	6	3,82 ± 0,53	3,31 ± 0,68	0,35 ± 0,05	0,20 ± 0,03	150,4 ± 16,1	141,9 ± 14,3

n = Number of observations; A = Sample collected 1 week before mating; B = Sample collected 1 week before lambing

Table 2 Phosphorus (P) content (mean ± SD) of blood, faecal, and bone samples collected from groups lambing in May during the experimental period

Group	Reproductive state	n	Plasma P, (mg/100 ml)		Faecal P, (%)		Bone P, (mg/cm^3)	
			A	B	A	B	A	B
P^-	Pregnant	24	4,07 ± 1,14	2,45 ± 0,98	0,17 ± 0,02	0,18 ± 0,03	146,4 ± 9,4	150,0 ± 17,8
	Non-pregnant	6	4,73 ± 1,07	3,23 ± 0,63	0,31 ± 0,20	0,20 ± 0,04	145,4 ± 12,8	153,0 ± 12,7
P^+	Pregnant	19	2,95 ± 0,90	2,90 ± 0,60	0,33 ± 0,17	0,25 ± 0,07	147,4 ± 8,7	152,7 ± 13,3
	Non-pregnant	11	3,40 ± 0,75	2,74 ± 0,91	0,34 ± 0,17	0,27 ± 0,08	145,0 ± 8,7	150,4 ± 10,5

n = Number of observations; A = Sample collected 1 week before mating; B = Sample collected 1 week before lambing

Table 3 Percentage ewes lambed and lambs born during May or October each year in the P⁻ and P⁺ supplemented groups

Measurement	P⁻ May	P⁻ Oct	P⁺ May	P⁺ Oct
1980				
ewes lambed, %		85,0		65,0
lambs born, %		85,0		65,0
1981				
ewes lambed, %	90,0	79,0	77,8	88,9
lambs born, %	100,0	79,0	83,3	94,4
1982				
ewes lambed, %	84,2	94,4	76,5	100,0
lambs born, %	100,0	116,7	76,5	100,0
1983				
ewes lambed, %	84,2		73,3	
lambs born, %	84,2		80,0	
Mean				
ewes lambed, %	86,2	86,0	76,0	83,9
lambs born, %	94,8	93,0	80,0	85,7

(Table 3) indicates a higher reproductive efficiency of the P^- group over the P^+ group. Thus P supplementation in this study did not increase reproductive efficiency.

The average birthmass of single lambs born in the P^- and P^+ groups is presented in Table 4.

No significant differences were found for birthmass between lambs of the P^+ and P^- groups born in the May and October lambing season or between the P^- and P^+ groups ($P > 0,2$) as a whole. The average birthmass of single lambs born in the P^- and P^+ groups were 4,3 ± 0,5 and 4,4 ± 0,6 kg respectively.

From the preceeding results it is evident that P supplementation to Karakul sheep (pregnant and non-pregnant) grazing natural pasture did not influence the P concentration of saliva, blood, faecal, and rib-bone, or reproductive efficiency. These results were recorded under poor feeding conditions where low protein and energy intakes were expected to have a detrimental effect on P absorption from the diet. Nevertheless no evidence of a negative P status was found.

Phosphate supplementation did not promote or increase reproduction during this study. Therefore, P supplementation to Karakul sheep grazing natural pasture in the Gordonia district appears to be unnecessary.

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Table 4 Birthmass (kg) of single lambs born during May or October each year in the P⁻ and P⁺ supplemented groups. Values in body of table represent mean ± SD with the number of observations in brackets

Year	P⁻ May	P⁻ Oct	P⁺ May	P⁺ Oct
1980	–	4,1 ± 0,6(15)	–	4,3 ± 0,8(13)
1981	4,6 ± 0,3(17)	4,2 ± 0,5(11)	4,7 ± 0,6(13)	4,2 ± 0,6(12)
1982	4,3 ± 0,6(14)	4,0 ± 0,7(11)	4,3 ± 0,6(12)	4,4 ± 0,4(18)
1983	4,2 ± 0,5(15)	–	4,4 ± 1,0(9)	–
Mean	4,4 ± 0,5(46)	4,1 ± 0,6(37)	4,5 ± 0,7(34)	4,3 ± 0,6(43)

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