Plasma copper, zinc and blood selenium concentrations of sheep, goats and cattle

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Concentrations of plasma copper, plasma zinc and blood selenium in sheep, goats and cattle, grazing together on natural pastures, were determined at two- to three-monthly intervals over a two-year period. Cattle had the lowest plasma copper concentrations, but no definite differences in plasma zinc concentrations between species could be found. Sheep had higher blood selenium concentrations than goats, with those of cattle being the lowest. Regression analyses within species indicated that blood selenium concentration was related to gluthatione-peroxidase activity, although correlations were generally too low for predictive purposes ($r \leq -0{,}61$). Distinct differences were found between species when blood selenium concentration was related to the haematocrit.

Plasmakoper-, plasmasink- en bloedseleniumkonsentrasies by skape, bokke en beeste is twee- tot drie-maandeliks oor 'n periode van twee jaar bepaal. Beeste het laer plasmakoperkonsentrasies as skape en bokke gehad, terwyl geen spesieverskille in plasmasinkkonsentrasies gevind is nie. Skape het hoër bloedseleniumkonsentrasies as bokke gehad terwyl dié van beeste die laagste was. Regresssie-analises binne spesies het aangedui dat bloedseleniumkonsentrasie verwant was aan glutatioonperoksidase-aktiwiteit, alhoewel korrelasies te laag was vir voorspellingsdoeleindes ($r \leq -0{,}61$). Groot verskille tussen spesies is gevind wanneer die seleniumkonsentrasie in verband gebring is met die haematokritwaarde.

Keywords: Cattle, goats, sheep, trace elements.

The Dorper (sheep) as well as Boergoat (goat) breeds were developed in South Africa. The hardiness and adaptability of these breeds make them suitable for meat production in arid, extensive regions. As animal production in the extensive areas takes place with little or no feed supplementation, it is of great importance to know whether the trace-element intake of these animals is adequate.

It has been well established that genetic differences exist between sheep breeds in their copper metabolism (Harrison, Van Ryssen & Barrowman, 1987). It has been established that chronic copper toxicity in South African sheep breeds occurs more frequently in Dorpers than Merinos (Bath, 1979). At present, possible differences in the metabolism of trace elements between local breeds and species such as the Dorper and Boergoat are ill-defined.

Two trials were conducted at the Nortier Experimental Farm to compare blood selenium (Se) and plasma copper (Cu) and zinc (Zn) concentrations between sheep, goats and cattle under extensive grazing conditions.

The Nortier Experimental Farm is situated on the western coast of South Africa. The farm is classified as representative of veld type 34 (Acocks, 1953), also described as the 'Strandveld'. In this region, natural pastures are utilized for extensive sheep, goat and cattle production.

Trial 1: Experimental animals originated from the commercial Dorper and Boergoat flocks and Simmentaler herd kept on this farm. At the beginning of 1986, 10 female animals, 8—12 months of age, were selected randomly from each of the three species. During 1986, blood samples were taken from these animals at three-month intervals throughout the year. During 1987, the same procedure was followed but another group of experimental animals was selected on the same basis as the previous year, and blood samples were collected every second month. These animals were not mated during the experimental period. All three species utilized the same veld during the trial.

Trial 2: Blood samples were taken from 15 young (< 10 months of age) and 15 old (> 24 months of age) sheep and goats which were not used for blood sampling during Trial 1, and from all the Simmentalers in the herd at that time, comprising 51 animals.

During Trial 1, blood samples (20 ml) were collected from the jugular veins in heparinized vacuum tubes (Vac U Test). Ten ml blood was kept for Se determinations and 10 ml was centrifuged and the plasma removed for Cu (1986 & 1987) and Zn (1987 only) determinations. Samples were kept at −20°C until analysed.

The same collection procedures were followed in Trial 2, with the exception that all blood samples were placed in a container at a temperature of *ca.* 10°C after sampling. All blood samples were taken within 3 h, after which they were transported to the laboratory while kept at a constant temperature. Gluthatione–peroxidase (GSH–px) activity was measured within 24 h after blood sampling.

Plasma Cu and Zn concentrations were determined by the methods used by Van Niekerk & Van Niekerk (1989). The GSH–px activity was measured according to the method described by Langlands, Donald, Bowles & Smith (1980). The haematocrit (Hc) was determined as described by Benjamin (1978), and blood Se concentrations were determined according to the method described by Koh & Benson (1983).

The results of Trial 1 were analysed as a two-way factorial experiment with species (sheep, goat or cattle) and time of sampling as factors. The P2V program of the BMDP statistical package (Dixon, 1981) was used for this purpose. The results of Trial 2 were similarly analysed as a 3 × 2 factorial experiment, with species and age (young/old) as factors. Applicable least significant differences were obtained by the Bonferoni method in both trials (Van Ark, 1981). Heterogeneous variances between species did not permit assessment of GSH–px activity by analysis of variance. These data were thus evaluated by the non-parametric Kruskal–Wallis analysis, and the means were compared according to the Dunn method (Van Ark, 1981). Selenium concentrations were regressed on GSH–px activity using the P5R polynomial regression program of the BMDP statistical package (Dixon, 1981).

From the results of Trial 1, it was evident that the effect of species interacted ($P \leq 0{,}01$) with time of blood sampling for all three minerals. The plasma Cu and Zn as well as blood Se concentrations for the respective sampling times, are thus given in Figure 1.

The plasma Cu concentrations of the small stock (sheep and goats) were generally higher ($P \leq 0{,}05$) than that of cattle. During the latter part of 1987 (March—November) this difference became less marked, resulting in the interaction. The cause of this finding is not known, but it is important to note that plasma Cu concentrations of cattle indicated a slight deficiency (*ca.* 60 µg/dl) over the entire experimental period (Underwood, 1977). The plasma Cu concentrations of the small stock species, on the other hand, varied within the normal ranges of 80—160 µg/dl during 1986. Indications of a marginal Cu deficiency were found in the small stock in 1987, as reflected by plasma Cu concentrations of 60—80 µg/dl.

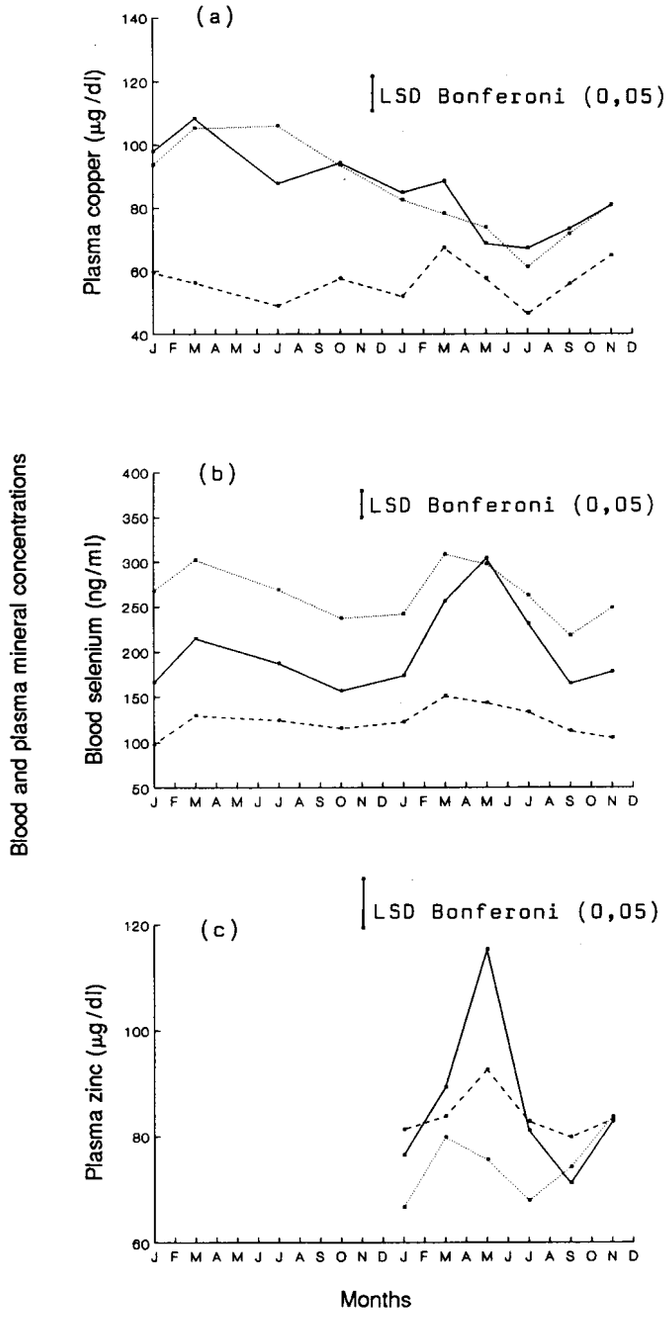

Figure 1 Concentrations of (a) plasma copper, (b) blood selenium, and (c) plasma zinc in sheep (.....), goats (——) and cattle (– – –), over a two-year-period in 1986/1987.

As for blood Se, sheep generally had higher ($P \leq 0{,}05$) concentrations than goats, which in turn had higher ($P \leq 0{,}05$) values than cattle (Figure 1). In May 1987 no difference was found between sheep and goats, contributing to the interaction between species and time of blood sampling. With regard to plasma Zn, no conclusive differences were found between species (Figure 1). Plasma Zn concentrations were indicative of a marginal deficiency (< 80 µg/dl) in sheep in January and July 1987.

If the plasma Cu concentrations of all three species during 1987 are taken as a criterion, a marginal Cu deficiency must be assumed for the Nortier Experimental Farm. No Se deficiency is expected, while Zn appears to be marginally deficient in sheep. Production and reproduction rates of the

Table 1 Selenium (Se) concentration, gluthatione-peroxidase (GSH-px) activity and haematocrit (Hc) concentration in the blood of sheep, goats and cattle

		Se (ng/ml)		GSH–px (min)		Hc (l/l)	
Species	– age (number)	Mean ± *SD*	Range	Mean	Range	Mean ± *SD*	Range
Sheep	– young (15)	284[a] ± 34	200—351	3,1[1]	3—4	0,40[a] ± 0,03	0,34—0,46
	– old (15)	255[a] ± 30	216—312	3,6[1]	3—4	0,31[b] ± 0,04	0,21—0,36
Goats	– young (15)	197[b] ± 33	141—253	3,4[1]	3—5	0,31[b] ± 0,04	0,20—0,36
	– old (15)	169[b] ± 30	124—220	3,9[1]	3—5	0,31[b] ± 0,04	0,24—0,41
Cattle	– young (18)	81[c] ± 17	56—107	7,2[2]	4—9	0,41[a] ± 0,03	0,36—0,45
	– old (33)	100[c] ± 21	62—150	7,6[2]	4—13	0,38[a] ± 0,04	0,30—0,46

[a—c] Values in the same column with different headings differ ($P \leq 0,01$) according to the Bonferoni method.
[1,2] Values in the same column with different headings differ ($P \leq 0,05$) according to the Dunn method.

sheep, goats and cattle are, however, quite high. A conception rate of 89%, a multiple birth rate of 159 lambs born/100 ewes lambed with a 9% lamb mortality were reported for the Dorper sheep flock over the period 1973 through 1984 (Cloete & De Villiers, 1987). Lamb growth averaged 0,27 kg/d in this flock, with equally high reproduction and production performances in the other species (personal communication: J.B. van der Vyver, 1989).

For the diagnosis of selenium responsive conditions in ruminants, both the determination of blood Se and GSH–px activity are regarded suitable methods (Langlands *et al.*, 1980). The inter-relationships of blood Se concentration, GSH–px activity and Hc were thus studied in Trial 2. The results of Trial 2 are given as the two-factor interaction between species and age, as it was significant ($P \leq 0,05$) for some variables (Table 1).

The mean blood Se concentrations did not differ significantly between the age groups within species, but did differ significantly ($P \leq 0,01$) between species. These results are in general agreement with those depicted in Figure 1. The GSH–px activity (min. reaction time) did not differ significantly between the sheep and the goats, but the reaction times of both small stock species differed significantly ($P \leq 0,05$) from that of the cattle. As for Hc (l/l) values, no definite conclusions could be made although the Hc of the goats tended to be lower, particularly when compared to that of the cattle.

The blood Se concentrations were regressed on GSH–px activity within species and the following equations were obtained:

Sheep:
$Y = 379,5 - 33,0(SE_b = 14,4)X \quad (r = -0,40, n = 30, P \leq 0,05);$

Goats:
$Y = 299,4 - 31,6(SE_b = 7,87)X \quad (r = -0,61, n = 30, P \leq 0,01);$

Cattle:
$Y = 127,8 - 4,7(SE_b = 1,4)X \quad (r = -0,43, n = 51, P \leq 0,01).$

The general relationship between blood Se and GSH–px activity is evident from the significant ($P \leq 0,05$) regression coefficients, but the spot test does not predict blood Se accurately, as reflected by r values $\leq 0,61$. The GSH–px spot test must therefore only be regarded as a screening test to identify Se responsive conditions and not to study GSH–px activity directly, owing to the insensitivity thereof. A reaction time of less than 4 min is regarded as sufficient, and of more than 10 min, indicative of a deficiency in sheep and goats. In cattle, a reaction time of less than 10 min is regarded as sufficient and of more than 15 min as deficient (personal communication: E.W.P. Heine, 1989). Most GSH–px in blood is located in the erytrocyte, and many workers expressed GSH–px activity relative to the amount of haemoglobin. Results (see Table 1) indicate that there might be marked differences between species in the Se content per unit red blood cells, when Se was related to the haematocrit. This difference was not evident between sheep and goats, but the cattle differed distinctly from the small stock species.

This species difference in blood Se as related to Hc and GSH–px activity should be studied further. Mabon (1969) concluded that it appears in calves that greater efficiency in the conversion of food into body mass is accompanied by a more rapid decline of red cell GSH–px content from the first to the twelfth week of life. According to Kidwell, Wade & Hunter (1955) there is an association between GSH–px concentration and rate of cell proliferation, protein synthesis and adult size in at least rabbits. Owens, Siegel & Van Krey (1970) selected cockerels for high and low body weight at eight weeks of age and found that in these lines, greater blood GSH–px activity is correlated with heavier body weights and that the difference between the lines was greater at younger ages. When seen against this background, there also appears to be scope for studying the variation in Se metabolism between individuals within the same species.

In conclusion, analysis of plasma samples from the livestock at Nortier suggested that cattle had lower plasma Cu concentrations than the small stock species. No definite difference in plasma Zn concentrations was found. Marked differences in blood Se concentrations were found between species. This indicate that the metabolism of this mineral also differ between species which could affect their nutritional need for Se.

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