MINERAL NUTRITION OF GRAZING SHEEP IN NORTHERN CHINA
II. SELENIUM, COPPER, MOLYBDENUM, IRON AND ZINC IN PASTURE, FEED SUPPLEMENTS AND SHEEP

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Summary

This study determined the concentrations of micro-minerals in pastures, in feed supplements and in grazing, reproducing ewes, at different times during the year, at three farms in Northern China. Samples were collected 5 to 8 times during the year and analysed for selenium, copper, iron, molybdenum and zinc. On two farms selenium concentrations in both pastures and animal tissues were low for part of the year. The lowest concentrations in pasture (< 30 μg/kg DM) and liver (< 100 μg/kg wet weight) indicated that productivity of the sheep may be reduced by a deficiency of this element. On one farm copper concentrations in the liver were in the deficient range (< 5 μg/kg wet weight) for part of the year. It is likely that this is a result of high intakes of iron from pasture (up to 4.5 g Fe/kg DM) and soil, as indicated by high concentrations of iron in faeces (up to 7 g Fe/kg DM). Molybdenum intake is unlikely to have had much influence on copper absorption because pasture concentrations of this element were not unusually high (1 to 5 mg/kg DM). Zinc in pastures on two farms was below 10 mg/kg DM for part of the year. On one of these farms, the concentration of zinc in faeces was below 30 mg/kg DM throughout the year and this is consistent with zinc intakes of 7 to 15 mg/kg. Despite these low intakes, the concentrations of zinc in plasma were consistently above deficient levels. No clinical signs of deficiencies of any of the elements studied were observed.

(**Key Words**: China, Sheep, Minerals, Selenium, Copper, Iron, Molybdenum, Zinc)

Introduction

Trace element deficiencies or toxicities may influence many aspects of animal production including growth, reproductive efficiency, wool production and mortality (Underwood, 1981). These deficiencies may be present as overt symptoms that are readily identified and corrected or, as marginal deficiencies that are not easily identified but may cause a significant depression in production (Judson et al., 1987).

Deficiencies may result from low concentrations of elements in the soil and plants, and, as with macro elements, are more likely to occur in grazing animals, dependent on unfertilised pasture and locally grown supplements for all feed requirements. Alternatively, deficiencies and toxicities may be induced by interactions between trace elements or between trace elements and other nutrients.

In China, trace element deficiencies and toxicities influence both animal production and human health. Liu et al. (1985), in a national investigation of plant material and animal feed stuffs, reported that 70% of the counties in China grew pastures with selenium concentrations less than 50 μg/kg. In the northern province of

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Heiliojiang, 93% of feedstuffs contained less than 20 μg/kg. The concentration considered to be minimum for sheep is between 30 and 50 μg/kg (ARC, 1980; SCA, 1990). White muscle disease, caused by selenium deficiency, has been reported in lambs (Liu et al., 1985). Low selenium intakes have also been linked with endemic diseases in humans (Chen, 1988). Copper deficiency has been reported in Xinjiang Uygur Autonomous Region and in the east of Inner Mongolia (R. Z. Yang, L. H. Wu, personal communication, 1989). The mountainous regions of China are also low in iodine and goitre in man and farm animals has been reported (Underwood, 1981).

While existing reports indicate that trace element problems do exist, there have been limited efforts to identify the range of elements that may be involved or to determine effects of location, physiological state of the animals or seasonal conditions on trace element status. The aim of this study was to investigate the trace element status of grazing sheep in three locations in Northern China (Masters et al., 1993) and describe the changes caused by seasonal variation and the different physiological states of the sheep. The farms, Huang Cheng (Gansu Province), Nanshan (Xinjiang Uygur Autonomous Region) and Aohan (Inner Mongolia Autonomous Region) are representative of major fine-wool sheep growing areas.

Materials and Methods

The locations, sheep type, management and production details are as previously described (Masters et al., 1990, 1993). The representative groups of 140 ewes, described in the preceeding publication (Masters et al., 1993) and the samples collected from them, were also used for the trace element studies. The samples included: blood and faeces (collected six to eight times per year from 30 sheep); liver, muscle, kidney, bone, lung and heart (collected five of six times per year from five or six sheep); pasture (collected five to eight times per year); and feed supplements.

Samples were prepared as described previously and analysed for iron, zinc, manganese, copper and molybdenum using an Inductively Coupled Argon Plasma Analyser (ICAP 9000 Jarrel Ash Division, Fisher Scientific Co.). Selenium was analysed using the method of Watkinson (1979). Bovine liver (NBS Standard Reference Material 1577a) was included in the analysis as a standard reference material.

Comparisons between farms and seasons were made using analysis of variance. When the interaction between farms and seasons was significant, the interaction error value was used to test the effects of farm and season separately.

Results and Discussion

Selenium

On all farms selenium concentrations in pasture (figure 1) were within or below the marginal range for sheep (ARC, 1980; SCA, 1990) of 30 to 50 μg/kg DM at some times during the year. Such estimates of requirements usually include a safety margin and are not always associated with clinical signs of deficiency. The low and different levels of selenium in pasture were reflected in the sheep tissues, with significant differences between farms ($p < 0.05$) and a significant farm × season interaction ($p < 0.001$) on selenium in plasma, liver and muscle (figure 1). Selenium levels tended to be lowest in summer, when pasture and animal growth are at their highest (Masters et al., 1990). Concentration of selenium in the liver fell below 90 μg/kg during the year at Huang Cheng and Nanshan. A high incidence of white muscle disease has been reported by others in sheep flocks with mean selenium concentrations in liver of less then 70 μg/kg (Gabbedy et al., 1977), and normal concentrations are above 100 μg/kg (Judson et al., 1987). Concentrations of selenium in muscle, fell below 25 μg/kg. Peter et al. (1988) reported increased live weight and wool growth when selenium supplements were given to weaner sheep with selenium concentrations in muscle of less than 25 μg/kg wet weight (100 μg/kg DM). These results indicate that ewes at Huang Cheng and Nanshan farms, but not Aohan, are at risk from selenium deficiency. The higher concentrations of selenium in tissues collected from Aohan farm probably resulted from the higher concentrations of selenium in pastures in summer and in feed supplements in winter and autumn (table 1).

Concentrations of selenium in plasma on all three farms (> 20 μg/L) were higher than those reported in the experiments of Langlands et al.

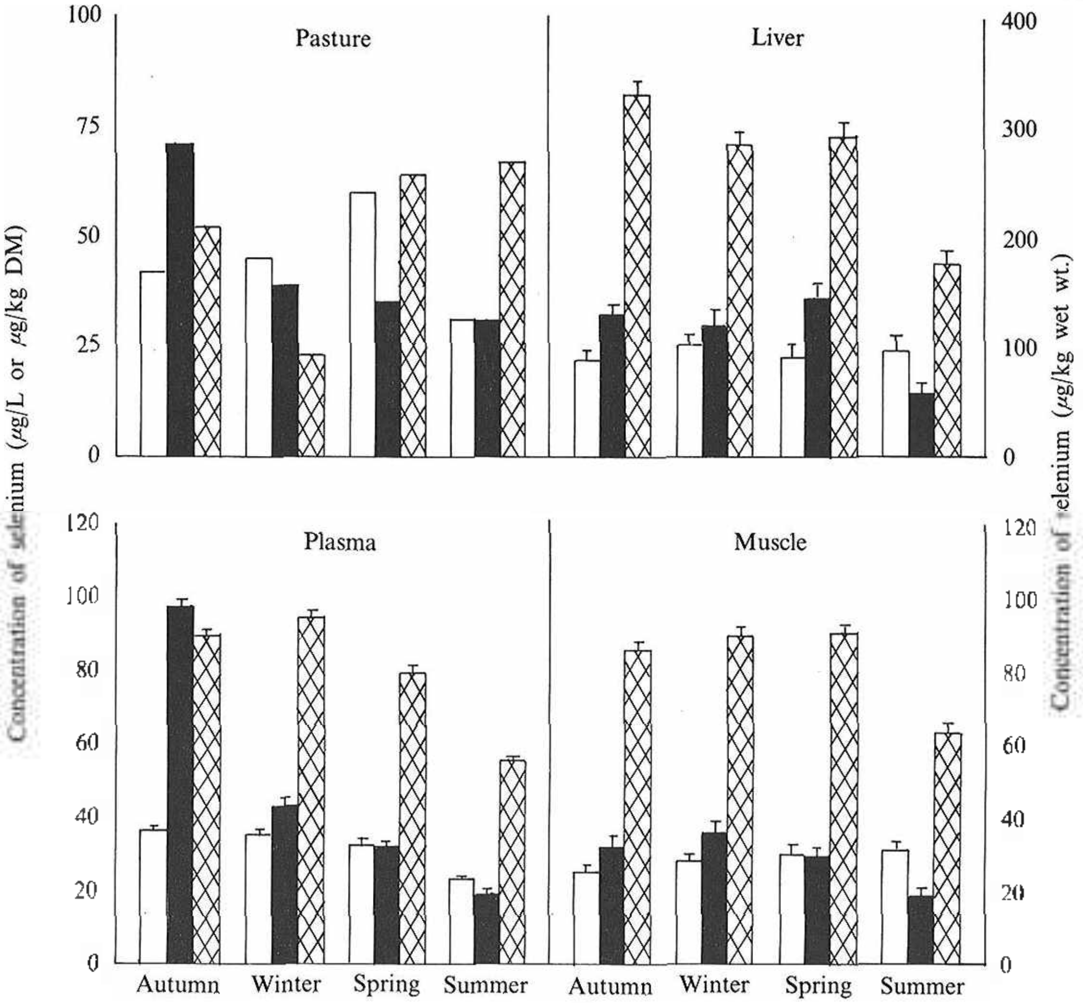

Figure 1. Selenium concentrations in pasture and in the liver, plasma and muscle, of reproducing ewes, at Huang Cheng (blank box), Nanshan (filled box) and Aohan (hatched box) farms during each season.

TABLE 1. CONCENTRATION OF TRACE ELEMENTS IN FEED SUPPLEMENTS (mg / kg DM)

	Concentrates			Hay			Silage		
	HC[1]	NS[2]	AH[3]	HC	NS	AH	HC	NS	AH
Selenium	0.021	0.092	0.083	0.021	0.047	–	0.021	–	0.06
Copper	4.50	11.3	11.6	3.27	6.38		4.57	–	4.14
Molybdenum	0.85	1.43	0.72	0.74	1.44	–	1.40	–	1.82
Iron	159	272	287	150	310	–	354	–	372
Manganese	26.6	36.0	28.7	33.8	53.0		53.4	–	56.7
Zinc	23.9	46.8	30.1	16.5	29.5	–	20.5	–	10.9

[1] Huang Cheng farm.
[2] Nanshan farm.
[3] Aohan farm.

(1990a,b,c) (5-19 μg/L). In these experiments marginal selenium deficiency in reproducing ewes resulted in reduced wool growth, fibre diameter, lambs weaned and live weight of lambs at birth and weaning.

Copper, Iron and Molybdenum

There were differences between farms in the concentration of copper in liver ($p < 0.001$) and plasma ($p < 0.1$) (figure 2). The lowest concentrations in the liver were at Huang Cheng farm (3.7 mg/kg wet weight). This is below the deficient level reported by Paynter (1987) of 5 mg/kg wet

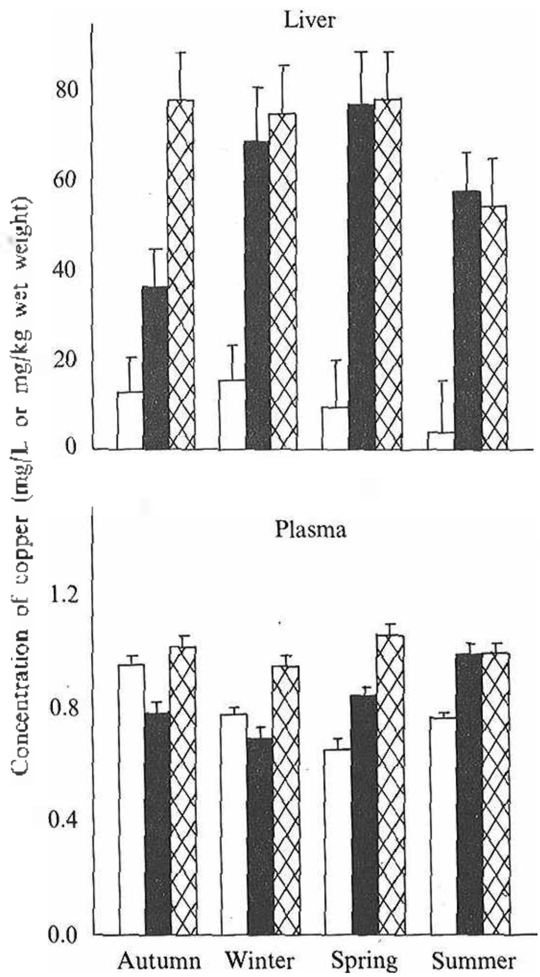

Figure 2. Copper concentrations in the liver and plasma of reproducing ewes, at Huang Cheng (blank box), Nanshan (filled box) and Aohan (hatched box) farms during each season.

weight and the concentration at which Hogan et al. (1971) reported depressed wool and body growth and connective tissue lesions (8.6-14.2 mg/kg). Copper in plasma did not fall as low as observed during severe deficiency (<0.3 mg/L) but approached the levels associated with marginal deficiency (0.6 mg/L) (Paynter, 1987). Copper deficiency can be induced by a lack of copper (Underwood, 1981), by high intakes of molybdenum and sulphur (Dick, 1953) or by high intakes of iron (Humphries et al., 1983). There are differences in the expression of copper deficiency related to the cause of copper depletion. For example, when copper deficiency has been induced by high molybdenum and sulphur, responses to copper supplementation may occur at higher concentrations of copper in the liver than when deficiency is induced by a simple lack of copper or by high intakes of iron (Bremner et al., 1987). This results because absorbed thiomolybdate complexes with copper in the kidney and liver to make it less biologically available (Gawthorne, 1987). As copper in pasture was only occasionally below requirements for sheep (< 5 mg/kg DM, SCA, 1990) on any of the farms (figure 3) and copper concentration in tissues was not related to the time of the year or physiological state of the ewes, the low concentrations in liver were probably caused by an interaction of copper with iron or molybdenum and sulphur. Iron in pasture was extremely high at Nanshan and Huang Cheng for part of the year (figure 4). The highest concentration of 4 g/kg DM was 100 times requirement (0.03-0.04 g/kg DM, SCA, 1990) and higher than the concentrations of iron shown to reduce copper status in other experiments with sheep (Wang and Masters, 1990). These high pasture concentrations were reflected in faeces with concentrations up to 7 g/kg DM at Huang Cheng and Nanshan (figure 4). Much of the iron measured in faeces may have been derived from soil contamination of pasture, and, at Huang Cheng, to the habitual consumption of soil caused by a lack of sodium (Masters et al., 1993). Consumption of high iron soils has previously been shown to reduce copper status in sheep (Suttle et al., 1984). Molybdenum in pasture was sufficiently high to interact with copper (Suttle and McLauchlan, 1976) but not as high as observed to cause severe copper deficiency (Hogan et al.,

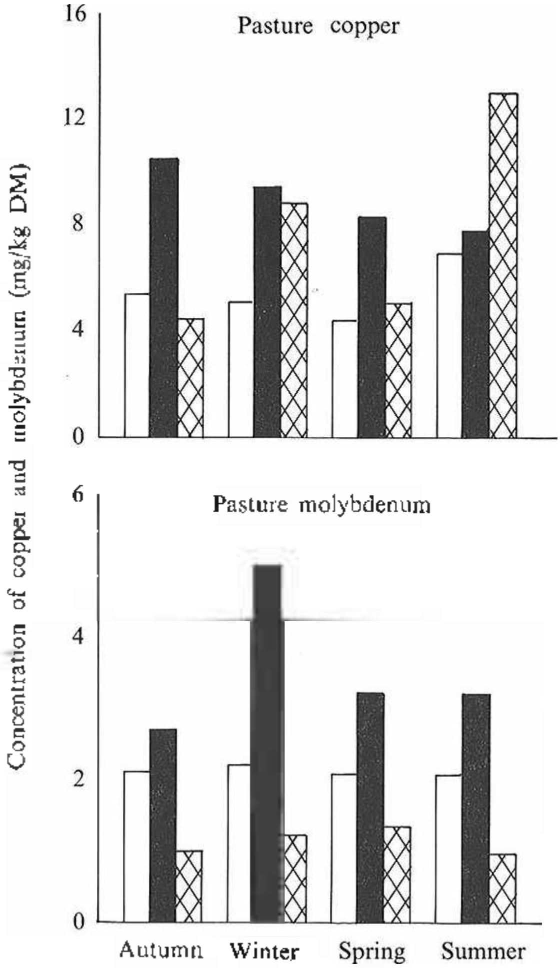

Figure 3. Copper and molybdenum concentrations in pasture at Huang Cheng (blank box), Nanshan (filled box) and Aohan (hatched box) farms during each season.

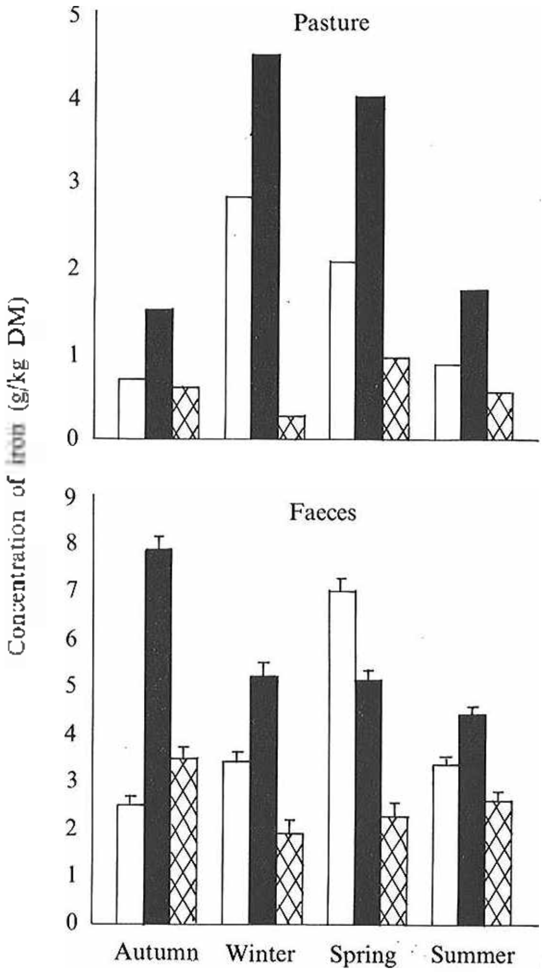

Figure 4. Iron concentrations in pasture and faeces at Huang Cheng (blank box), Nanshan (filled box) and Aohan (hatched box) farms during each season.

1971).

Zinc in pasture ranged from 4 to 37 mg/kg DM (figure 5). The lower values were below the recommended intakes for sheep (9-15 mg/kg DM, SCA, 1990). Some low zinc values in faeces were also observed (figure 5). An estimation of pasture zinc concentrations can be made using faecal concentrations. When dry matter digestibility (DMD) of pasture is 50% and zinc absorption (and retention) from the gastro-intestinal tract is also 50%, the concentration of zinc in faeces would be equal to that in the ingested feed. In reality, DMD would usually be above 50%, possibly exceeding 80% at some times of the year, and zinc absorption would be less than 50% (SCA 1990). The concentration of zinc in faeces would therefore be 2-4 times higher than in the ingested feed. This indicates that the intake of zinc at Aohan farm was between 7 and 15 mg/kg DM. These low values in pasture and faeces may also be indicative of a lack of zinc for optimum pasture growth (Robson and Gartrell, 1979).

Despite the low zinc intakes, particularly at Aohan farm, the concentrations of zinc in plasma did not indicate clinical deficiency (0.4 mg/L, Mills et al., 1967). Nor did they fall below those observed by Masters and Fels (1980) when they reported reproductive responses, to zinc supplements, in grazing ewes (approximately 0.5 mg/L). The higher zinc values in this current study are

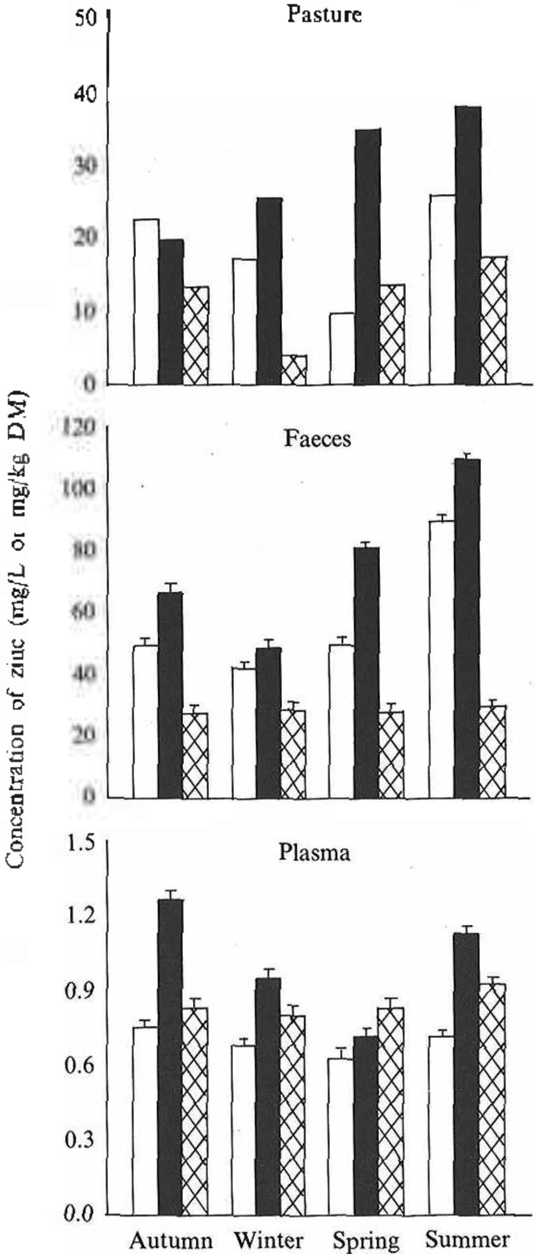

Figure 5. Zinc concentrations in pasture and in the faeces and plasma of reproducing ewes, at Huang Cheng (blank box), Nanshan (filled box) and Aohan (hatched box) farms during each season.

probably a result of the low productivity of the ewes due to a lack of many nutrients (Masters et al., 1990).

There were differences in the trace element concentrations in pasture and sheep both between farms and between seasons on farms. As with macro-minerals, (Masters et al., 1993) these differences are likely to be related to rainfall, soil type, pasture species and the use of supplements. Although no clinical signs of deficiency of any of the elements were observed during the study, the low concentrations of selenium at Huang Cheng and Nanshan, and copper, at Huang Cheng, are consistent with marginal deficiencies of these elements. A preliminary report on responses to copper and selenium supplements, at Huang Cheng farm, supports this conclusion (Yu et al., 1991). Such deficiencies may reduce productivity (Judson et al., 1987). Supplements providing these elements should be evaluated. In addition, responses to zinc, in grazing sheep (Masters and Fels, 1980) have been reported at zinc intakes similar to or above those observed at Aohan. An evaluation of zinc supplements on this farm is also justified.

Sheep on all farms require additional salt throughout the year (Masters et al. 1993), therefore provision of micro-elements, mixed with the salt would provide a convenient, inexpensive and effective means of ensuring adequate intakes of all micro-elements.

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