DIFFERENCES IN THE COPPER TOLERANCE OF BRITISH SHEEP BREEDS AND A POSSIBLE RELATIONSHIP TO THE SOIL CHEMISTRY OF THE REGIONS OF ORIGIN OF THE BREEDS.

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Abstract

Sheep are peculiarly sensitive to copper toxicity at low dietary levels compared with cattle, pigs and poultry. They can also show susceptibility to copper deficiency at dietary intakes not much less than optima. The range of tolerance between deficient and toxic dietary levels is low. Further, breed differences appear to exist in the tolerances such that deaths from copper toxicity in one breed have occurred in mixed breed flocks while other breeds are unaffected. These breed differences also appear in countries such as New Zealand, Canada and Australia where UK sheep have been exported. Our hypothesis is that these breed differences relate to the areas of origin in the UK, specifically to the areas where they evolved as landraces over many generations in relation to the differing chemistry of the soils and bedrock. The sheep were adapted metabolically to local nutritional and micro-elemental regimes. Using wool elemental analysis as a surrogate for body burden, we present the data on the differences between four UK breeds raised under identical nutritional and management conditions. This is a preliminary to work on the chemistry of wool clips taken in the areas of origin of the breeds and to the local soil chemistry.

Introduction

Copper toxicity in sheep is an increasing problem, with recent Ontario and UK autopsies of suspected copper poisoned sheep showing high blood, kidney and liver levels of copper. In the past and as an ongoing problem in sheep rearing, copper deficiency has also been a problem, especially in Australia but also in Britain where the condition of swayback in lambs is well known in certain areas. Copper supplements, often as mineral licks, were put out in fields in certain areas to counteract this. Feed stuffs, hay, silage, water supply, pasture, mineral supplements and underlying geology and soil chemistry are all possible causes and variables in both toxicity and deficiency.

Breed type may well be a factor in this as reports have indicated certain breeds as being particularly at risk (eg. Henderson 1990, Woolians et al, 1983, Littledike and Young, 1993). These breeds include the Texel, a breed from the sandy Texel Isles in the Netherlands; the North Ronalsay, a primitive breed fed entirely on seaweed from the Scottish Orkney islands (Penny, 1999) and the Suffolk from the drained marshland area of eastern England.

The accidental feeding of mineral supplement designed for cattle or horses will very readily kill sheep. Mineral copper in supplement for sheep needs to be less than 5 ppm while horses and cattle require in excess of 25 ppm. To complicate the picture further, copper is used as a growth additive in commercially produced pig and poultry feed, with substantial levels being used eg. 150 ppm in pig feed. The intensive mass production units for hogs in the USA and Canada and for poultry broiler production means many thousands of animals are confined on a small acreage. The spreading of manure from such hog and poultry operations onto land subsequently used as sheep pasture has led on several occasions, to the death of sheep from copper poisoning due to accumulation in the surface soils and to uptake into the pasture and hay plants. Water supply can also be a problem in new barns where copper pipes are used.

Our hypothesis is the sheep breeds originating from areas of low copper availability would evolve mechanisms for effective uptake of copper which could pose a problem if that local breed is later transported to areas of higher copper availability or given mineral supplements with elevated copper. The Rare Breeds Survival Trust in Britain removed some of the numerically vulnerable North Rondaldsay sheep to the mainland and to another island in the 1970's. The better nutrient regimes they encountered led to copper toxicity deaths and are recognition that these sheep are metabolically different. Similar experience is occurring for the very popular Texel breed of sheep, which are sought after as a breed in Europe and North America for increasing carcass qualities.

Sheep breeds evolved in rather high copper areas may have evolved biochemical mechanisms for reducing uptake and chelating the copper so that it was not a problem. Such sheep raised in low copper areas may show deficiencies.

One way of assessing a sheep’s copper status without killing it is to use wool samples. This is akin to the use of hair for assessing the nutritional status of humans, mice, rats, etc. for arsenic, lead, cadmium and zinc (Grace and Lee, 1992). A number of researchers have used wool to estimate either body burden (often correlating levels with those in blood, liver and kidney) or as an indicator of environmental pollution (Wooliams et al, 1983, Stevenson and Wickham, 1976, Awad et al, 1974, and Birks and Vrzgula, 1990).

An interesting aspect of copper in wool analysis is that coloured or black wool has been known for at least a century to respond to copper applications. Copper deficient wool loses its crimp while copper deficient black wool loses both its crimp and its colour. It becomes white. In a recent experiment at Leeds University, a number of Black Welsh Mountain sheep were subjected to a low copper diet and basically became white. Shepherds showing sheep in coloured classes at shows in Canada used a potentially lethal mixture of nicotine sulphate and copper sulphate in the diet a few weeks before shows to maximize pigmentation (but, they emphasized that you had to be careful with it.)

<u>Methods</u>

Wood samples were taken from sheep at a farm near Peterborough, Ontario, where four breeds, all originally from areas of the UK but having been brought to Canada over the past 150 years are maintained under identical management condition. They are pastured from May to October and fed on local grown hay and some mixed grain from October to April. Samples of wool were sheared from the flank and from the neck of ewes who had lambed and from mature rams. The wool was collected in March 1999. The breeds used were Cotswold, Dorset (polled), Shetland and Shropshire. All wool was then washed in distilled water and in a rinse of dilute nitric acid to remove surface dirt. It was then dried in the air prior to preparation for analysis. Samples of approximately 0.2 g were then taken for digestion in concentrated nitric acid and diluted to 50 ml with double-distilled water. After filtering, the samples were then analyzed using inductively coupled plasma emission (ICP-MS).

The opportunity was taken to analyze for other elements known to relate to copper metabolism in sheep, notably molybdenum (where high % can induce copper deficiency), as well as zinc, iron, selenium, and sulphur. In addition, the bases calcium and magnesium were determined.

Since the farm flock also had both coloured and white animals in two of the breeds, samples of coloured and white wool were compared.

Results

The preliminary results of the wool analysis for the four species are shown in Table 1. Copper concentrations varied from 0.72 ppm to a high of 1.78 ppm so the range is quite limited. No significant differences occurred between breeds in copper levels under this uniform management regime. However, in the Cotswold longwool sheep, the black rams had wool with 1.43 ppm Cu while the white wool from a ram of similar age (3 years) was 1.00. These animals also differed in Mo and Se levels, and especially in Ca and Mg levels in their wool. In all cases, the black wool was higher in elemental concentrations. In the Shetlands, the black ram (#18) showed lower Cu but again high Mo, Mg, and Ca. Both the Cotswold and the Shropshire nursing mothers had lower Ca and Mg than the rams, probably a function of lactation, which can lead to calcium and magnesium deficiencies and imbalances.

Table 1. Elemental analysis of washed wool from four breeds of sheep raised under identical nutritional and management conditions. Each value is the mean of 3 samples unless noted and the analysis were done using ICP-MS on 0.2 g samples of flank wool. Wool collected March 17, 1999. Values in ppm.

Breed of sheep		**Cu**	**Mo**	**Se**	**Zn**	**Ca**	**Mg**	**Fe**
Cotswold								
	black ram	1.43	0.21	0.16	20.6	316	41	19
	white ram	1.00	0.02	0.11	16.4	74	14	12
	white ewe	1.16	0.03	0.04	24.1	142	18	19
	white mother	1.02	0.04	0.08	15.8	58	11	6
Shropshire								
	white ram	1.05	0.04	0.14	25.4	99	31	22
	white ewe (2 reps)	1.24	0.02	0.04	25.7	101	15	7
	white mother (2 reps)	1.11	0.07	0.06	18.3	82	12	14
Dorset (polled)								
	white ram (2 reps)	1.11	0.01	0.04	23.9	114	19	9
	white ewe (1 rep)	0.72	0.01	0.02	20.8	168	30	28
	white mother (2 reps)	1.78	0.07	0.07	30.5	159	26	31
Shetland								
	black ram (1 rep)	0.70	0.07	0.02	16.3	326	39	25
	white ewe	1.52	0.03	0.12	18.0	128	28	9
	brown mother (1 rep)	1.47	0.17	0.08	23.2	151	22	14

Discussion

The relative uniformity of results between the breeds under this nutrient regime of adequate diet suggests the elemental analysis is working. In the only other ICP-MS analytical study of wood that we know, e.e. from New Zealand, the authors noted that the ICP method seemed to give results about as expected for Zn, Al and Fe, compared with other methods such as atomic absorption spectrophotometry, that the authors were more familiar with. However, they noted that ICP-MS was not fully quantitative and for Al and Fe gave results about one third of expected. This is also our experience to date. Recoveries from reference material gave 26% for Cu, 31% for Se, 26% for Ca and Mg, 29% for Zn and just 20% for Fe.

As we try to improve the protocol and relate it to organ levels in autopsied animals, we will strive to improve the methods for cleaning and preparing the wool for analysis. For comparative purposes, however, the method already seems useful. We now will examine these same breeds of sheep under more copper stressed situations where underlying metabolic differences may begin to show up.

This is the beginning of a much larger study which examines the hypothesis of latent metabolic differences due to geographically distinct areas of origin.

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References

Awad, F.I., H. E. El-Guindy, I.A. El-Hetw, Y. L. Awad and F. A. Fakmy (1974). Normal copper levels of different organs, blood and wool of Egyptian sheep. Egypt. J. Vet. Sci. 11. 85-92.

Bires, J. and L. Vrzgula (1990). Wool as an indicator of sheep exposure to Cu, Fe, Zn, Mo, As, Pb, Cd and Se from an industrial emission source. Ekologia (CSFR). 9. 419-428.

Grace, N. D. and J. Lee (1992). Influence of high zinc intakes, season and staple site on the elemental composition of wool and fleece quality in grazing sheep. New Zealand J. Agric. Res. 35. 367-377.

Henderson, D. C. (1990). The Veterinary Book for Sheep Farmers. Chapter 11. Trace Elements, Minerals, Vitamins, and Water, pp 435-476. Farming Press, Ipswich, UK.

Littledike, E. T. and L. D. Young (1993). Effect of sire and dam breed on copper status of fat lambs. J. Anim. Sci. 71. 774-778.

Penny, G. (1999). A study in the prevention of copper toxicity in North Ronaldsay sheep. The Ark. Winter issue. 17. No. 4. 134-135.

Stevenson, J. R. and G. A. Wickham (1976). Seasonal and other effects of copper and zinc concentrations in the wool of New Zealand Romney sheep. N.Z. J. Agric. Sci. 19. 217-220.

Wooliams, J. A., G. Wiener, N. F. Suttle and A. C. Field (1983). The copper content of wool inrelation to breed and the concentration of copper in the liver and plasma. J. Agric. Sci. 100. 505-507.