THE BONE FLUORIDE OF EWES AND LAMBS IN N.S.W.

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SUMMARY

Metatarsal bones of Border Leicester/Merino ewes (>4 y.o.) and lambs (<1 y.o.) were collected from each of nine agricultural areas in N.S.W. and analysed for fluoride. Significant differences were found between the regions, the lowest value for ewes being from the N. Tablelands, and the highest from the S. Tablelands (162 ± 4.0 and 477 ± 10.7 mg fluoride per kg bone ash respectively). Corresponding values for lambs were 22 ± 0.8 mg/kg (N. Tablelands) and 50 ± 1.2 mg/kg (S. Plains). The range for all ewes was 67-938 mg/kg and for lambs 7-97 w/kg. The toxic threshold for metatarsal fluoride in sheep is 2000 mg/kg, while sub-acute fluoride ingestion can have adverse production effects. Further investigation is therefore warranted. (Keywords: fluoride, metatarsal bone, sheep).

INTRODUCTION

Fluorides are widely distributed in Nature, forming 0.065% of the earth's crust. In excessive amounts fluoride is extremely toxic, but because it is a cumulative poison, pathological effects may occur before animals are diagnosed as fluorotic, and production may be adversely affected.

Sheep may ingest fluoride via bore-water (Harvey 1952; Harvey and Moule 1954), superphosphate (O'Hara and Cordes 1982; O'Hara et al. 1982), phosphate supplements such as licks, or from proximity to aluminium smelters (Wheeler and Fell 1983). The maximum dietary daily allowance of fluoride for sheep has been set in the U.S.A. at 60 mg/kg for breeding ewes and 150 mg/kg for feeder lambs, but intakes at which pathological (or production) effects occur are not known (National Academy of Sciences 1974).

Recent work at our laboratory has shown that 30 mg fluoride ion per litre (mg F/l) in drinking water given to pregnant ewes and their lambs reduced wool production of the lambs by some 18%, due principally to reduced staple length (Wheeler et al. 1985). The important implications of this finding prompted an investigation into the current fluoride status of ewes and lambs in N.S.W., using metatarsal bones collected from nine recognised agricultural areas.

MATERIALS AND METHODS

Survey design

Fifteen metatarsal bones of both ewes (>4 y.o.) and lambs (<1 y.o.) were collected from abattoirs serving nine of the twelve statistical agricultural areas in N.S.W. Wherever possible Border Leicester x Merino animals were chosen. Bones were collected between November 1984 and January 1985.

Samples from each abattoir were collected when appropriate sheep were available, usually over a short time within the three-month period. The extent to which the sheep may have represented more than one flock is not known.

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Analvsis of bones

Each bone was skinned, cleaned of adhering tissue, weighed and dried at 105°C for 2 h. After cooling and re-weighing, a dorsal/plantar sawcut was made on each bone (Suttie and Kolstad 1974), and the bone dust collected. Each sample was well mixed, 0.5 g ashed in a nickel crucible at 600°C overnight, and 0.05 g of ash analysed for fluoride (Stewart et al. 1974), using perchloric acid digestion and a combined fluoride ion-specific electrode (Orion 96-09-00, Linbrook International Pty. Ltd., Crows Nest, N.S.W.). A composite sample of bone dust was analysed by two other laboratories and results found to be comparable with our method.

Statistical analysis

Analysis of variance was used to determine differences between regions for both ewe and lamb bones.

RESULTS

The results of the bone fluoride analyses are shown in Table 1.

Table 1 Metatarsal fluoride content of sheep from agricultural regions of N.S.W.

Region	Bone ash fluoride (mg/kg)					
	Ewes (>4 y.o.)			Lambs (<1 y.o.)		
	Mean*	± S.E.	Range	Mean*	± S.E.	Range
Northern Tablelands	162^{a}	4.0	90 - 235	22^{e}	0.8	7 - 38
Northern Slopes	248^{abc}	4.3	107 - 502	28^{e}	0.9	20 - 36
Northern Plains	209^{ab}	5.8	144 - 344	33^{e}	0.8	27 - 40
Central Tablelands	322^{c}	4.2	155 - 691	49^{f}	1.0	24 - 77
Central Slopes	189^{ab}	3.6	67 - 303	35^{ef}	0.9	19 - 57
Western Plains	322^{c}	6.1	189 - 484	49^{f}	1.8	38 - 84
Southern Tablelands	477^{d}	10.7	170 - 938	31^{e}	1.0	21 - 47
Southern Slopes	299^{bc}	5.8	153 - 485	Not available		
Southern Plains	302^{bc}	6.1	203 - 538	50^{f}	1.2	25 - 97

* n = 15. Means with different superscripts are significantly different from one another ($P<0.005$).

Differences were apparent between the regions, with values for ewes being lowest in the N. Tablelands (162 ± 4.0 mg/kg) and highest in the S. Tablelands (477 ± 10.7 mg/kg); corresponding values for lambswere 22 ± 0.8 mg/kg (N. Tablelands) and 50 ± 1.2 mg/kg (S. Plains).

DISCUSSION

Metatarsal bones were selected for analysis because they have been used for the diagnosis of fluoride toxicosis in cattle, and because coccygeal vertebrae are virtually absent in sheep, due to tail-docking. In addition, the metatarsal bone is readily available from abattoirs. Fluoride concentration in the metatarsus is higher at the proximal and distal ends and on periosteal surfaces than in the shaft. Bone-dust from a dorsal/plantar sawcut has been found to give a representative sample of fluoride concentration, and is more practical than ashing and grinding the whole bone (Suttie and Kolstad 1974).

As might be expected from the cumulative nature of fluoride deposition in bone, mean values from the ewes were greatly in excess of those from the lambs, despite the large variation within each region. While the N. Tablelands showed the lowest values for both ewes and lambs, the high values obtained in ewes from the S. Tablelands were not reflected in the lambs from that area. The reason for this difference is not known but could be because animals had been moved from one region to another, particularly during the drought. Confirmation of area differences is therefore needed through more detailed studies, particularly because bones may have represented only one flock.

For the ewes, the mean values of bone fluoride were below 322 mg/kg for all regions except the S. Tablelands (477 mg/kg). Toxic levels for compact bone in sheep begin at 2000 mg/kg (Jackson and Weidmann 1958), and while most mean values were well below this level, it is of concern to note that the highest individual value was 938 mg/kg, and some others were in the range 500-700 mg/kg. The level at which bone fluoride concentration reflects pathological or production effects is not known. The levels obtained for adult sheep in this survey (67-938 mg/kg) may be compared with those from New Zealand (42-990 mg/kg), (Stewart et al. 1974) in sheep tail-bones. Cancellous bones such as the coccygeal vertebrae are considered to contain twice the fluoride concentration of compact bones such as the metatarsus (Suttie and Kolstad 1974; Debackere and Delbeke 1979). Thus levels from N.S.W. could be considered twice as high as those occurring naturally in N.Z. sheep during 1969-1971. The exact source of dietary fluoride for N.S.W. sheep is not known but is likely to exclude industrial emissions and to include water and superphosphate. Soil ingested during grazing may also be a source of minerals (Healy et al. 1970).

Bone fluoride concentration in lambs reflects fluoride absorbed via the placenta and mammary gland as well as that ingested after weaning (Wheeler et al. 1985). The range observed in this study (7-97 mg/kg) indicates a variable intake, with the high values well below toxic levels. In our earlier controlled experiment, tail-bone fluoride of lambs at weaning was 105 ± 26.9 mg/kg when during pregnancy the mothers drank town water of approximately 1 mg F/l. Values for lambs whose mothers were given 30 mg F/l water were 580 ± 117 mg/kg, and such lambs showed reduced wool production (Wheeler et al. 1985). The highest survey values for lamb metatarsal bones would be intermediate between the previous control animals and experimentally high fluoride animals (coccygeal values), and the likelihood or extent of any reduction in wool production is not known.

Most research into the adverse effects of fluoride has been done with cattle, and includes deleterious physiological effects on bones, teeth, kidneys and adrenal glands; reduced milk production; increased milk fluoride content; reduced iron absorption; changes in thyroid and parathyroid hormones and in calcium magnesium and phosphate homeostasis (Wheeler and Fell 1983; Wheeler et al. 1985).

Since sheep are considered to be relatively sensitive to fluoride (Patterson 1977), further work is needed in order to determine levels of fluoride ingestion which result in sub-acute toxicity, and show adverse physiological or production effects such as reduced wool production or fertility, lowered birth-weight of lambs, interference with calcium metabolism during pregnancy and interactions with iodine in marginal iodine deficiency. Clearly the results of this survey indicate that in some N.S.W. sheep dietary fluoride intake is high enough to cause concern, and field studies are needed to determine whether such intake is related to reduction in health or production.

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