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The Effect of Soluble-glass Boluses Containing Copper, Cobalt and Selenium on the Blood Composition of Ewes

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ABSTRACT

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An experiment was carried out on a site where herbage selenium content is known to be low, to examine the value of soluble-glass boluses as a means of providing supplementary copper, cobalt and selenium to ewes.

Sixty-one Welsh half-bred ewes were divided into two groups. Thirty ewes were given a single glass bolus and 31 were left as untreated controls. Measurements of plasma copper and caeruloplasmin concentrations, serum vitamin B_{12} concentration and erythrocyte glutathione peroxidase activity all showed significant increases owing to treatment with soluble-glass boluses. These glass boluses also gave protection to the foetus and the young lamb in its early life.

INTRODUCTION

Acute deficiencies of trace elements induce easily recognisable signs but marginal deficiencies are difficult to recognize and the distribution of their occurrence is very difficult to define. Marginal trace-mineral deficiencies may induce nothing more than slight growth retardation, indistinguishable from simple undernutrition or sub-clinical parasitism. In the next few years the strategy is likely to be purely on prophylaxis to alleviate trace-element deficiencies in order to increase productivity and consequently profitability.

Disadvantages of the parenteral route of copper administration have led to a renewed interest in the oral route. The phosphate-based soluble-glass boluses developed by Telfer et al. (1983) provide an alternative method of trace-element supplementation. These glass boluses contain trace elements and dis-

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solve at a desired rate when placed within the reticulo-rumen of ruminant animals, such that each individual animal can obtain a full year's supplementation of these trace elements.

Previous work by Telfer and Zervas (1982) and Zervas (1983) has shown that soluble glasses containing copper can release this element, which is absorbed and utilised by the ruminant animal. Soluble-glass boluses containing copper, cobalt and selenium have been tested on grazing ruminants (Telfer and Zervas, 1984; Telfer et al., 1984; Trengove and Judson, 1985; Carlos et al., 1986; Zervas, 1988) and the results have proved that these soluble glasses prevent deficiencies of these elements.

The aim of this experiment was to test the efficacy of these soluble glass boluses in ewes which were housed for about half a year and were kept for the rest of the year in an area where nutritional myopathy is very common and causes great losses in lambs and calves.

MATERIALS AND METHODS

Sixty-one Welsh half-bred ewes were randomised into two groups. The first group of 30 ewes were given a single glass bolus at the beginning of their pregnancy, while the other group of 31 ewes were left as untreated controls.

The ewes were kept indoors from Day 0 to lambing (March) and fed on hay (10 mg Cu kg^{-1} DM, 0.9 mg Mo kg^{-1} DM, 3.0 g S kg^{-1} DM, 0.10 mg Co kg^{-1} DM, 0.03 mg Se kg^{-1} DM) and concentrates (12 mg Cu kg^{-1} DM, 1.0 mg Mo kg^{-1} DM, 2.1 g S kg^{-1} DM, 0.12 mg Co kg^{-1} DM, 0.07 mg Se kg^{-1} DM). Soon after lambing they were turned on to high-quality pasture.

The glass boluses (COSECURE) which were used in this experiment are phosphate-based glasses and exhibit the property of being soluble. The sheep size soluble-glass boluses weigh about 35 g, are 50 mm long, taper from 17 to 19 mm in diameter and contain 14% copper, 0.63% cobalt and 0.265% selenium. Their release rate in the rumen is 2.53 mg cm^{-2} day^{-1} and the daily supply is about 11 mg copper, 0.5 mg cobalt and 0.21 mg selenium at the beginning of the administration and 6, 0.22 and 0.11 mg, respectively, 6 months later. The retention rate is about 98% (G. Zervas and S.B. Telfer, unpublished data, 1984). The properties of these glasses have been described in detail by Telfer et al. (1983), and Knott et al. (1985).

Blood samples were taken at the time of administration (Day 0) and subsequently at Days 44, 70, 100, 134, 178, 218, 274 and 408 after treatment. The blood samples were analysed for plasma copper and caeruloplasmin concentrations, serum vitamin B_{12} concentration and erythrocyte glutathione peroxidase activity (GSHPx). Blood samples were also taken on three occasions from lambs (aged 2–14 days at Day 1 in Fig. 4) which were born from treated (43 lambs) and control (37 lambs) ewes. Those blood samples were analysed only for erythrocyte glutathione peroxidase activity. After the third blood sampling (Day 28 in Fig. 4) all lambs were injected with a Se/vitamin E compound because some lambs from control ewes had died from white muscle disease.

Total copper in plasma was determined directly by atomic-absorption spectrophotometry on an IL 1S1 AA spectrophotometer (Instrumentation Laboratory Inc.) after diluting the plasma 1 to 9 with double-distilled water. Plasma caeruloplasmin concentrations were determined by the method of Henry et al. (1974), erythrocyte glutathione peroxidase activity by the method of Anderson et al. (1978), and the vitamin B_{12} concentration in serum by using a No-boil vitamin radioassay kit (RIA Products, Inc.).

The results for each sampling time were analysed by Student's *t*-test.

RESULTS AND DISCUSSION

Blood analysis for copper or caeruloplasmin (CP) provides a basis for assessing whether copper status is normal (8–25 μmol Cu l^{-1} and >15 mg CP/100 ml plasma) or low (<8 μmol Cu l^{-1} and <15 mg CP/100 ml). Plasma copper and caeruloplasmin concentrations in sheep given glass boluses or no treatment are displayed in Fig. 1. Administration of the glass bolus resulted in a significant ($P<0.05$) increase in the plasma caeruloplasmin concentrations during Days 134–218 of the trial. There were no significant differences in the mean plasma copper concentrations between groups, because all sheep had adequate copper. An increase in liver copper content of treated sheep should

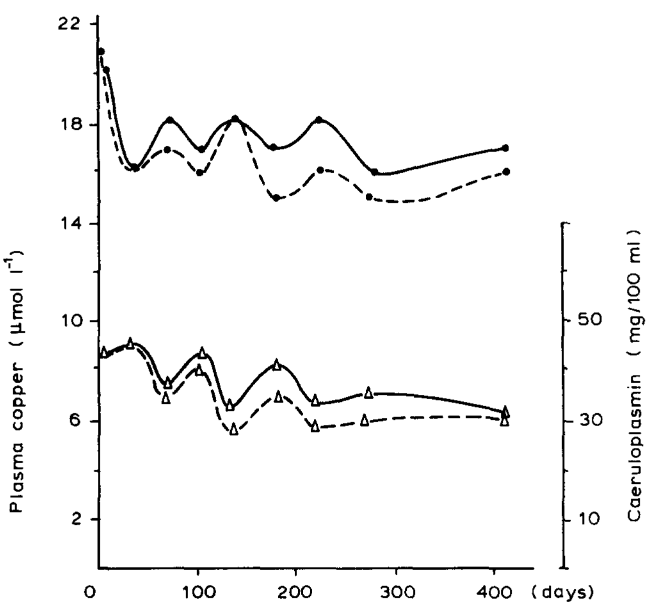

Fig. 1. Plasma copper (●) and caeruloplasmin (△) concentrations of treated (——) and control (- - -) ewes.

have occurred but it was not convenient to do liver biopsies to confirm it. Trengove and Judson (1985) have shown that mean liver copper concentrations of Merino sheep which received glass boluses were significantly greater than those of sheep in a control group for up to 44 weeks after administration, but never reached the high copper level over which copper toxicity is to be expected.

Housed sheep fed on concentrates are more susceptible than grazing sheep to copper toxicity (Ross, 1966) and the Welsh breed of sheep is more sensitive to high copper doses than other breeds (Herbert et al., 1978; Woolliams et al., 1983). The treated sheep of this experiment did not show any toxicity signs although the diet was relatively high in copper and the sheep were housed for about 5 months per year. Thus, the additional supply of copper from a soluble-glass bolus was not toxic to these sheep.

Vitamin B_{12} concentration in serum is the criterion most frequently employed for diagnosis of cobalt adequacy in the living animal. The concentration of serum vitamin B_{12} regarded as adequate for sheep is 400 ng l^{-1}. Serum vitamin B_{12} values for all sheep were high at the beginning of this field trial, declined during the winter months and rose afterwards. Significant differences ($P<0.001$) in values of treated sheep occurred at Days 44, 70, 100 and 134 (Fig. 2). Subsequently, the elevated vitamin B_{12} values of all sheep may have hidden the effect of cobalt release from the glass boluses.

Measurement of the whole blood activity of the seleno-enzyme glutathione peroxidase is widely used to assess the selenium status of animals. In sheep,

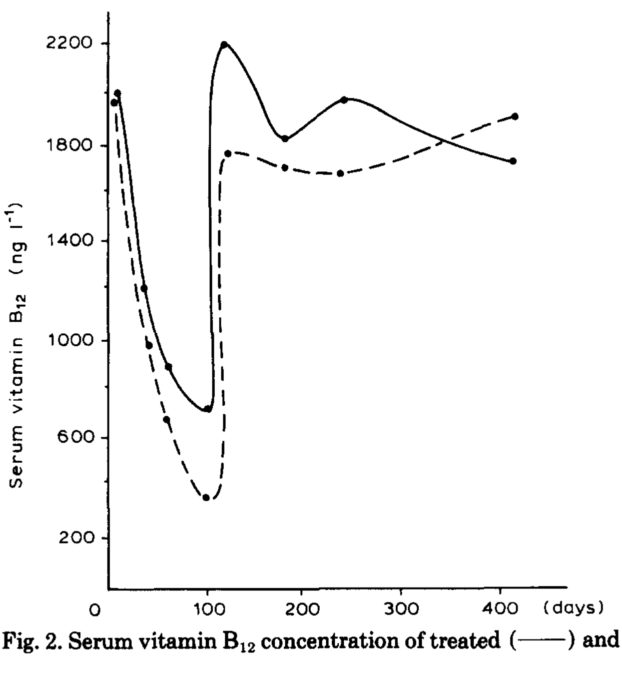

Fig. 2. Serum vitamin B_{12} concentration of treated (——) and control (- - -) ewes.

the selenium content and the activity of this enzyme in the blood are closely related. For predictive purposes the finding of whole blood GSHPx activity of 18 units ml^{-1} packed red cell volume (PCV) provides a convenient measure of selenium status and thus of the risk that myopathy will occur.

The results in Fig. 3 show that differences between treated and control ewes in erythrocyte glutathione peroxidase activity were highly significant ($P<0.001$) at Days 44–218. The present work also shows that the glass boluses, by releasing selenium, ensured a substantial supply of selenium for the lambs. The erythrocyte glutathione peroxidase activity of lambs born from the

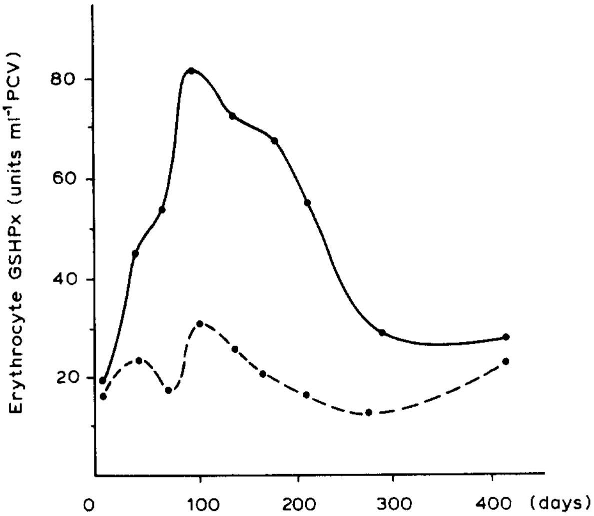

Fig. 3. Erythrocyte glutathione peroxidase activity of treated (——) and control (- - -) ewes.

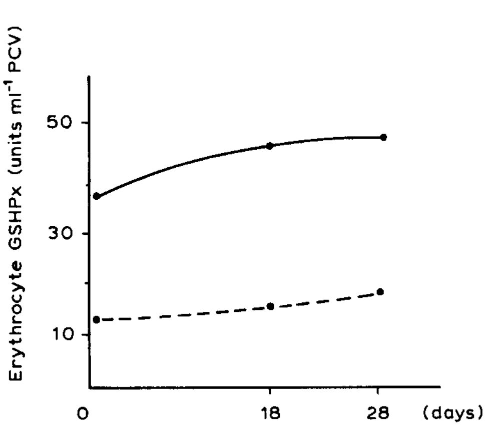

Fig. 4. Erythrocyte glutathione peroxidase activity of lambs born from treated (——) and control (- - -) ewes.

treated ewes was significantly higher ($P < 0.001$) than that of lambs born from control ewes (Fig. 4).

Hidiroglou et al. (1969, 1971) have shown that selenium administration to the mother enhanced the selenium concentration of foetal tissues, during gestation and during suckling, because the milk selenium level of ewes supplemented with selenium was higher than that of unsupplemented ones, at least for the first 2 months of lactation. These findings would explain the higher erythrocyte glutathione peroxidase activity of lambs born from treated ewes and the better protection against perinatal losses from nutritional muscular dystrophy.

In our trial the mortality of lambs from the control ewes was high, and forced the farmer to inject all the lambs with a Se/vitamin E compound about a month after their birth. Survival records, unfortunately, were not kept. Increased preweaning survival of lambs by ewe treatment with selenium has been shown by Kott et al. (1983) and improved lamb viability among ewes receiving a commercial mixture containing both sodium selenite and vitamin E by Ruttle and Smith (1976).

In conclusion, soluble glass boluses can successfully prevent a selenium deficiency in a practical situation for about a year and can also give protection to the foetus and the young lamb in its early life.

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REFERENCES

Anderson, P.H., Berrett, S. and Patterson, D.S.P., 1978. Glutathione peroxidase activity in erythrocytes and muscle of cattle and sheep and its relationship to selenium. J. Comp. Pathol., 88: 183–189.

Carlos, G., Zervas, G., Driver, P.M., Anderson, P.B., Illingworth, D.V., Al-Tekrity, S.A. and Telfer, S.B., 1986. The effect of soluble glass boluses on the copper, cobalt and selenium status of Scottish Blackface ewes. In: C.F. Mills, I. Bremner and J.K. Chesters (Editors), Trace Elements in Man and Animals. Commonwealth Agricultural Bureaux, London, pp. 714–716.

Henry, R.J., Cannon, D.C. and Winkelman, J.W., 1974. The determination of plasma caeruloplasmin activity. Clinical Chemistry. Harper and Row, London, New York, 2nd ed., pp. 78–80.

Herbert, J.G., Wiener, G. and Field, A.C., 1978. The effect of breed and of dried seaweed meal in the diet on the levels of copper in liver, kidney and plasma of sheep fed on a high copper diet. Anim. Prod., 26: 193–201.

Hidiroglou, M., Hoffman, I. and Jenkins, K.J., 1969. Selenium distribution and radiotocopherol metabolism in the pregnant ewe and foetal lamb. Can. J. Pharmacol., 47: 953–962.

Hidiroglou, M., Hoffman, I., Jenkins, K.J. and Mackay, R.R., 1971. Control of nutritional muscular dystrophy in lambs by selenium implantation. Anim. Prod., 13: 315-321.

Knott, P., Algar, B., Zervas, G. and Telfer, S.B., 1985. Glass - A medium for providing animals with supplementary trace elements. In: C.F. Mills, I. Bremner and J.K. Chesters (Editors), Trace Elements in Man and Animals. Commonwealth Agricultural Bureaux, London, pp. 708-714.

Kott, R.W., Ruttle, I.L. and Southward, G.M., 1983. Effect of vitamin E and selenium injections on reproduction and preweaning lamb survival in ewes consuming diets marginally deficient in selenium. J. Anim. Sci., 57: 553-558.

Ross, D.B., 1966. The diagnosis, prevention and treatment of chronic copper poisoning in housed lambs. Br. Vet. J., 122: 279-284.

Ruttle, J.L. and Smith, G.S., 1976. Effect of selenium on feedlot gains of lambs. J. Anim. Sci., 43: 3 (abstract).

Telfer, S.B. and Zervas, G., 1982. The release of copper from soluble glass bullets in the reticulorumen of sheep. Anim. Prod., 34: 379-380 (Abstract).

Telfer, S.B. and Zervas, G., 1984. The effect of TRACER-GLASS-L on the copper, cobalt and selenium status of lambs. Anim. Prod., 38: 561 (Abstract).

Telfer, S.B., Zervas, G. and Knott, P., 1983. Water soluble glass articles, their manufacture and their use in the treatment of ruminant animals. U.K. Patent Application 2116424 A.

Telfer, S.B., Zervas, G. and Carlos, G., 1984. Curing or preventing deficiencies of copper, cobalt and selenium in cattle and sheep using tracer. Can. J. Anim. Sci., 64 (Suppl.), 234-235.

Trengove, C.L. and Judson, G.J., 1985. Trace element supplementation of sheep: evaluation of various copper supplements and a soluble glass bullet containing copper, cobalt and selenium. Aust. Vet. J., 62: 321-324.

Woolliams, J.A., Suttle, N.F., Wiener, G., Field, A.C. and Woolliams, C., 1983. The long-term accumulation and depletion of copper in the liver of different breeds of sheep fed diets of differing copper content. J. Agric. Sci., Camb., 100: 441-449.

Zervas, G., 1983. The prevention of copper deficiency in ruminants by means of soluble glass rumen bullets. Ph.D. Thesis, University of Leeds, pp. 146-255.

Zervas, G., 1988. Treatment of dairy sheep with soluble glass boluses containing copper, cobalt and selenium. Anim. Feed Sci. Technol., 19: 79-83.