RECENT DEVELOPMENTS IN TRACE ELEMENTS IN ANIMAL PRODUCTION (INVITED REVIEW)

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SUMMARY

There is a continual need for further research to understand in greater detail the metabolism and function of trace elements, From recent studies it has been noted that:
(a) The Se requirements of dairy cows have become more accurately defined and cattle, when compared with sheep,are less sensitive to Se deficiency. (b) High Mo intakes and not the associated decrease in the Cu status of cattle is responsible for the decrease in cattle fertility, (c) The use of the expected response approach rather than the present criteria of 'deficient', 'marginal' or 'adequate' for describing the Co status of lambs enables a more informed decision to be made on whether or not to supplement with Co. (d) In some situations high mortalities in pre-weaned lambs have been found to be associated with Cu deficiency; Cu supplementation markedly increased the lambs' resistance to disease,

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INTRODUCTION

The importance. of 'the trace elements such as Se, Co, Cu, Mo and I in sheep and cattle production has been well documented, while responses to Zn and Mn supplementation have also been reported, At present much still has to be. investigated concerning their metabolism, biochemical and physiological functions, their interactions with other dietary consituents and the factors influencing their requirements, not only for sheep and cattle, but also other species such as goats and deer. The present review covers studies reported during the last 5 years,

SELENIUM RESPONSES IN DAIRY CATTLE

Selenium deficiency is a common trace element problem in livestock and while the signs of Se deficiency are well defined in sheep less is known about Se nutritionin cattle, Two recent studies in New Zealand have provided new information on the Se nutrition of dairy cattle. The first investigation (Fraser et al, 1987) (Rangitaiki Plains; North Island) involved 8 herds (59-217 cows) with mean herd blood Se-levels ranging from 84 to 148 nmol/l. Each herd was divided into 2 groups with 1 group acting as the control, while the other group was given 40 mg Se subcutaneously at 2 monthly intervals starting from August,

The relationship between the mean herd blood Se concentrations and the responses to Se supplementation was not well defined. Two herds (mean blood Se concentration 84 and 119 nmol/l) showed significant increases (8 - 10%) in milk volume and fat yield, while a third herd (blood Se concentration 93 nmol/l) showed only a significant increase (4%) in fat yield in response to Se supplementation. The other 5 herds (Se blood concentrations '97, 112, 124, 130 and 148 nmol/l) were non-responsive to Se,

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The second study (Tasker et al. 1987) (Taranaki, North Island) involved 3 herds (143 - 173) cows) with mean herd Se blood levels of 115, 132 and 204 nmol/l for herds A, B and C respectively. The herds were again divided into 2 groups with the Se treated group receiving 500 mg Se as Ba selenate as a subcutaneous injection. The Se treatment maintained the blood Se levels above 700 nmol/l for over 8 months. A significant increase (7%) in milk production to Se supplementation was observed in the herd where the blood Se was previously less than 115 nmol/l. An improvement in reproductive performance to Se supplementation was also observed as the submission rates for the first 21 days of the breeding season increased from 78% to 94% in herd A while the conception rates to first service increased from 60% to 78% (herd A) and from 42% to 59% (herd B).

From limited observations it appears that dairy cattle may be less sensitive to low Se intakes when compared with sheep. In New Zealand, sheep respond to Se treatment in terms of improved fertility and growth rates when their blood Se levels are less than 130 nmol/l while responses are variable between 130 - 250 nmol/l (Sheppard et al. 1984). Further, it has also been reported that while there were no differences in the incidence of dry cows between Se supplemented and unsupplemented beef cattle, there was a significant response to Se supplementation in terms of growth rate and improved fertility in sheep grazing the same pasture.

COPPER-MOLYBDENUM AND CATTLE FERTILITY

Evidence for the involvement of Cu in the fertility problems of cattle is conflicting. Indications of a possible relationship between Cu and fertility in New Zealand has come from reports of cattle grazing pastures on peat soils where Cu deficiency is associated with high pasture Mo. Those investigations where a response to Cu therapy (52 to 72% increase in conception rates) have been observed, have usually been uncontrolled studies and the Cu status of the cows has not been clearly defined (Hunter 1977).

The metabolism of Cu is complex and the Cu status of cattle can be altered by increasing the intakes of Zn, Cd and Fe as well as Mo in the presence of S. In a detailed study (Phillippo et al. 1985) on Cu status and fertility, 35 Hereford x Friesian heifers *100* to 120 days of age which had been reared on a low Cu diet were divided into 4 groups and given the following treatments: (1) Basal diet containing 4 mg Cu, *0.1* mg Mo, 100 mg Fe and 2.8 S g/kg DM [C group], (2) Basal diet + 500 mg Fe/kg DM [+Fe group], (3) Basal diet +5 mg Mo/kg DM [+Mo group] and (4) Basal diet with a restricted intake [C-R group] to give a growth rate similar to the +Mo group. The Cu status of the +Mo and +Fe groups was markedly reduced as the mean Cu concentrations in their livers were significantly. lower than those of the C and C-R groups (3.7, 4.2 *v* 60.8, 44.0 mg/kg DM). The blood Cu levels followed the same pattern as the hepatic Cu concentrations with the +Mo and +Fe groups having blood Cu values below 0.2 mg/L. Near puberty the mean liveweights of the +Mo group (and C-R group) were significantly lower than for the C and +Fe groups (283, 268 v 313, 310 kg) while the mean age of puberty for the +Mo group was greater than for the other groups (343 *v* 286 -days). The reproductive performance of the +Mo group was impaired as its pregnancy rate of 30% was about half of that observed in the C, +Fe and C-R groups. The peak plasma LH concentration during a synchronised oestrus was found in the +Mo group to be about half of that determined in the other groups. The enhancement of the secretion of LH by the administration of LH RH did not alter the fertility. Likewise the administration of Cu for 8 weeks did not cause the cows to return to normal oestrus behaviour even though the Cu and Mo status returned to normal. These data show that the infertility in cattle associated with 'peat scours' is due to an excess intake of Mo and not to the lowered Cu status of the animal.

DIAGNOSING TRACE ELEMENT DEFICIENCIES

Severe trace element deficiencies are relatively easy to diagnose from tissue, vitamin or mineral concentrations (eg liver B_{12}, blood Se or liver Cu) and are usually associated with specific signs (eg goitre in I deficiency or white muscle in Se deficiency). However, many of the trace element problems encountered are marginal deficiencies and are associated with non specific signs such as poor growth rates, lowered milk production and fertility problems.

To identify the trace element which is limiting animal production it is important that the appropriate samples for the various analyses be collected. The trace element content of the soil has been found to be of very limited value, with the possible exception of Se and Co, for determining the mineral status of the grazing animal as many factors can influence the amounts of trace element taken up by plants and absorbed by animals. In the New Zealand situation soil Se and Co concentrations below 0.5 µg/g and 2 µg/g respectively may indicate a possible Se and Co deficiency in animals, provided that they have grazed the pastures for some time, on a particular soil type (Watkinson 1981; Clark 1983). The mineral content of the plant can be useful because based on a knowledge of dietary trace element allowances, the trace element(s) that could be causing the deficiency as well as any dietary interactions can be identified. For example the influence that herbage Cu has on the Cu metabolism of ruminants can only be assessed if the pasture concentrations of Mo, S, Zn and Fe are also known (Suttle 1983).

The mineral status of the animal is best determined from the concentration of trace elements and vitamin B_{12} as well as the enzyme activities (eg: glutathione peroxidase) associate with the various tissues (eg blood, liver). Production response trials can be used to define marginal trace element deficiencies as well as relating the tissue concentrations of trace elements and vitamin B_{12} to animal performance.

A new approach relating trace element or vitamin tissue concentrations to an expected production response and the probability of an economic response has been proposed for assessing Co deficiency in sheep in New Zealand (Wright et al. 1984). From a large number of trials (20 lambs/group) data on the serum vitamin B_{12} (pmol/L) concentrations from unsupplemented animals and the associated growth responses (g/day) to Co supplementation were plotted (Fig. 1) and a curve relating the liveweight response to serum vitamin B_{12} levels fitted to give the expected response curve. As Co deficient sheep should only be treated if there is a good probability of obtaining an economic response, which is currently 10 g/day, a second curve was then calculated and plotted (Fig. 1) based on the probability of getting an economic response of at least 10 g/d. In this example (Fig. 1) given a mean flock serum vitamin B_{12} level of 250 pmol/L the expected liveweight response would be 12 g/d and the probability of obtaining this response would be 0.65. The presentation of the information on the serum vitamin B_{12} levels in this way allows for a more considered judgement to be made by the farmer in consultation with his veterinarian on whether or not to treat the lambs with Co.

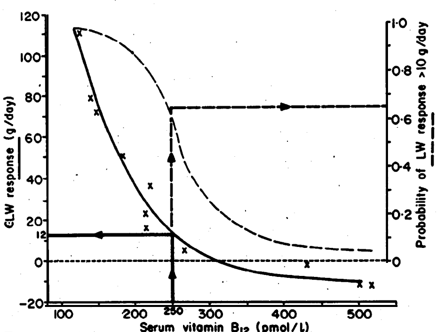

Fig. 1

As more data become available the relationship between the liveweight response and serum vitamin B_{12} levels can be better defined and a database can be built up from future field trials. The same approach could be considered for Se and perhaps Cu.

DISEASE AND COPPER DEFICIENCY

The effect of malnutrition on infection and function of the immune system is well established. An infection results in changes in protein metabolism, basal metabolic rate and distribution of trace elements (Suttle and Jones 1986). These changes reflect the important role that nutrients play in mounting a resistance to the pathogen. Recent reports have implicated Cu in a lowered resistance to disease in young lambs. One study involved 468 lambs born to 4 groups of animals of varying Cu status as assessed from plasma Cu levels. There were 2 lines of sheep genetically selected for low [L] and high [H] concentrations of Cu in the plasma within an interbred Scottish Blackface x Welsh Mountain population as well as unselected Scottish Blackface [B] and Welsh Mountain [W] breeds. The Scottish Blackface have a lower plasma Cu level than the Welsh Mountain (Woolliams et al. 1984; Woolliams et al. 1986). All sheep were grazed on improved hill pasture, divided into early and late lambs with weaning occurring at 12 weeks.

During the first few weeks of lambing a higher mortality was observed in the 'low' Cu breed types (L and B). Within each breed group 1 g cupric oxide needles were given to half the lambs at 4.5 to 7.5 weeks of age. The late lambs also received 0.5 mg Cu by injection 4 weeks prior to being dosed with cupric oxide needles. From birth to 12 weeks of age the lamb mortality was 35%, 22%, 8% and 2% for the B, L, H and W breed groups respectively. Swayback, a nervous disorder, accounted for only 15% of the lambs which died before weaning. The pre-weaning mortality was due to various organisms which include Escherichia coli and Pasteurella haemolytica. Delayed swayback accounted for most of the post-weaning deaths. Treatment with Cu, besides preventing swayback, markedly decreased the incidence of mortality in the pre-weaned lambs as only 5 of the 110 dead lambs had been treated with Cu.

To study the effect of Cu supplementation of pregnant ewes on the mortality of the pre-weaned lamb, half a flock of 299 ewes comprising of B, W, L and H breed types were treated with 4.0 g of cupric oxide needles 8 weeks before the start of lambing (Suttle et al. 1987). The pastures grazed contained on "average 4.2 mg Cu/kg DM, and 3.2 mg Mo/kg DM as well as over 3.5 g S/kg DM. The mortality at 4 weeks of age, expressed'as lamb deaths to total born, was significantly reduced in lambs from the Cu supplemented ewes in the groups which are the most susceptible to Cu deficiency. In the B breed type the lamb-deaths were decreased from 30% to 5% and in the L breed group the decrease was from 29% to 13%. Further, at 6 weeks there was also a significant liveweight response evident in the lambs from the Cu treated ewes.'

It is not understood how Cu deficiency affects the immune system and increases the susceptibility of the lambs to infections. It has been observed, that low blood Cu levels are associated with a reduced microbiocidal activity of the phagocytes in the peripheral blood in sheep and cattle and this was possibly due to a reduction in the intracellular activity of the enzyme superoxide dismutase. As most of the lambs died before 2 weeks of age maternal influences on disease resistance via the colostrum or altered development of the foetal immune system may be important.

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