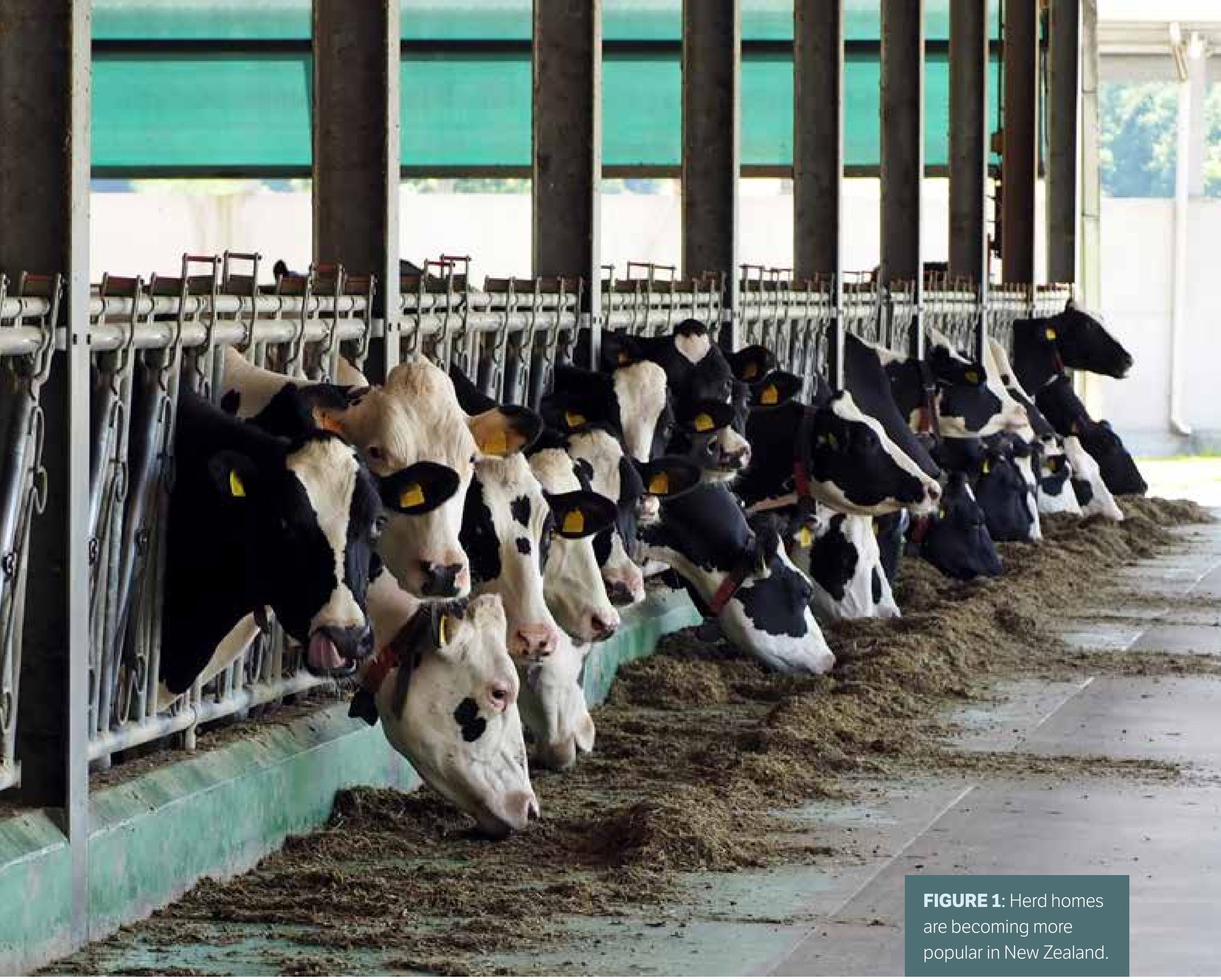

FIGURE 1: Herd homes are becoming more popular in New Zealand.

Trace elements and the bigger picture

Alice Fraser, of IDEXX Laboratories, Palmerston North, and Stefan Smith, of the Farm Animal Division at Massey University's School of Veterinary Science, look at how the changing face of farming may require new trace element studies.

THE FOUR TRACE elements commonly associated with production in farmed livestock are copper (Cu), selenium (Se), cobalt (Co) and iodine (I). These micro-nutrients are recognised as playing vital roles in animal health and performance in the traditional pasture systems across New Zealand that, in the past decade or more, have diversified, ultimately changing the face of farming here. Feeding systems such as forage crops, cut-and-carry, feed lots, total mixed ration (TMR), brewers' grains, the importation of palm kernel expeller (PKE) and zero grazing systems are all relatively new compared to the farming processes that were in motion when the original trace element production trials were undertaken some 40–60 years ago.

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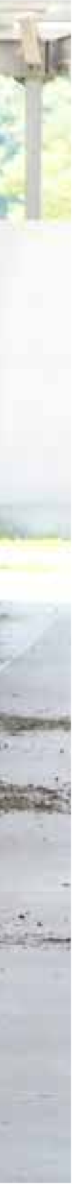

In addition, the genetic advances throughout all the production industries have been staggering. Consider that today's capacity of lamb meat exports is close to what it was 25 years ago, despite the sheep population being effectively halved. Likewise, dairying has seen increased stocking rates and subsequent increased milk solid production per hectare, which have come hand in hand with a marked increase in reliance on the application of nitrogen-based fertilisers for short-term gain, but long-term pain. The latter is now being rectified, and much crop research is going into the use of alternatives such as plantain for dairy cattle, with its 'soil-modifying' properties, including reduction in nitrogen leaching.

All these changes are dynamic, and currently there is much debate among industry advisors on which trace element supplement programme is best for each system. Some of this information is being sourced from overseas, but while it is possibly correct in the source countries, it requires locally produced, peer-reviewed data to back it up. Supplementation programmes are expensive, and the end-user needs to be able to base their monetary decisions on robust information that is evidentially based.

That leads us to ask whether the original trace element studies, while still invaluable, can be applied as accurately to the new systems. Is it time for these trials to be revisited under current conditions?

MONITORING

Trace element monitoring of livestock gives essential farm data and enables the implementation of appropriate supplement programmes, but it should not be limited to the animal. Interactions exist between soil, herbage and livestock tissues; for investigations to be thorough, these interactions need to be considered prior to providing advice on supplementation.

SUPPLEMENTATION PROGRAMMES ARE EXPENSIVE, AND THE END-USER NEEDS TO BE ABLE TO BASE THEIR MONETARY DECISIONS **ON ROBUST INFORMATION THAT IS EVIDENTIALLY BASED**

For example, there are strong interactions between soil pH and Cu. The simple act of adding soil-beneficial lime tends to increase the soil pH. In doing so, it increases the soil negative charge, which in turn increases Cu+2 ion binding to the soil organic matter, subsequently decreasing the Cu uptake by plants and, therefore, intake by animals. Adding lime will also increase the bioavailability of molybdenum (Mo) to plants, increasing animal exposure, resulting in interference with Cu uptake by the formation of reticulo-rumen thiomolybdates. Mo concentrations above 2mg/kg dry matter (DM) herbage are capable of stripping liver Cu stores. Mo is also added in fertiliser supplements to encourage clover species (after overuse of nitrogen has caused depletion by overgrowth of grass species). Awareness of these interactions is important when investigating trace elements, and an understanding of the bigger picture is essential.

COPPER

With autumn beckoning, proactive monitoring of liver Cu stores is key – the optimal data coming from liver biopsies, and some useful data from cull cow livers from processing plants, checking for those optimal liver Cu concentrations of >300μmol/kg (Ellison, 1994). Serum/Plasma Cu or ferroxidase levels provide useful monitoring data, particularly group average figures, but don't give the early depletion indication that liver data does. In ruminants grazed on pasture, a winter decline in liver Cu stores occurs, considered to be associated with several factors, including fetal demand, reduced DM intake and increased soil ingestion.

However, there is little data determining the effects of some of the new farming systems such as supplementary forage crops for cattle (including plantain or lucerne/chicory), or the brassicas, fodder beet or TMR. We know that dairy cows require approximately 120mg Cu per day, and that over-supplementation results in accumulation of this trace element with toxicities recorded. For example, it is now well known that PKE contains higher levels of Cu than pasture, although this was not widely recognised until cases of Cu toxicity occurred following the administration of routine levels of supplementation to cattle, done without awareness of the higher levels of PKE Cu (Hill, 2012). Therefore, knowledge of the total daily Cu intake and group animal monitoring, particularly of liver Cu, are important to prevent over-supplementation. This is particularly so where there is any underlying active liver disease (eg, sporidesmin toxicity), often simultaneously monitored via serum GGT.

Currently, there have been few, if any, bioavailability studies undertaken to identify the rate of accumulation of Cu in the herbage of some of the new plants on different soils, or the bioavailability of Cu to animals once present in this herbage. Without this information, the old data sets from pasture are currently being used to formulate nutrition guidelines for modern-day ruminants, which may now be inappropriate. Undertaking these studies for the different feeding systems in our modern ruminants should be considered at a national level, and may be a wise investment.

UNIQUE GEOGRAPHY PRESENTS CHALLENGES TO FARMING

Some New Zealand soils, often of volcanic origin, are low in trace elements, so pastures are low too. The maps are indicative of deficient regions.

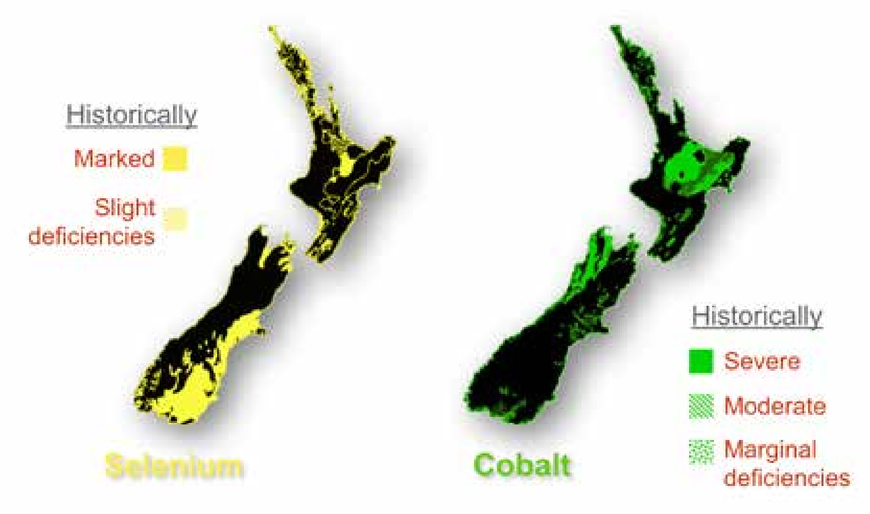

FIGURE 2: Geographical distribution of Se and Co deficiency in New Zealand.

studies undertaken by Grace and Knowles (2002) do not support the higher suggested Se levels from the Northern Hemisphere, with no further production response recorded from the lower level of Se supplementation in pasture-fed animals.

A possible key reason for the difference in the recommended Se supplementation between the Northern and Southern Hemispheres is likely to be related to the high levels of the allied antioxidant, Vitamin E, in fresh herbage compared to stored forages and the traditionally pasture-based livestock diets here in New Zealand. In addition, the usual low level of polyunsaturated fatty acids in dairy cow diets lowers the demand for vitamin E activity. However, as farming practices evolve here, with intensification and the need to relieve the land of persistent grazing and heavy feet in some areas, there will be a gradual increase in

SELENIUM

Se is regarded as the great antioxidant, with its multitude of tissue-protective and robust immune system functions (as part of the selenoenzymes), plus its link with thyroid hormone functions, in which it has an important role to play in maintaining a healthy metabolism and optimal growth rate (Wichtel, 1998). Se deficiency is widespread throughout New Zealand (Figure 2, AgResearch). Serum Se is the routine test used for monitoring livestock Se levels (where intake is potentially variable), and the red blood cell associated enzyme (glutathione peroxidase) tested in EDTA samples is used when Se intake is considered to have been stable (over the lifespan of the red blood cells – or approximately four to five months).

However, it is well known that serum Se levels in ruminants in New Zealand are set significantly lower than those in the Northern Hemisphere. Historical inverse J graphs (Figure 3) established from many New Zealand

RELATIONSHIP BETWEEN BLOOD SE CONCENTRATIONS AND GROWTH RESPONSE IN LAMBS

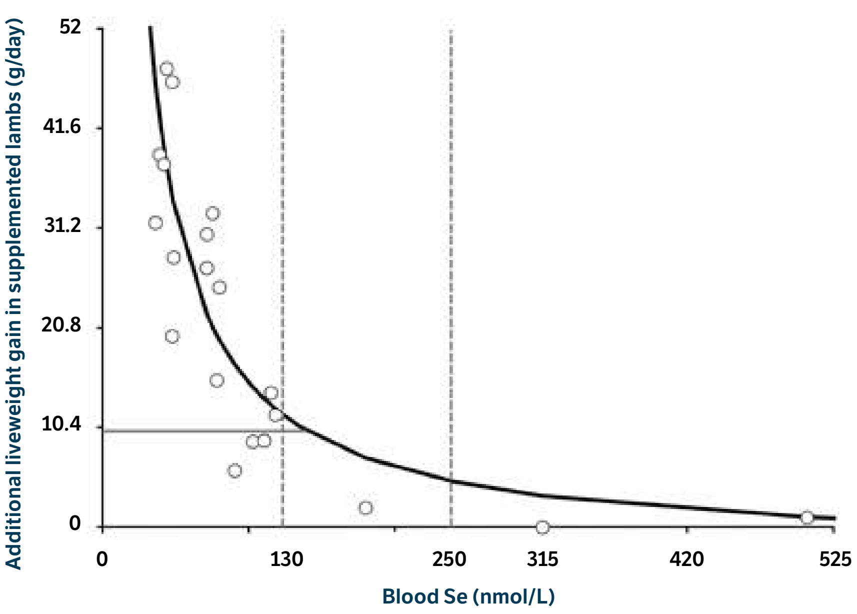

FIGURE 3: J graph, production response to Se supplementation in lambs (Grace and Knowles, 2002).

the dietary proportion of harvested forages and total mixed rations, leading to a potential decrease in vitamin E levels, which could in turn lead to an increased Se requirement. Again, new research is now required to determine any production response from an increase in Se supplementation. As an industry, we should be wary of turning to overseas data, with its own panel of genetic, dietary and environmental variables. If herd homes like that in Figure 1 become more commonplace, this research, as suggested by Laven (2018), is overdue and much needed.

SOIL INTERACTIONS

Se supplementation and assessment is also multifactorial, and interactions between soil, herbage and animals are important factors to consider. Se is not an essential element for plants, but soil conditions affecting reduction/oxidation reactions (REDOX) play a vital role in allowing Se uptake by plants, which in turn determines the success of any pasture supplementation programme. As the soil dries out during spring, oxygen enters the soil pores, allowing selenide to oxidise to Se metal, which in turn oxidises to selenite, and then on to selenate, the form available for plant uptake. Consequently, spring is the optimal time to apply Se fertilisers for optimal animal supplementation.

COBALT

Co is the third trace element of the important four, incorporated into the vitamin B12 molecule (required for glucose metabolism), levels of which are easily measured in livestock serum samples. In ruminants, the vitamin is manufactured by rumen bacteria, hence pre-weaned animals depend on their liver stores and the B12 in milk, and are the most at risk of deficiency.

There is an interaction with soil REDOX and the element manganese (Mn), and a need to assess soil Mn concentrations, along with animal testing for vitamin B12. Again, as soils start to dry during spring, Mn oxidises to manganese oxide (MnO), to which Co is very strongly bound. As the demand from lambs increases as the season progresses into summer, Co disappears onto the MnO, resulting in 'bush sickness', or vitamin B12 deficiency. Preventing this is dependent on the level of Mn in the soil, with cobaltalised fertilisers used successfully on farms low in Mn. On farms with high soil Mn, vitamin B12 supplementation would be more appropriate. Regarding the grazing of livestock on forage crops and new grazing systems mentioned above, the bioavailability of Co from these practices is currently unknown. As a result, the old data sets will continue to be referenced until further research is undertaken, with the inverse J curves determined by Clarke et al (1989) being the best source of data available.

IODINE

Increased use of brassica crops (which are low in I and contain goitrogens) over the winter has influenced the occurrence of goitre caused by I deficiency/thyroid dysfunction in livestock, which in the case of pregnant livestock is most commonly manifested as stillbirths or weak neonates.

Iodine supplementation programmes are routinely instigated well before brassica grazing. Diagnosing an I deficiency/thyroid dysfunction before the onset of clinical effects is problematic owing to a lack of data and difficulties in correlating total serum I with thyroxine levels (T4). The most accurate means of diagnosing fetal iodine dysfunction is via necropsy of stillborn calves/lambs, and identification of thyroid hyperplasia or goitre via thyroid gland weight:body weight (g:kg) or histopathology. Serum T4 levels of dams are affected by factors such as stresses, nutritional factors and reproductive status, and are particularly variable in the post-calving phase, but can be of use in group monitoring for an indication of longer-term assessments during other stages of reproduction. Similarly serum inorganic I may provide some useful group monitoring data.

CONCLUSION

The intention of this article was to highlight and create discussion regarding some of the complex trace element interactions arising as a result of changes in modern farming. When you're on farm harvesting those all-important samples to monitor the livestock trace element status, you may not have time to dig for soil samples. However, some strategic questioning is likely to unearth interesting factors affecting the livestock status, and may help you make sense of the trace element monitoring data and formulate optimal supplementation programmes.

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