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Mineral Advice in Ruminants: Are we getting it right?

Written by:

Dr Annie Williams NSch

June 2025

A NUFFIELD FARMING SCHOLARSHIPS REPORT

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A NUFFIELD FARMING SCHOLARSHIPS REPORT (UK)

NUFFIELD Farming Scholarships

Date of report: June 2025

"Leading positive change in agriculture. Inspiring passion and potential in people."

Title	Mineral Advice in Ruminants – Are we getting it right?
Scholar	Dr Annie Williams
Sponsor	The Richard Lawes Foundation
Objectives of Study Tour	1. To evaluate ruminant nutrition advice on a global scale 2. To assess the complexity of balancing minerals and evaluate how we may improve on- farm advice in the UK 3. To investigate global markets for mineral nutrition, how minerals are sold on farm, and what impacts farmer purchasing decisions 4. To understand who is responsible for "advice" on farm and evaluate how to drive positive change
Countries Visited	UK, Brazil, USA, Canada, Germany, Japan and New Zealand
Messages	For many minerals we have a low level of certainty about animal requirement; this means suggested optimum levels are likely to change over time and we must move with the science and equip ourselves to communicate this effectively. There are lots of on farm variables that alter mineral supplementation requirement. Measurement and diagnostics should be used strategically to provide information that can be used to assess mineral provision, animal response, and alter the plan if required. "I don't know" is a powerful statement! Mineral nutrition is a complex subject, and the science is evolving. There are improvements that can be made on lots of farms, but specialist trained knowledge is often needed to facilitate change and implement the latest science. There are some specific challenges-such as reducing copper supply in dairy diets-where we need to drive change for improved animal performance and health. Understanding some of the barriers to change, and implementing new knowledge exchange strategies could provide solutions.

EXECUTIVE SUMMARY

Optimising mineral nutrition can maximise animal performance, but it is a competitive area of the market, and the advice given is often commercially biased or outdated. The objective of this study was to evaluate mineral nutrition in ruminant production and analyse the advice being communicated by professionals on farms. The countries visited included the UK, Brazil, USA, Canada, Germany, Japan, and New Zealand, where farmers, nutritionists, academics, laboratories, specialist consultants, and veterinarians were consulted.

Textbook values for the mineral requirements of ruminants have not remained static since they were first published. These values have evolved as more studies have been conducted and additional evidence about requirements has become available. Despite this, for many minerals, there remains a low level of certainty regarding animal requirements. Minerals can be categorised into three groups: those for which there is extensive data allowing for a defined "requirement"; those with limited data where only an "adequate intake" can be suggested; and those known to be necessary but lacking sufficient quantitative or experimental evidence, instead showing a physiological "response" to dietary changes. Scientific understanding continues to evolve, and numerous on-farm variables can alter the optimum mineral balance for a particular group of animals. Understanding the level of certainty and the factors that can influence mineral formulation is crucial. The complexity is further increased by the wide range of mineral products available, particularly those claiming improved bioavailability, which require careful scrutiny and appropriate data for precise diet formulation. Mineral nutrition should be tailored to each farm system, as a one-size-fits-all approach rarely optimises outcomes.

Measurement, monitoring, and diagnostics—such as analyses of feed, forage, blood, and liver mineral concentrations—should be strategically employed to provide decision-makers with insight into the current nutritional strategy and any potential improvements. Analyses should be conducted in a timely manner, and data should be presented clearly to aid interpretation and always be evaluated in context.

On-farm advice is difficult to assess, but one of the most important yet challenging insights from many conversations was the significance of the phrase "I don't know." Farmers often reported receiving incorrect or insufficient information and indicated they would have had greater trust in their advisors had uncertainty been acknowledged. Copper continues to be a contentious issue in dairy nutrition, with cases of toxicity persisting in the industry. The "more is better" approach and competitive feed formulations are barriers to progress. Lessons learned from copper management can inform future efforts to align mineral supplementation with evolving scientific insights, ultimately enhancing animal health and performance.

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DISCLAIMER

The opinions expressed in this report are those of the author alone and not necessarily those of the Nuffield Farming Scholarships Trust, of the author's sponsor, or of any other sponsoring body.

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CHAPTER 1: PERSONAL INTRODUCTION

The Author, Annie Williams [Source: Author's Own]

It's been a long standing joke amongst my friends, family and colleagues that I'm a little bit obsessed with mineral nutrition, so I don't think any of them were surprised when they saw the title of my Nuffield study. I have worked in mineral nutrition, both commercially and academically since 2010, completing a PhD in 2020 in mineral bioavailability in dairy cows and sheep. Throughout that time I've been able to work across the world and to problem solve mineral balances on farms throughout the UK and Europe. Working commercially illustrated to me that there were a lot of problems caused on farm by people providing poor or insufficient advice, often based on limited evidence. When I worked academically, this highlighted that a lot of the research being conducted was either not suitable for commercial practise or the knowledge was not transferred effectively to those that could implement it on farm. This led me to my Nuffield topic to try to explore this further, understand whether it was the same issue globally and try to find some solutions.

Cliché as it is, I am not from a farming background and everything I have learnt about farming in the UK has come from the endless list of people who have been willing to give up their time to help me to learn. I found exactly the same thing in every country I explored on my Nuffield travels;people willing to give up their time to discuss a topic I'm passionate about.

Thank you to my sponsor, The Richard Lawes Foundation, for this amazing opportunity.

CHAPTER 2: BACKGROUND TO MY STUDY SUBJECT OF MINERAL ADVICE

Nutrition is one of the key pillars for successful performance and health in ruminants. Within nutrition there are many variables to balance, and minerals- both macro and micro (trace elements) - is one of them. Optimising mineral nutrition can maximise animal performance but is a competitive area of the market and advice given can be commercially biased, or not in line with the latest science.

Minerals are important for all of the body's physiological processes. I often liken them to the oil in a car. Energy and protein are the fuel; f you run out of fuel the effects are immediate. For the majority of minerals the effects are more subtle inefficiencies in the running of the vehicle, but these multiply over time to negatively impact performance of the animal. Mineral deficiencies with an immediate outcome such as milk fever (calcium deficiency) or grass staggers (magnesium deficiency) are also possible but these are usually well understood.

Having undertaken lots of academic research in mineral nutrition and worked commercially in the industry for a number of years I chose this topic because one of the common responses to questions about evaluating mineral supply on farm are; "different sales reps are always trying to sell me more expensive minerals", or "it's too complicated and it hasn't gone wrong yet so we'll just stay as we are" or "we measured 10 years ago and selenium was low so now we always supplement". To an extent, all of these statements are true. There are lots of companies selling minerals into the UK market, mineral nutrition is complex and it can go wrong if not balanced correctly. But I wanted to further explore the opinion of those within the industry to assess some of the barriers to change and analyse the advice being provided.

I wanted to evaluate whether these barriers were the same across the world, or whether there were other countries that were better at giving mineral nutrition advice and what we could learn from them in the UK. I set out to investigate how complex the subject really is, how much uncertainty there is about cow requirement or effects of different mineral sources, and who are the advisers that could drive positive change across the sector? I wanted to drill into the detail of the best advice we can give for mineral nutrition for cattle and sheep in the UK, whether global research is applicable to our systems and how much development there will be on mineral nutrition in the future. What I didn't anticipate was a major interest in the "advice" part of my project title. Understanding how advice is delivered on farm, and how that differs globally has been a fascinating discovery in this project and something that I've dug a little deeper into as I've travelled.

CHAPTER 3: MY STUDY TOUR

The countries I visited on my study tour were the UK, Germany, Brazil, USA , Canada, New Zealand and Japan (Figure 1). Appendix 1 has more details on the countries visited during my study tour.

Figure 1 - Countries visited on my study tour

CHAPTER 4: MINERALS – ARE THE GOALPOSTS MOVING?

"Understanding is not error it is randomness. Science is statements of what is known with different degrees of certainty. Not of what is true and what is not true. We are never sure of anything" Professor Norman St Pierre, June 2024.

4.1 Animal mineral requirements

I think it is important to recognise that scientific development can often be interpreted by those outside the process as a "moving of the goalposts" or a mistake that has now been rectified. Scientific development is progress and an indication of greater understanding. Mineral requirements for ruminants have not remained static but have evolved as further evidence has become available. During my travels this subject was challenging because decision makers are generally looking for a high degree of certainty. The level of certainty we have about mineral nutrition varies depending on the individual mineral and the animal; more data is available for dairy compared to beef.

The Author, Annie Williams attending Amercian Dairy Science Associate Conference in Florida [Source: Authors Own]

I met with Professor Bill Weiss at the American Dairy Science Association (ADSA) meeting in Florida in June 2024. Professor Weiss was responsible for the mineral chapter in the new NASEM (National Academies of Sciences, Engineering, and Medicine; previously National Research Council) requirements for dairy cows which was published in 2021. The new NASEM has altered some mineral values compared to previous publication to make them more biologically correct. The authors only produced a requirement for calcium, phosphorus, magnesium, sodium, chloride, sulfur, copper and zinc. For most other minerals and vitamins adequate intake figures were stated, because certainty and evidence was insufficient to state a requirement. For some dietary factors, there is not enough data to state a requirement or adequate intake, but we know that cows do respond when they are added to the diet.

Requirement*	Confidence in the data that there is adequate evidence to produce a number that will meet the needs of 50% of the population
Adequate Intake	You need to feed the mineral, but there is a lower level of confidence, less data available and therefore an absolute number for requirement cannot be produced.
Response	Minerals that are required, but we don't know how much is required. Response is normally a production response.

* Note: if this number is used, 50% of animals will not receive enough mineral – there is no safety factor. If formulating you should add a safety factor of 20%. Requirement also assumes that animals are already of adequate mineral status.

Examples of response:

Amy Stoner, NSch 2024, Annie Williams (the author) and Mr Mega, Wagyu Farm Owner on farm in Japan [Source: Authors Own]

Case Study: Japan; response to Vitamin A

I visited Mr Mega, a Kobe beef breeder in Japan. On his farm they alter vitamin A concentration in the diet to increase fat marbling in intramuscular fat by hyperplasia. An example of cattle responding to vitamin concentration in the diet.

Case Study: USA; response to Chromium

At Cornell Nutrition Conference, October 2024, Professor Stephanie Hansen of Iowa State University demonstrated that supplementation with chromium in the transition period increased milk yield during lactation, enhanced insulin senstitivity and reduced lipolysis.

Beef and sheep requirements haven't been updated since 2016 and 2007 respectively. There is less published research on mineral nutrition for beef and sheep compared to dairy, but I would suggest we do have a greater understanding of mineral absorption and metabolism which may alter these values. Professor Weiss suggested that research may have stagnated because of the expense of conducting trials that truly identify how a mineral is absorbed. In

order to accelerate our understanding of mineral nutrition further we need to undertake this type of research.

This report is not designed to produce numerical values that can be used for diet formulation, but rather to highlight the science and complexity involved in optimising mineral balance, identify areas and variables that are poorly understood and promote discussion about the advice being given on farm.

4.2 Are requirements changing?

Travelling from California to New Zealand highlighted the difference in cattle genetics across these two contrasting production systems. In California they are mainly using Holsteins to produce high volumes of milk, focused on butterfat production from high concentrate diets. In New Zealand solids are also the focus, but from predominantly grazing cows. In both of these systems genetics are accelerating to aid production and produce robust cows but it's unlikely that these cows have exactly the same mineral requirements. At the High Input Dairy conference hosted by AgriSearch in Northern Ireland the acceleration of genetics compared to our understanding of nutritional requirements of those animals was highlighted.

At the ADSA meeting in Florida in June 2024, Professor Norman St Pierre discussed the differences in optimising a system opposed to maximising the system. He demonstrated this by showing that when milk price is low it may be advantageous to reduce milk yield but improve income over feed cost even though the cow is capable of higher production. The same principle applies to minerals. Calculated requirements are a human concept based on averages. Some cows in the population will respond positively when fed at levels above the calculated requirement. The response to what we feed, the value of the output from that response, and the cost of additional nutrient all affect how we formulate and this may be different depending on farming system and context.

It was actually when stepping away from cattle and sheep that I gained a greater understanding of this. Examining dairy goat production and equine nutrition in New Zealand really shone a light on ensuring the diet is appropriate to the way the animal has evolved and any breeding we have done to alter those genetics. Horses are often kept in systems and fed diets that are not optimised to the animal and therefore do not produce the best outcome. When formulating for ruminants we need to ensure we are following the latest science but also that the mineral plan is suitable and practical for the farming system.

Dairy goats in New Zealand [Source: Authors Own]

4.3 Factors affecting mineral requirement

Production systems

The animals demand for mineral is not only dependent on breeding and performance but also the type of production system it is in. Production systems change the demand for mineral because they can alter biological processes within the animal and also the antagonists in the diet. Antagonists are components of the diet that interfere with the absorption and metabolism of other minerals in the diet. Particularly in grazing or high forage systems assessment of antagonists should be a critical part of mineral audits.

Author, Annie Williams, on Rachel Baker's NSch 2024 farm, North Island New Zealand [Source: Authors Own]

The seasonal nature of production systems can also impact mineral requirement. For example, New Zealand is particularly focused on spring block calving systems and utilising a lot of pasture in the diet. During breeding cows may have a higher demand for minerals to enhance fertility. When I was in New Zealand it was apparent that it was relatively common practise to check, and optimise if necessary, the cows mineral status around mating and often around dry off. In pasture based systems seasonal fluctuation in mineral levels within the forage are also more likely and depend on a variety of factors, such as soil type, soil pH, weather, stage of growth in the season. These variables are impossible to fully control but by understanding them we can have the knowledge to predict when mineral imbalances may be a problem.

Youngstock

Ruminants have evolved to transfer minerals through the placenta or milk to their offspring. Young ruminants have a digestive system closer to a monogastric, which dramatically increases the absorption of many minerals from the diet compared to adults. Throughout my travels there were big differences in the approach to supplementation of youngstock with practises varying from no mineral provision to *ad libitum* access to loose mineral. More focus is needed on improving our understanding of mineral absorption and metabolism in young ruminants to aid mineral formulation. But we also need a greater understanding of diagnostics for youngstock to determine whether they are of optimum mineral status.

Case Study: Germany

A mineral insufficiency was identified in calves born on a dairy farm. When this was rectified by alterations to mineral in the dry cow diet, calf growth rates improved by 50%.

Diverse swards

Many of the farmers that I spoke to on pasture based systems were interested in diverse swards. For minerals specifically, I think these offer some resilience in systems. Plants within diverse swards have different rooting depths and absorption of minerals within the soil. This is likely to mean that diverse swards provide a wider range of minerals than for example a monoculture of ryegrass. However, this could have both positive and negative effects. Diverse swards are likely to be able to enhance the intake of minerals that have a positive effect on animal health, but also could increase those that are antagonistic to these minerals.

Case Study: New Zealand

Mark Anderson a dairy farmer using a regenerative approach that includes diverse swards, commented that this has increased the phosphorus, potassium and calcium in the forage.

Mark Anderson soil sampling, South Island New Zealand [Source: Authors Own]

4.4 Mineral bioavailability

Bioavailability = The efficiency with which a natural or manufactured source of an element delivers the element to storage or supplies it to metabolically active tissue (Wapnir, 1998).

Mineral bioavailability is an increasingly discussed topic, especially as new products enter the market. Theoretically if bioavailability of a mineral source is increased, the amount supplied in the diet can be reduced. I think it's important that we understand the mechanism by which bioavailability is improved, alongside understanding the function of the mineral in the body. Nutritionists around the world all agreed that companies need to supply data on bioavailability in order for them to formulate the best possible diet and equations calculating mineral supply need to be evaluated within the context of the availability of the mineral to the animal.

A detailed review of mineral supplements is outside the context of this report, but the scientific evidence for supplements should be considered. Legislation varies between countries, particularly for sustained release products. I think the claims, advice and regulation on these products needs further consideration in the UK.

CHAPTER 5: MINERALS – MEASUREMENT, MONITORING AND DIAGNOSTICS

"We've just got our liver biopsy results back. Do you want to see the results? How do you know you're getting it right, it you don't measure?" Farmer, New Zealand, January 2025

5.1 Measurement of minerals

Measuring of minerals can be split into monitoring or diagnostics. Options for measuring are to measure the animal themselves through bloods and livers, measure the diet they consume or measure the soil that feeds the plant. There are pros and cons of all of these methods and the measurement needs to provide valuable information to change diet decisions on farm in order to be useful.

5.2 Feed and Forage

Measuring feed and forage for mineral concentration can be used to calculated the amount of supplementary mineral that should be added to the diet, and highlight any possible excesses in the diet. In the USA, Professor Bill Weiss provided some critical points for feed sampling to obtain accurate analysis, and ensure that the results can be used to recognise change in the composition of the diet:

1. Whatever you do, do it at least twice, independently each time. This means taking more than one sample and analysing it separately, not mixing samples.
2. If feed has obvious visual variation (such as TMR) you need to take more samples.
3. Labs should report analytical variation. This helps us to understand whether a feed has truly changed in its composition.
4. Book values can be better if farm variation is small.

Visual representation of data is important to a person's understanding of data. I often find some of the UK analysis confusing and difficult to interpret. Data is only useful if it can be turned into information that can be used on farm. In New Zealand, I was shown a mineral analysis from Eurofins Laboratory, in collaboration with Agvance Nutrition, which showed the values for minerals and how they translated to meet plant and animal requirement. The data clearly showed the areas in which there was potential shortfall for the animal, and therefore clearly

provided information for diet formulation. This type of analysis could be a critical step forward in farmers, agronomists, nutritionists and vets working together holistically to generate the best outcomes for the system through discussion of the requirements of the plants and animals within it. Timelines for decision making were also a critical point of conversation. New Zealand mainly operates a tight spring block calving system with a few critical timepoints in the year where data is required for rapid decision making. Even in those very busy times the labs are providing analysis within 24 hours of submission. This is critical for turning data into information that can be used to alter plans on the farm, and change nutritional planning, for example increasing or decreasing mineral supplementation.

FEED QUALITY		Units	Results	ⓘPlant Range	ⓘPlant Nutrition Desired	ⓘDairy Cows	ⓘAnimal Nutrition Desired
ⓘ NU123	Dry Matter (DM)	g/kg	189	180~240			
ⓘ NUD88	Crude Protein (CP)	g/kg dm	167	140~220			
ⓘ NUD90	Crude Ash	g/kg dm	83	70~110			
ⓘ NUE56	Organic Matter (OM)	g/kg dm	917	880~920			
FIBRE / CARBOHYDRATES							
ⓘ NUD83	Neutral Detergent Fibre (NDF)	g/kg dm	461	410~520			
DIGESTIBILITY / ENERGY							
ⓘ NUE50	Metabolisable Energy (ME)	MJ/kg dm	12.2	9.5~11			
ⓘ NUD76	Digestibility (DOMD, gOM/kg DM)	g/kg dm	761	609~917			
MACRO ELEMENTS							
ⓘ NUD46	Nitrogen	%	2.7	4.5~5.5			
NU268	Phosphorus	%	0.42	0.35~0.4		0.24~0.4	
NU279	Potassium	%	2.42	2.5~3		0.6~1.2	
NU341	Sulfur	%	0.31	0.28~0.4		0.18~0.4	
NU056	Calcium	%	0.58	0.25~0.5		0.4~0.8	
NU187	Magnesium	%	0.19	0.16~0.22		0.19~0.25	
NU324	Sodium	%	0.28			0.12~0.3	
ⓘ NUD75	Chloride	%	1.51				
ⓘ NU117	Dietary Cation-Anion Difference (DCAD)	meq/kg dm	154				
TRACE ELEMENTS							
NU196	Manganese	mg/kg	127	25~30		25~40	
NU108	Copper	mg/kg	5	6~7		7~20	
NU046	Boron	mg/kg	8	6~15			
NU394	Zinc	mg/kg	20	20~50		20~40	
NU168	Iron	mg/kg	172	50~60		10~200	
ⓘ NU097	Cobalt	mg/kg	0.17			0.04~0.2	
ⓘ NU232	Molybdenum	mg/kg	1.37			0.05~1	
ⓘ NU294	Selenium	mg/kg	0.08			0.03~0.3	
ⓘ NU350	Titanium	mg/kg	16				

Figure 2 - Eurofins and Agvance Nutrition analytical report for grass; showing plant and animal nutrition desired

Pierre De Villiers, Nutritionist using NIR for forage analysis Zealand [Source: Authors Own]

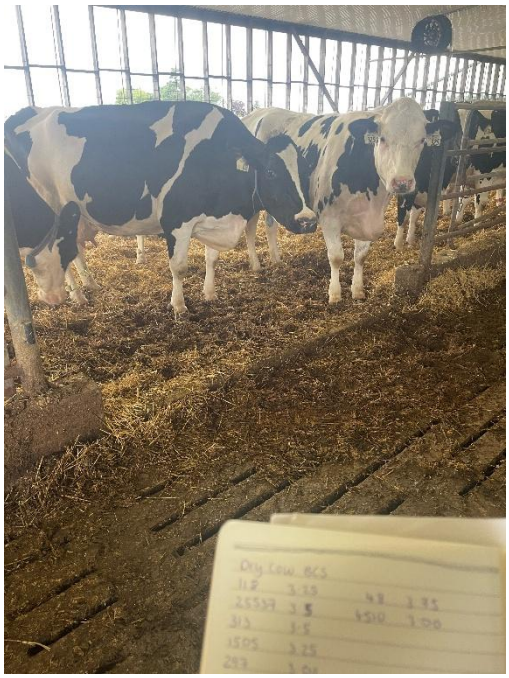
5.3 Bloods and Livers

Diagnostics are more useful for referring to tests that are run on the animal to identify a deficiency, toxicity or under supply that may be causing issues within an individual or group of animals. Diagnostics are often followed up with an intervention, but there were definite differences in the countries that I travelled as to whether they were followed up with monitoring.

Monitoring can be used to build a picture of mineral status within a particular group of animals, on an individual farm, or within a region. In New Zealand monitoring of blood trace elements and macro minerals and liver trace elements at critical points in the production cycle is commonplace. Although it was

frequently commented that once you have a picture over 4/5 years of monitoring it often doesn't change very much. And there were a number of farmers that said their monitoring didn't change any management practices on the farm.

Know what you're measuring and why you're measuring it. Is it for diagnostic purposes or as part of a monitoring programme that needs mapping out? Ruminants on a full TMR diet where the inputs in the diet are known don't need an extensive monitoring programme. Ruminants in grazing or more extensive systems where inputs are variable, likely require a monitoring programme to assess mineral status and adjust as appropriate for optimum animal performance.



Body condition scoring cows in Canada, with nutritionist Havie Carter [Source: Authors Own]

Globally, there are differences in the reference ranges used to report results from blood and liver mineral testing in cattle and sheep. Most of the reference ranges that we use were developed many years ago and may not always be appropriate on modern farms. We must assess diagnostics in line with the context of the animals we are testing and not just act on them as a single value.

5.4 Bulk Milk Analysis

In New Zealand some nutritionists are using bulk milk analysis for selenium to measure the efficacy of supplemented selenium in the diet and make alterations where required. This is similar to some work that has been undertaken in the Netherlands to develop a system in which milk can be used to inform animal status for some minerals and provide information that leads to dietary change. In Ireland and Japan milk mineral testing also happens, for example for iodine, for milk entering the export market. This is a market access requirement as opposed to something that is used to provide data on farm, but the use of milk mineral concentration for minerals that are transported in milk is a developing area with further research likely happening over the next few years.

CHAPTER 6: ADVICE – WHO'S GIVING IT AND WHO'S GOOD AT IT? A GLOBAL COMPARISON.

"Good advice is all about tailoring it to the audience you're talking to. It might seem boring to you, but to create change you've got to keep at it giving the same advice over and over again" Academic, USA, June 2024

6.1 Country Comparison

I set out to investigate the on farm advice being given on mineral nutrition. Having worked in the UK for many years I knew there were some negative perceptions on the advice being given, with many feeling they are being oversold, or the person advising does not have enough knowledge to make good evidence based decisions. The area of diagnostics is also challenging, and I have definitely seen poor advice acted upon from poor interpretation of diagnostic information. I asked some people in the UK what their thoughts were on mineral advice;

"Sales people present everything as fact and you're constantly trying to figure out the truth. They'll never say 'I don't know' they just make something up" Farmer, UK, March 2024

"Lots of people selling feed do not understand mineral balance" Anonymous, UK October 2024

"*Commercial interest will always win over sound technical advice" Anonymous, UK, March 2025*

I wanted to understand if this was similar globally or if there were countries where the perception of on farm mineral advice was more positive. In New Zealand there were two prominent groups of people providing advice on farm; the vet and the consultant. A vet in New Zealand commented that the farmers most trusted advisor is their consultant, and they get most of their advice from discussion groups. Talking to farmers, a lot of the feedback about mineral advice was similar to the UK, with the feeling that minerals were often sold through fear that if you do not provide enough mineral production and animal health will suffer, rather than a thorough analysis of the mineral needs of the animals on that particular farm.

This was in contrast to the USA and Canada where there were a greater number of specialists for minerals and nutritionists were the primary advisor. Feedback in the USA and Canada was different;

"It's the nutritionist's job to get the diet right, it's our job to present it to the cow correctly" Farmer, Wisconsin, June 2024

"I pay my nutritionist to do a job, I trust them to formulate the best option for my cows" Farmer, Canada, July 2024

In general, feedback from farmers was more positive with a greater trust in the advisor not just selling product. Farmers actually wanted advisors to be a little bolder about taking up the latest science and innovation.

"Nutritionists are not brave enough with the latest science" Farmer, California, January 2025

Farmers in Japan and Brazil were asking for more input and advice on farm. They felt they were having to make a lot of decisions themselves and would have valued some input from people with more knowledge.

Discussing feeding advice on a Japanese dairy farm [Source: Authors Own]

6.2 The power of "I don't know"

There are numerous articles on on the power of saying "I don't know", highlighting that it simultaneously presents intellectual curiosity and humility and can build trust in the person asking the question.

Huw McConoghie explaining the latest science on cattle lameness at Zinpro First Step Conference, Germany [Source: Authors Own]

From my conversations on mineral advice around the world I really wanted to highlight to those in the industry that we shouldn't be afraid of "staying in our lane". Say "I don't know" when posed with a question you're not sure about. In the UK I think many advisors and vets working on farm are guilty of feeling under pressure to know everything. But that is impossible; mineral nutrition is complex, it's developing, and there are hundreds of products on the market. Sometimes specialist knowledge is required to give the best advice. This could apply to many areas of advice on farm not just minerals.

Science is always progressing and developing, that is what makes it so exciting! This can be a complex message to convey. Humans by nature are cautious of change. As indicated in Chapter 4, knowledge of minerals is still developing, there

are some minerals where our confidence and evidence for the numbers we use to formulate is relatively low. This means this is likely to evolve and develop over time. We must follow the science as evidence develops to allow ruminants to perform at their maximum potential and when giving advice we must be confident in explaining why the philosophy has changed. This doesn't mean the number was wrong initially; it was just suggested on the basis of evidence available at the time, which has now developed.

However, we must be careful to scrutinise the evidence and not afraid to challenge in order to ensure evidence based science continues to improve our understanding and evolve our recommendations. For example, it was widely accepted that phosphorus is strongly linked to cattle fertility, and while this statement is not completely flawed, the science was extrapolated beyond the context of the evidence available. Phosphorus does limit fertility if the animal is deficient, but if the animal already has sufficient phosphorus extra will not improve fertility any further. In the UK as in other countries we are on a journey to reduce phosphorus inputs into dairy cow diets. Other countries such as USA and the Netherlands have been more successful at reducing phosphorus in dairy diets at a faster rate, but this is primarily through legislation. Legislation is one way of driving rapid change, but I also saw examples of changemakers that were delivering without legislation. Copper in the USA was a strong example of this (Chapter 7).

CHAPTER 7: THE DAIRY COW COPPER DISCUSSION

"People are unwilling to adjust due to a lack of confidence in their own understanding and therefore being unable to justify when challenged"
Anonymous, August 2024

7.1 Copper in dairy cows

The copper discussion has been rumbling for my whole career so I think it's interesting to try and understand whether we have seen significant change and if not why not?

Copper is a mineral required for many of the body's biological processes. It can cause problems if not provided in sufficient amounts in the diet or if provided in excess. This is complicated by potential antagonism from other minerals in the diet. There are many scientific reports on excessive copper supplementation and high liver copper concentration and we still see significant cases of copper toxicity in the UK, including animal death. In discussion, most farmers and nutritionists are more concerned with the implications of copper deficiency than copper excess. Opposed to researchers where there are growing concerns about copper excess in dairy cows and the effects this has on their performance and health. This is further clouded by the number of copper supplements on the market, particularly those which aim to provide a higher bioavailability. In New Zealand there were similar concerns about copper toxicity. During a visit to Awanui Scientific they commented that they report some very high liver copper concentrations, particularly for cows fed with palm kernel as a proportion of the diet. Excess copper reduces dry matter intake, milk yield, growth rates and fertility.

7.2 Why do we get copper excess in dairy cows?

Reasons identified for high liver copper concentrations in dairy cows, in no particular order:

- Supplementation of multiple sources of copper into the diet.
- Copper supply (particularly in TMR) in the diet in excess of requirement.
- High levels of copper in compound feed, formulating to legal maximum, rather than animal requirement.
- Calves born with high concentration of copper in the liver, from cows with excessive liver copper concentration.
- Excessive provision of copper through milk replacer and compound feed to youngstock – this is theoretical, there is ongoing research in this area.

7.3 How do we create change across the industry?

During my travels I had a number of conversations about copper provision in diets. One of the areas that was highlighted in the UK was a narrative that “more is better” (this narrative exists for many minerals) and a fear that if feed companies and nutritionists reduce copper in diets when feed tickets are compared they may be out-competed by those who have a higher copper content. This highlighted the need for strong knowledge transfer about nutrition, understanding that the aim is to balance and optimise, not over supply and to highlight the implications of copper excess.

The author visiting Trouw Nutrition GB, from left to right Isabelle England, Annie Williams, Nacia Bonnick and Laura Tennant [Source: Authors Own]

An example I discussed in detail is Trouw Nutrition’s Responsible Mineral Strategy. This strategy aims to address mineral imbalances and advise against over supplementation. I think this is a powerful message from a company that is reliant on selling minerals not advice, and highlights how strong the scientific evidence is in this area.

While travelling in the USA I asked a number of academics and nutritionists how they had reduced copper supplementation in dairy cow diets. The academics were clear that it was due to consistently communicating and displaying the same messages and showing evidence of improved animal performance. A number of academics highlighted that they had been delivering the same messages for around 20 years, and had managed to drive change. They expressed that audiences often need to hear the same messaging repeated several times in different formats to be confident in making a change.

The author visiting dairy farms in the USA [Source: Authors Own]

In the UK copper in dairy diets still needs reduction to improve animal health and performance. In order to drive change we must calculate the economic benefits of achieving better copper balance, this was critical to the success of copper reduction in the USA. I will be working on this message, alongside many others in the industry, to try and drive change in this area. Copper is used as an example here, I have no doubt that as cows and research evolves there will be other minerals where the messaging will change. Hopefully, we can use what we have learnt about uptake of new research and adoption of research for copper to implement actions plans for other minerals as knowledge evolves.

CHAPTER 8: RECOMMENDATIONS

A one-size fits all approach is often desirable but is unlikely to optimise all systems. Cows are changing, and optimum mineral nutrition is likely to change over time; there are many variables that effect optimisation on farm. Individual systems should be assessed to create a mineral programme on the farm that is beneficial for animal production, cost effective and aligned with practicality. Excessive supplementation should also be avoided for the benefits listed previously, but also to reduce excretion of minerals into the environment. This philosophy also applies to small ruminants, but there is less available evidence helping us to design diets for maximum productivity. More research is required.

8.1 Recommendations for farmers

There is so much conflicting information in the advice given about mineral balance but if a product sounds too good to be true, it probably is! Minerals are important for animal physiology, and important for performance, but they will not fix problems caused by other factors. For example, biotin will not fix lameness if it is caused by an abrasive turn on exit from the milking parlour.

- Assess whether the diet meets the requirements of your animals.
- Include every input if you are doing a mineral audit. Don't forget mineral supplements such as blocks and licks.
- Choose the best possible supplementation method that is practical for your system. For example, in feed often gives us the greatest control and widest choice of products to use, but if the animals are grazing only then a suitable alternative is necessary.
- Consider how you will measure success.
- Speak to your vet or a consultant about measuring and managing mineral status and if required seek specialist advice.

Considerations for grazing animals!

Products in this category (boluses/drenches) are often unregulated, with regard to proof of efficacy.

Do your research and ask the manufacturer for data that illustrates product efficacy before you administer. Any reputable supplier should be able to provide this.

8.2 Recommendations for nutritionists and consultants

The UK has so many diverse farming systems which can make application of research complicated. Some research may only translate well into fully housed, total mixed ration dairy herds, whereas other research may be better applied to sheep grazing the uplands. These animals clearly have extremely different demands but so does a dairy cow yielding 7,000 litres compared to 14,000 litres.

Consider;

- How certain am I about requirement?
- Do I have accurate data for mineral concentration of the diet?
- Is there anything different about these animals that may change their requirement or response?
- How am I going to measure if my plan is effective?
- Is the supplementation plan that I'm suggesting practical on farm and fitting with the philosophy of the decision maker?

8.3 Recommendations for vets

There is so much to be gained from better measurement of minerals, particularly trace elements, on farm. Measuring allows you to understand how the animals are responding to the diet and then the diet to be altered to improve animal health and performance. Mineral diagnostics can be challenging to interpret as reference ranges vary throughout the world. It's important that the results are put into farm context and that we understand whether the variable measured is a result of long term or short term mineral status. Diagnostics are evolving and over the next few years it is likely we will see more tests available which should aid our decision-making , but could also add confusion if not interpreted correctly.

Work with the nutritionist and farmer to measure, change, and monitor. Collaboration using everyone's knowledge and experience will drive the best outcome for the animal and their performance.

Don't be afraid to say "I don't know", mineral nutrition is complex and taking time to assess the evidence or seek further advice is better than communicating incorrect information.

CHAPTER 9: AFTER MY STUDY TOUR

My study tour was an amazing opportunity to travel to countries I have never experienced before and to step away from the day-to-day to focus on learning and exploring. It has certainly given me confidence to think bigger in terms of my own career and to aim to provide leadership to the sector. Observing science in other countries also highlighted to me that in the UK we need to work even harder to implement scientific research into commercial practise and tighten the relationship between academics, industry, and farmers. Networking and collaboration is something I believe is a powerful tool and I intend to be part of the solution to help drive these valuable collaborations.

Alongside my day job, which I thoroughly enjoy, I continue to build my global mineral consultancy business, which helps farmers, vets, and nutritionists with some of the actions highlighted in this report. I will also work on finding solutions to the issues discussed in this report, such as reducing copper in dairy cows, increasing our understanding of mineral requirement particularly in youngstock, implementing mineral measurement that provides an effective mechanism for action on farm, and training the industry on the latest research on mineral nutrition.

Science is always evolving and new evidence developing; after my study tour I strive to continue to learn and develop and also continue to travel to other countries to learn from their scientists and farmers.

CHAPTER 10: ACKNOWLEDGEMENT AND THANKS

My scholarship was sponsored by The Richard Lawes Foundation, thank you so much for the amazing opportunity and support they have given me, especially to Bobby Lawes, in allowing me to complete my Nuffield Farming Scholarship.

Completing a scholarship with a significant travel schedule alongside a demanding work life while living on my own and looking after Ida (labrador) and Fred and Jack (horses) was never going to be easy. I am so grateful to all of my friends (especially Steph, Emily and Bethan) who always find a way to support and take on the significant burden of looking after my animals. They have house, dog and horse sat for no less than 20 weeks over the last two years and I could not have done it without them. I would also like to thank other friends, family and colleagues for allowing me to talk about minerals even more than I usually do!

A big thank you to my Nuffield mentor, Owen Atkinson (2010 NSch) for his support and commitment to mentoring throughout my scholarship.

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APPENDICES

Appendix 1 – Countries visited on Nuffield study tour

Country	Comments
UK, March 2024 – May 2025	Speaking to stakeholders across the supply chain to understand strengths and weaknesses for mineral advice across the UK in order to compare to the countries that I visited on my study tour. Attended British Society of Animal Science Conference.
Germany, June 2024	Invited to attend Zinpro First Step Conference, discussing lameness and transition management in relation to mineral nutrition.
Brazil, March 2024	Nuffield Contemporary Scholars Conference, followed by farm visits in Matto Grosso, gaining a better understanding of nutrition on farm for beef and dairy.
USA, June 2024, October 2024 and January 2025	The majority of the data that we use to estimate dairy cow mineral requirement is from USA. I wanted to travel here to understand whether using this data is appropriate for diet formulation of minerals in the UK. I also wanted to compare their fully housed, full total mixed ration (TMR) systems with those in the UK and understand the influences on buying decisions for mineral supplementation on farm. Spent time visiting farms with nutritionists, discussing with farmers and visiting key stakeholders in the supply chain, such as feed companies. Attended American Dairy Science Association Conference, Florida and Cornell Nutrition Conference New York
Canada, June 2024	Canada operate a quota system for milk, and I wanted to gain a greater understanding of how this effects the decisions that are made on farm and the type of advice that is provided. Spent time visiting farms with nutritionists and discussing with farmers.
New Zealand, January 2025	The reason I travelled to New Zealand was to understand more about pasture-based systems, how much minerals fluctuate within those systems and how we manage that with supplementation. A major objective was to understand the use of diagnostics and how involved vets are with interpretation of mineral testing and nutritional advice on farm.

	New Zealand is also unique with a disease called facial eczema. Facial eczema is prevented by using high doses of zinc to bind the toxin. This zinc is not for nutritional reasons but I was still interested to learn whether it changed the perception on supplementation of minerals more widely.
Japan, March 2025	My u wanted to understand how cattle were fed in a system that I had very little knowledge of. Visited a variety of dairy farms and Wagyu breeding, growing and finishing units.

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