Research project: Assessing Mineral Deficiency of Crossbred Cows & Minerals in the Natural Feed (Pasture & Fodder) to Improve Fertility in Northern Province and North Western Province, Sri Lanka

Report -Full Version Final

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Executive Summary

Trace element disorders are a well-known cause of production problems for the dairy industry. However, as Suttle indicates, (1) *they carry more than their fair share of blame for poor cattle performance. They are the* ***least probable explanation*** *of any production or fertility issue.*
The requirements for dairy cattle in the tropics in small holder farmers are extrapolated from the very different intensive dairy farms in temperate regions.

Given these caveats, this project has shown that the crossbreed cows sampled in the four areas were all deficient in Cobalt and in Iodine.
Additional dietary supplements of Cobalt and Iodine would be beneficial.
The most beneficial for fertility and production is likely to be Cobalt supplementation.
Cobalt is synthesized into Vitamin B12 (also known as Cobalamin) by the rumen microflora. Vitamin B12 is an essential vitamin for the metabolism of fatty acids and proteins. It is also required for DNA synthesis. Deficiency impairs metabolism, reduces appetite and production. It may lead to anemia. It is possible to measure levels of Vitamin B12 directly.
Milk is an important source for Vitamin B12 in humans.

Iodine is required to produce thyroid hormones. Deficiency leads to reduced appetite and growth rates, decreased milk production and goitre in young animals. It can cause stillbirth and perinatal mortality.
Milk is an important source of Iodine for human nutrition.

The levels of Copper were adequate in the cows, but the low levels of Molybdenum mean that any additional dietary copper may be easily absorbed and may cause problems. The level of copper was generally low in the fodders, but adequate in the cows showing that the copper available is easily absorbed.

The levels of Selenium were adequate to high.

The mineral levels in the feeds were variable with no specific differences between the regions. Paddy/rice derived by-products were generally low in minerals.

The mineral levels in the commercial supplements were variable from batch to batch. The one supplement where the stated levels were recorded for the project (Super Mineral Mix) had poor correlation with one of the two samples taken.

Further studies on the data from this project will look at the levels of protein and energy in the diets.

Recommendations

1. Supplementation of Cobalt and Iodine to dairy cows.
2. If possible, this supplementation should be done as a pilot with the monitoring of Cobalt, Vitamin B12 and Iodine levels and fertility parameters. The only specific diagnosis of mineral responsive disorders is to confirm that there is a response to supplementation.
3. A recommendation to dairy feed manufacturers to include Cobalt in their feeds.
4. The situation is likely to be similar in goats and sheep, hence a study to measure the mineral levels in sheep and goats would be beneficial.
5. Monitoring of stated levels in commercial mineral supplements and publishing the results so that advisors are aware of the levels in different products.
6. Caution should be used in advising the use of general-purpose minerals with high copper levels because copper may be easily absorbed due to low Molybdenum levels.
7. Funding should be sought to look for funding in to a “One Health” project looking at the effect of supplementation of cows with Cobalt and Iodine on the health, Vitamin B12 and Iodine levels in the cattle and the small holder farmers.

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Introduction

Following a successful exploratory *Train the Trainer* trip to Sri Lanka with YGro to train Dairy Extension Workers, there was a request to look at other projects. (2) This project is the next step in helping smallholder dairy farmers to increase production and provide an increased income for the farmer and their family.

During their civil war, which ended in 2009, northern Sri Lanka lost approximately 50-60% of its dairy cattle. Climate change is affecting the rainfall and the sustainability of rice farming on paddy fields. As a result, it is now government policy that a move is made toward dairy farming.

Sri Lanka currently imports 60% of the milk they consume as dried milk powder (3).
To promote self-sufficiency as a country, the various governmental, non-governmental and private sector organizations in Sri Lanka have offered financial support to encourage dairy farming. The DAPH subsidies AI, vaccinations and certain feed ingredients for dairy cattle. However, one factor limiting the progression of the dairy industry is poor fertility.

There is some anecdotal evidence to suggest that mineral deficiencies are present because, when given supplementation, fertility has improved. Nevertheless, it is possible that mineral supplementation has coincided with cows returning to energy balance post-calving. There has been no published information on the mineral status of dairy cows in Sri Lanka.

Fertility is a major driver of dairy production. Cows produce milk after calving and production peaks 2-3 months after calving. It then declines over the course of the lactation. The time between a calf being born and the next calving is the calving interval. The accepted standard is to have an average calving interval as 365 days.

The main economic impact of increased calving interval is on milk production. Firstly, increased calving interval means that the average production per cow per day will be reduced, as cows spend proportionally more time in late lactation when yields are lower; and, secondly, during late lactation the margin between milk income and feed costs is lower and thus the profit margin per litre is decreased. Hence, poor fertility means that cows spend longer producing lower amounts of less efficiently produced milk. In the context of small holder farmers, these cows were milking for a maximum of 3-5 months post-calving before drying off. This is probably indicative of poor nutrition and poor water access reducing fermentation in the rumen and the energy for milk production.

The main objective of the current study is to directly impact Sri Lankan small holder farming by establishing the baseline mineral status of small holder dairy cows and their fodder, hence that evidence-based veterinary advice can be given. On small farms it is difficult to obtain meaningful data because of the variable nature of the observations. By collating the data across a village or range or group of farmers, it should be possible to get meaningful data.
It would then be possible to identify where the focus for improving fertility should be.

In conjunction with local DAPH Veterinarians, samples were collected from 30 cows in 4 regions of Northern and North Western Provinces in Sri Lanka (Vavuniya, Mannar, Jaffna and Kurunegala). The cows were walked using a halter to a common point in the communities where samples were taken. Forage samples were provided by the farmers. These included: Paddy straw, Napier grass-CO3/CO4 (*Pennisetum perpureum* X *Pennisetum americarnum*), Azolla (mosquito fern, duckweed fern, fairy moss, water fern), Guinea grass *(Panicum maximum*) and the legume, Gliricidia (*Gliricidia sepium*). Samples of concentrates that were used by farmers for feeding dairy cattle were taken.
The breed, colour and body condition scores (BCS) and fertility parameters were also recorded. The BCS was assessed in accordance to the Penn-State method. The main breeds are native crosses with Sahiwal, Jersey or Friesian.

The samples were measured by students from the University of Surrey for the most relevant minerals associated with fertility: Copper/Molybdenum, Iodine, Cobalt and Selenium by Inductively coupled plasma mass spectrometry.

Following the literature review which highlighted human health problems of chronic kidney disease of unknown etiology (CKDU) which is believe to be caused by exposure to high levels of Nitrates, Arsenic or Cadmium, a discussion on the levels of Arsenic & Cadmium and there effect on human and animal health will be included in future reports.

This was a voluntary project and has been carried out by students supported by those who have given their time and expertise to the project to whom our thanks go.

Boundaries and cut offs

The trace element requirements and levels for cattle are variable. There is not a definitive range that can be used.

Trace element requirements are variable and known to vary with age (4), sex (5) growth stage (6), breed and genotype (7).

It is expected that different breeds would have slightly different dietary requirements in the same setting. However, the data on indigenous or other breeds is lacking.

Illness and parasitic infections can also increase the mineral requirements due to imposed oxidative stress (8). Published values are variable and only approximate the minerals requirements (9).

The rumen fermentation will vary according to the presentation of the diet and the water availability for that fermentation. Hence free-grazing cows selecting plants and diet will be different to zero-grazing cows (cut and fed) given the *same* diet. Diets presented as whole in the trough will be fermented in the rumen differently to mashes or diets that are well chopped and mixed.

Because of the interplay between minerals and their variable absorption and bioavailability. It is not possible to diagnose mineral deficiency from the levels in the diet.
The most accurate picture can be obtained from blood (or if it was available, liver levels). This shows the levels in the cows and how the minerals have been absorbed from the diet.

The technique used in this study, ICP-MS, is used routinely to identify levels of minerals in many samples-plants, soil contamination etc. However, the standard techniques for blood sampling cattle focus on the important mineral-containing enzymes or proteins.
Normal practice would be, for Selenium; glutathione peroxidase, for Cobalt; cobalamin/Vitamin B12 and for Iodine; T4 (Thyroxine) levels.
These were not available to this project.

Care needs to be taken in looking at values as different authors use different definitions. The levels are usually on a Dry Matter (DM) basis, but some are on an As Fed (AF) or fresh basis. Most are on mg/kg or mg/litre basis, however some are on mmol/kg. When looking at diets some authors look at requirements on mg/day for different classes of animal whereas others use mg/kg in the diet. There is also a difference when looking at pasture values or fodder values compared to the whole diet.

Unit transformation from Suttle (1)
For Iodine
1ppm=µg/mL; 1ppb =1 µg/L= 1 ng/mL;
1 nmol/L of T4 =508 ng/L of I= 0.508 µg/L of I
1 mol/L of T4 contains 4 mol/L I

For Copper;
1ppm= 1000 ppb; 1 µg/L= 1 ng/mL=10-3 µg/mL;
1mg/dL=0.01 mg/mL=10 µg/mL
1 µmol/L of Cu =63.5 µg/L

For Cobalt;
1ppm= 1000 ppb; 1 µg/L= 1 ng/mL=10-3 µg/mL;
1 mol of B12 contains 1 mol of Co
1 pmol/L B12 contains 1pmol/L Co= 59 pg/L=0.059 ng/L
1 µmol/L of Co =58.9 µg/L

For Molybdenum;
1ppm= 1000 ppb; 1 µg/L= 1 ng/mL=10-3 µg/mL;
1mg/dL=0.01 mg/mL=10 µg/mL
1 µmol/L of Mo = 100 µg/L

For Selenium;
1ppm= 1000 ppb; 1 µg/L= 1 ng/mL=10-3 µg/mL;
1mg/dL=0.01 mg/mL=10 µg/mL
(For serum these do not convert exactly with GSH-Px as there are several Selenium-containing enzymes)

The mineral requirements and normal levels for dairy cattle in the tropics are mostly extrapolated from developed country values. There is little research to establish the relevance of these into situations in the tropics. There is significant interplay between different minerals and vitamins in the effects that they show. For example, high levels of vitamin E reduce the requirements for selenium. Therefore, while it is possible to give general guidance, there are considerable variables and unknowns.

Most authors use a range of values as abnormal mineral status may cause either disease or reduced production. In any group of animals there will be a range of responses, those that can tolerate abnormal mineral status and those that show pathology. Dairy fertility looks at the number of cows conceiving and so can only be looked at in epidemiological groups. Poor mineral status in a group will reduce the fertility parameters in that group. For smallholder farmers, production parameters are difficult to interpret over only a few cows.

In this project the following terms are used:
Deficient: levels at which clinical or pathological signs of deficiency should be apparent in some individuals.
Marginal: levels at which subclinical effects may prevail, such as reduced immune response, or reduced growth rate.
Adequate: levels sufficient for optimum functioning of all body mechanisms with a small margin of reserve to counteract commonly encountered antagonistic conditions.
High: levels elevated well above normal but not necessarily toxic.
Toxic: levels at which subclinical, clinical or pathological signs of toxicity would be expected to occur.

The boundary values are taken from the following publications:
Mineral Tolerances of Animals, William P. Weiss (2008)
Mineral Levels in Animal Health: Diagnostic Data, Robert Puls (1994)
Trace Element Disorders, NF Suttle, Chapter 9 Bovine Medicine Edited by AH Andrews
NRC Minerals in Cattle Nutrition (2001) P105-161

The boundary values for serum in the results are as follows:

Table 1 Boundary values (parts per billion) of trace minerals for blood serum in dairy cows

	Mineral									
	Co		Cu		Mo		Se		I	
Deficiency Level	Lower Limit (ppb)	Upper Limit (ppb)	Lower Limit (ppb)	Upper Limit (ppb)	Lower Limit (ppb)	Upper Limit (ppb)	Lower Limit (ppb)	Upper Limit (ppb)	Lower Limit (ppb)	Upper Limit (ppb)
Deficient	LOD	0.70	LOD	550	LOD	10.00	2	25	10	50
Deficient to Marginal							25	30	50	80
Marginal	0.70	0.90	550	599			30	80	80	100
Adequate	0.90	15	600	1500	10	100	80	300	100	400
High	15	3000	>1500		>100		300	3500	700	3000
Toxic	3000						>3500		>3000	25000

LOD = Limit of Detection
ppb = parts per billion
1 mg/kg = 1 ppm

Methods

Samples were collected from 30 cows in 4 regions of Northern and North Western Provinces in Sri Lanka (Vavuniya, Mannar, Jaffna and Kurunegala) totaling 120 samples. The cows were walked using a halter from their respective homes to one common point in the communities where samples of hair, blood, milk and serum were taken.
The first three letters were used to identify the centre from which the samples originate.
(WIG refers to UK dummy samples from Wigton to test the project protocols).

The breed, colour and body condition scores (BCS) were also recorded. The BCS was assessed in accordance to the Penn-State method.

Feed samples included all concentrates, forages (bought or harvested), and mineral supplements as fed to the dairy cattle. The quantity fed in the ration was recorded. This was packaged and delivered to University of Surrey for mineral analysis.

The local fodder names were used for identification. Future studies will use photographs in an aid to identify local fodders.

- Azolla — *Azolla pinnata*, an aquatic fern grown in tanks.
- CO-3/CO-4 — *Pennisetum perpureum* X *Pennisetum americarnum*. Various trade names and hybrid varieties for improved hybrids of Napier grass. But these were all grouped under CO-3.
- Gliricidia — *Gliricidia sepium* a leguminous tree.
- Ipil Ipil — *Leucaena leucocephala* a leguminous tree.
- *Cyperus* spp. — *Cyperus corymbosus* a native tropical plant. Local Sinhala name is "*Gal ehi*". Local Tamil name "*Korai*" (கோரை).
- Black pigweed *Trianthema portulacastrum.* Local Sinhala name is *"Sarana".*
- Paddy straw — *Oryza sativa*. Straw by-product of rice production.
- *Echinochloa* spp. English names are Cockspur or Barnyard grass or Wild millet and local Tamil name is *Kolichchoodan* (கோழிச்சூடன்).
- Local grasses and *Cynodon* spp. English name is Scutch grass or Bermuda grass. Local Tamil name is "*Padar Pul*" (படர்புல்)- *Digitaria eriantha*, common Name (Pangola grass).

Concentrates included:

- Beer waste - Brewers grains (barley)
- CIC dairy cow feed- commercially available pelleted feed for dairy cows
- Prima milk mash- commercially available barley/coconut residue for dairy cows
- Dhal Red Lentil mix (Made from the pods of red lentils)
- Rice bran
- Rice polish
- Wheat bran
- Various home/locally made mixes using locally available by-products from coconut, rice or cereal production

The following data were recorded:

- Sample reference, farmer name, cow VS registration number, breed, BCS.
- Age, date of first calving, number of calvings, pregnancy status, and number of services.
- Date of last mineral supplement & minerals used.
- Forage type & quantities fed, concentrates and quantities fed.

The samples were analysed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) using an Agilent 7700x Series ICP-MS with MassHunter Workstation software (Agilent Technologies, UK). Full methodology is available in the student dissertation report by Joseph Clarkson.

Results

The full Data Sets are available in Appendix 1 Excel spreadsheets.
Sri Lanka Combined results by cow
Sri Lanka Biomarkers Trace Element Data
Sri Lanka Plant and Feed Analysis
Sample Registration Kurunegala/Mannar/Vavuniya/Jaffna

The blood serum results for the cows.
The cows are deficient in Iodine and Cobalt.
All the copper levels are adequate. The low levels of molybdenum mean that any supplementation will be easily absorbed.

All the selenium levels ranged from adequate to high especially in Vavuniya and Jaffna.

Table 2 Serum micro mineral levels of dairy cows

		Co	Cu	Mo	Se	I
Number of cows within concentration ranges	Deficient	120	0	120	0	97
	Deficient to Marginal				0	23
	Marginal	0	1	0	0	0
	Adequate	0	119	0	90	0
	High	0	0	0	30	0
	Toxic	0	0	0	0	0

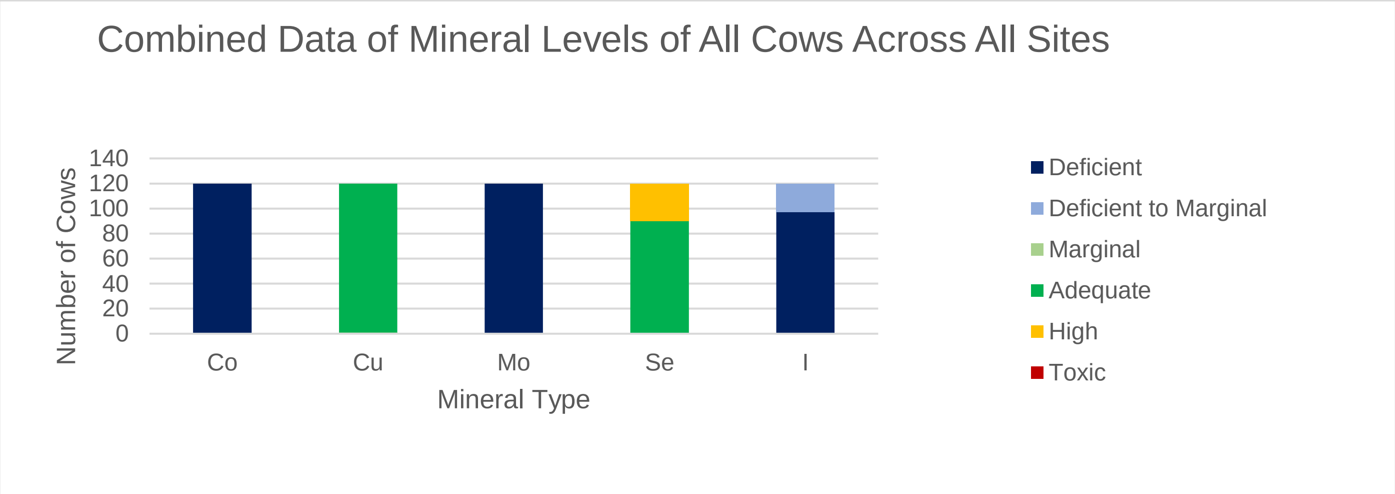

Figure 1 Serum micro mineral levels of dairy cows: combined data of micro mineral levels of all cows across all locations

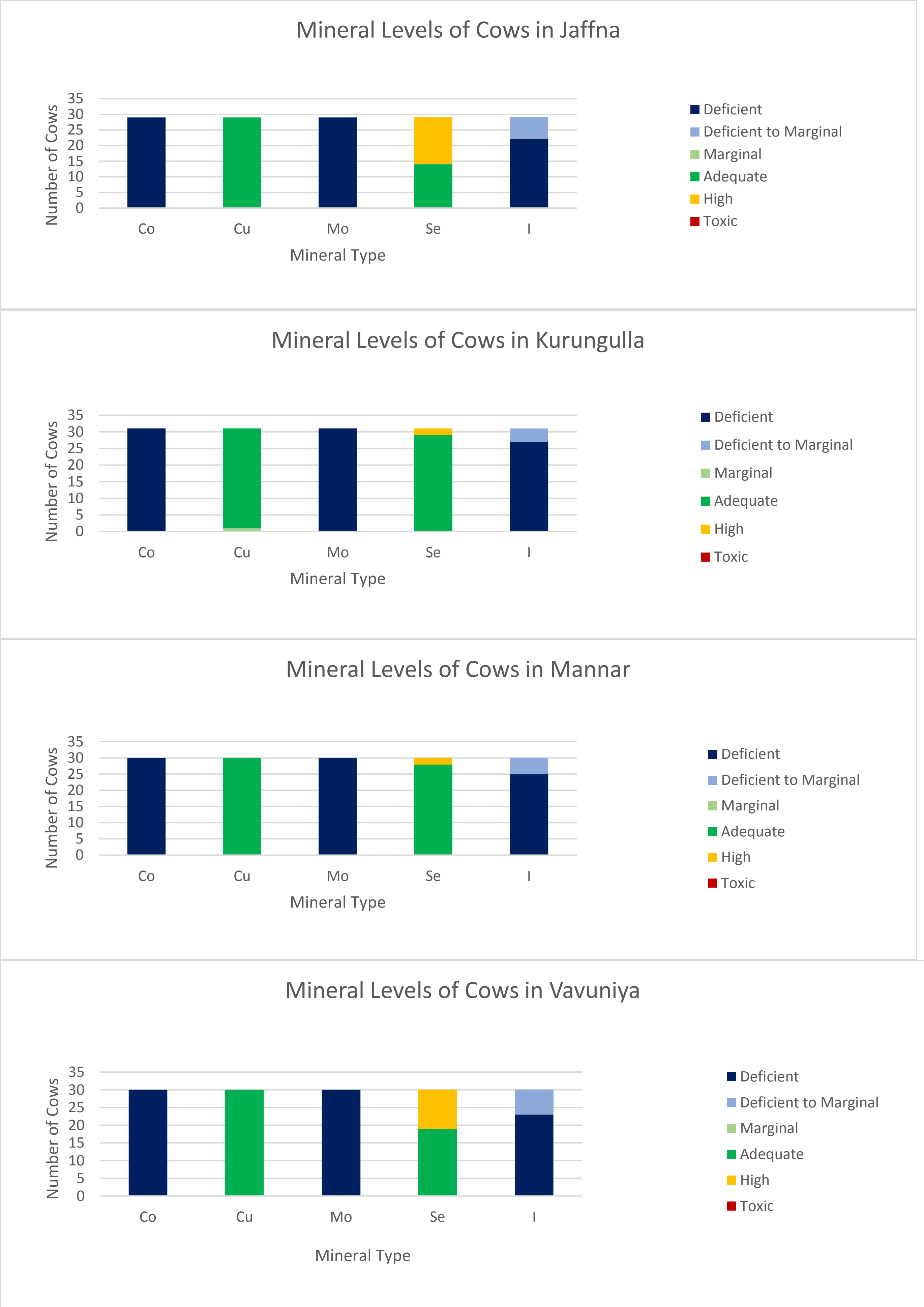

Figure 2 Serum micro mineral levels of dairy cows: levels in different locations

Cattle Feeds-Cobalt

The NRC minimum dietary requirement is 0.11 mg/kg for maintaining Vitamin B12 levels. Levels of 0.25 to 0.35 mg/kg have shown to improve production parameters independent of Vit B12 levels (10). As higher levels of Cobalt are required for poorer quality fodder the higher level is shown on the charts (yellow line).

Toxic levels are 30 mg/kg and is exceedingly rare.

Most of the rice-based feeds as expected were low in Cobalt. Black pigweed or *Trianthema portulacastrum* (Sarana) and Ipil Ipil were generally adequate in Cobalt. Whereas, Azolla was high in Cobalt and CO3 grass was generally low in Cobalt. *The Azolla chart is reported separately as it had much more variable mineral levels with some being high.

The CIC dairy mix was except for one sample below the level of detection.

There were no specific regional differences but variation within different regions.

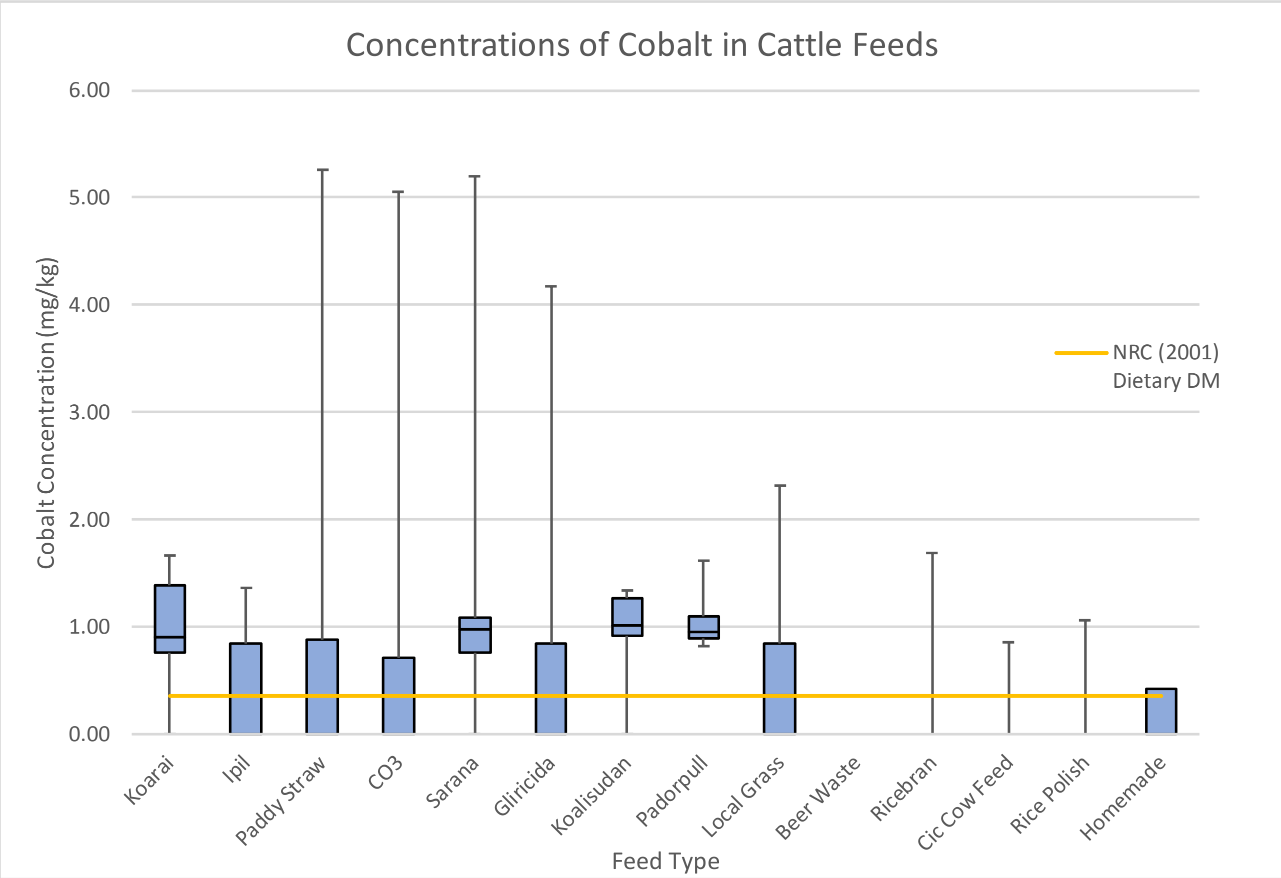

Figure 3 Cobalt levels in cattle feeds

Cattle Feeds-Copper/Molybdenum
The NRC minimum dietary requirement is around 15 mg/kg for adult lactating cattle depending on the level of antagonists (yellow line).
The level of Molybdenum in commonly utilized feeds was low; below the NRC 10mg/kg where it can interfere with copper absorption.

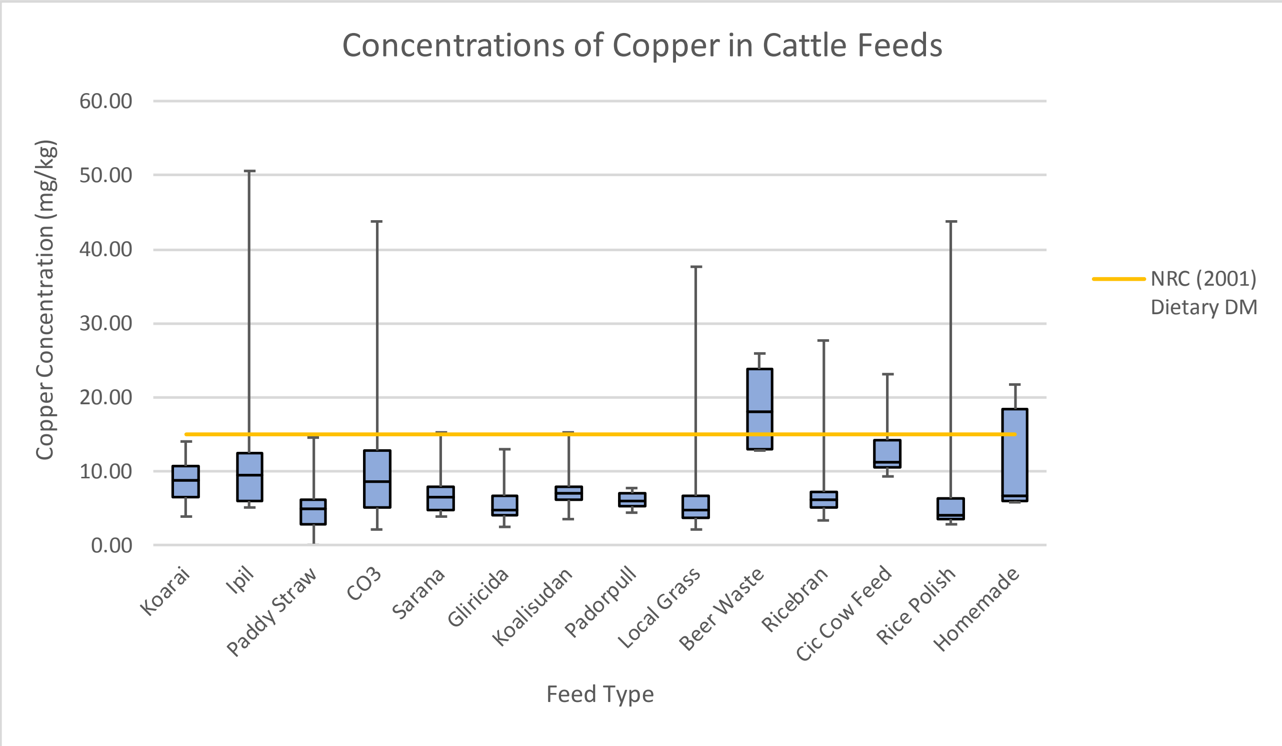

Figure 4 Copper Levels in Cattle feeds

The toxic level of copper according to the NRC is 40 mg/kg. However, this is for an American context with antagonists present and causing chronic toxicity and an acute haemolytic crisis. From personal experience, levels below this can cause production problems and transition period problems in the UK. Copper levels from liver or kidney samples are the only way to diagnose chronic copper poisoning.

A few fodders had levels approaching or above this toxic level. This, however, would be diluted out by other feeds.
Most forages commonly utilized in the study areas were below the 15 mg/kg NRC level, but the Copper was being absorbed and all cows had adequate copper serum.

In the field there is no minimum requirement for Molybdenum. For while it is an essential element present in some enzymes, its requirement is so small to make deficiency very rare (11). It is measured as it is an antagonist for Copper absorption. The low levels of Molybdenum are not a problem but does mean that Copper is easily absorbed. This means that the risk of Copper toxicity needs to be considered when using supplements.

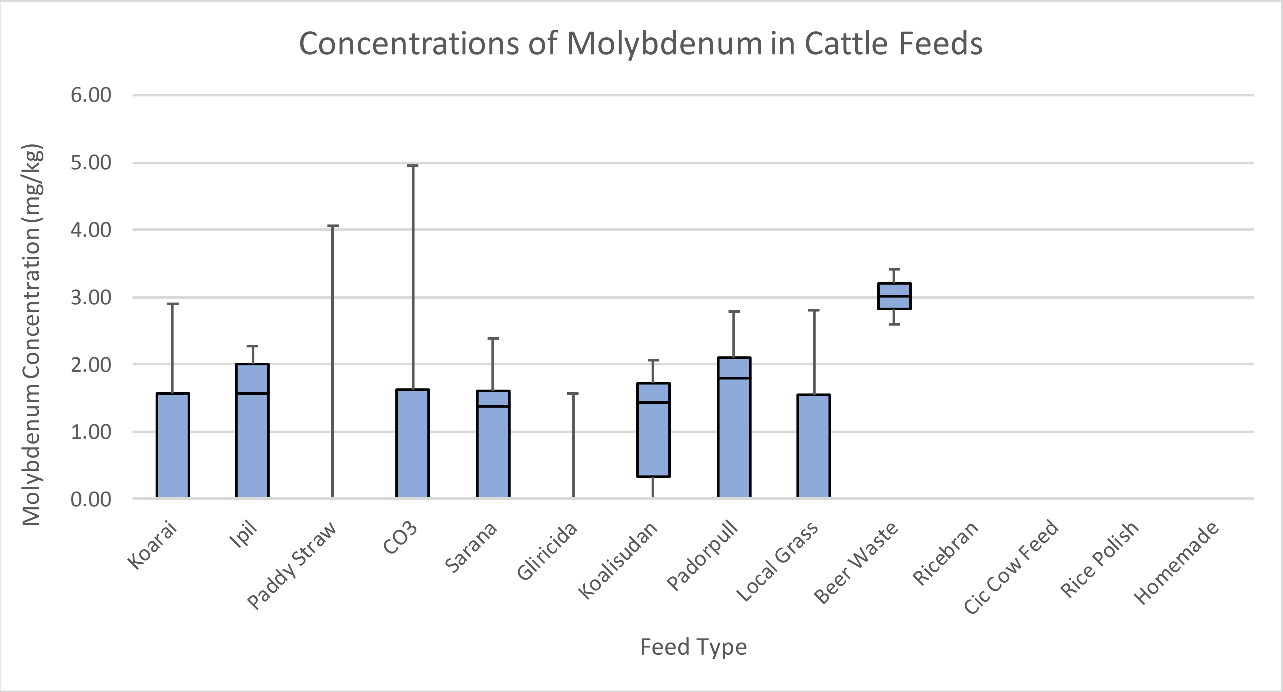

Figure 5 Molybdenum levels in cattle feeds

These are well below the NRC 10 mg/kg where Molybdenum can interfere with copper absorption.

Cattle Feeds-Selenium

The NRC minimum dietary requirement is around 0.3 mg/kg for adult lactating cattle (yellow line). Chronic toxicity can occur when cattle are fed diets with 5 to 40 mg of selenium/kg for a period of several weeks or months.

Most of the commonly utilized fodders in the study area were around the dietary requirements except for most of the rice/paddy products.

All the cattle had high levels of serum Selenium.

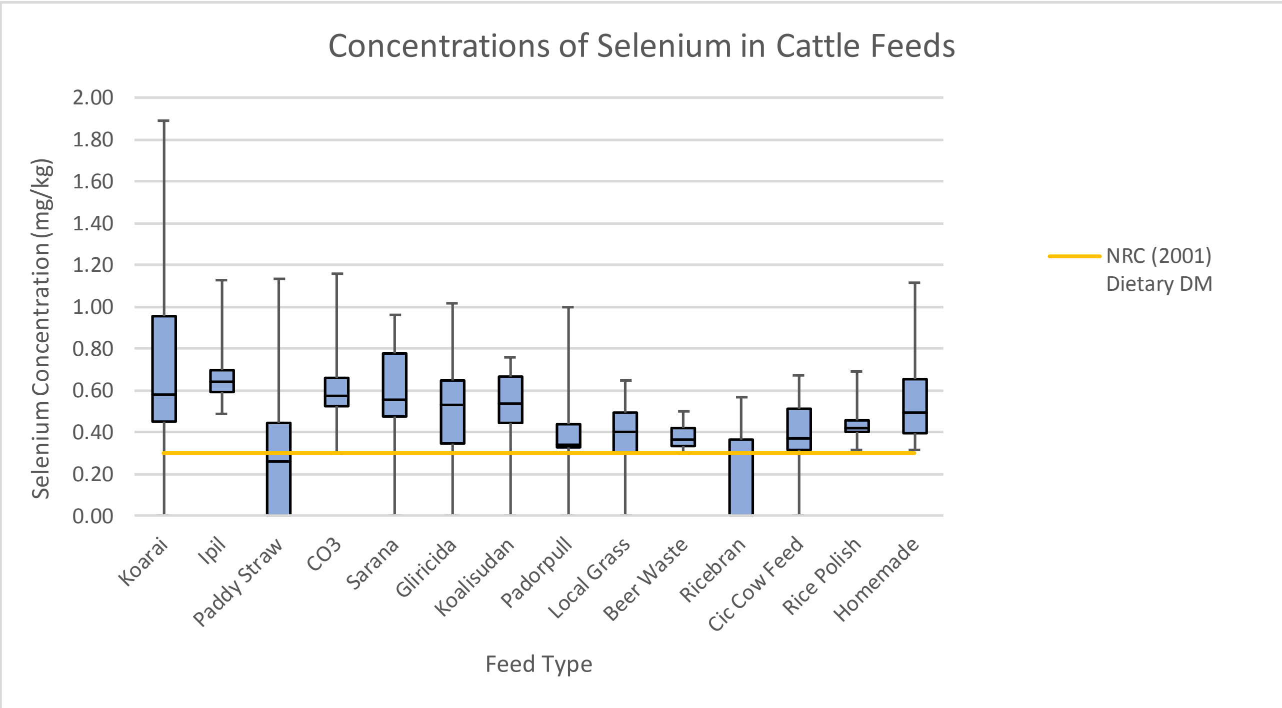

Figure 6 Selenium levels in cattle feeds

Cattle Feeds-Iodine
The NRC minimum dietary requirement is 0.33 mg iodine/kg of dietary DM. The Iodine values for the cattle feeds are not currently available but will form part of a future report

Figure 7 Iodine levels in cattle feeds

The levels of Iodine in Feed are not available in this report

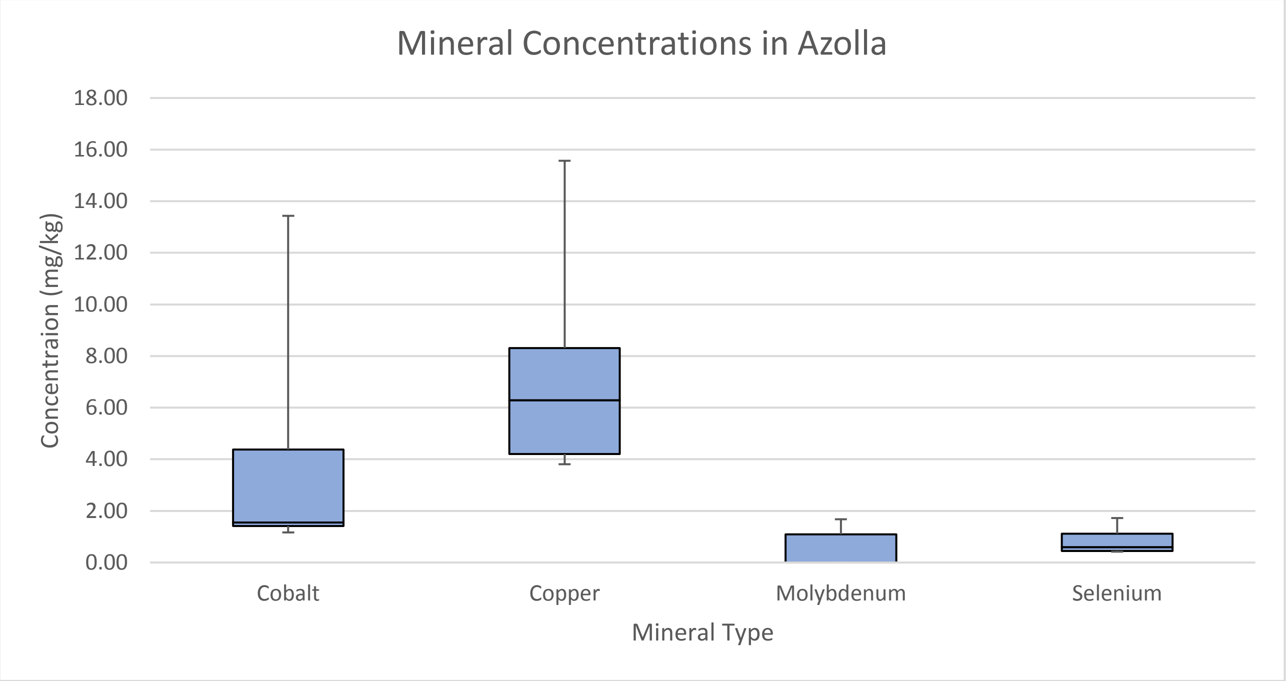

Figure 8 Mineral Levels in Azolla

Mineral Supplements

The use of mineral supplements is a well-recognised part of farming practice. However, the quality of the supplements tested in this project would mean that care should be exercised. The assessed levels of copper were double the certified value in one of the *Super Mineral* supplement batches (Mannar). Unfortunately, the certified levels in the other supplements were not recorded. Batch to batch variation in the Super Mineral copper level varied by a factor of three and by 50% in the Aminol.

Table 3 Mineral Levels in various commercial mineral supplements (The stated level for Super Mineral Mix is in red)

Mineral Levels in commercial supplements

	Sample	Co	Cu	Mo	Se
		mg/kg	mg/kg	mg/kg	mg/kg
Jaffna Mineral mix	**JMM**	<LOD	236.09	<LOD	15.36
MAN Fertigen	**MF**	21.77	1188.33	<LOD	85.65
Karunagala Aminol	**K7A**	21.78	1276.25	<LOD	28.90
Jaffna Aminol	**JA**	15.19	819.06	<LOD	29.85
Jaffna Super Mineral Mix	**JSMM**	15.21	1057.61	<LOD	44.62
MAN Super Mineral Mix	**MSMM**	109.97	3477.74	3.32	32.76
Super Mineral Mix Certified level	Stated level	21	1100	-	45

Discussion

Trace element disorders are a well-known cause of production problems. However, as Suttle indicates, they carry more than their fair share of blame for poor cattle performance. They are the **least probable explanation** of any production or fertility issue. They are part of the problem but are not the silver bullet that farmers and mineral salesmen would like to think that they are.
Poor nutrition in terms of energy and protein has a much bigger role to play.
Ruminants ferment their feed and two thirds of a dairy cow's energy comes directly through the rumen wall as volatile fatty acids from that fermentation.
Hence, before considering mineral status as a problem, ensuring adequate access to good quality feed and water is much more important.
In thinking about fertility in dairy cows, the transition period, 3 weeks before calving to 3 weeks post calving, is an important determinant of both production and fertility. It is beyond the scope of this discussion but is likely to be more important than mineral status.

As discussed in *Boundaries and cut offs*, the bioavailability and absorption of minerals is complex, and requirements variable. It is not possible to diagnose mineral deficiency from the levels in the diet.
The only definitive diagnosis of trace element responsive conditions is that they respond to supplementation and that this is demonstrated in a controlled way.

These results show that both cobalt and iodine are low in the cows and that improving the levels in the diet may prove beneficial.

Cobalt
The cobalt is utilised by microbes in the rumen to synthesise Vitamin B12. Dietary levels of 0.04-0.06 mg/kg DMI (Suttle) are usually enough to ensure that Vitamin B12 in animals are maintained at normal levels. Recent work is suggestive that production parameters can be improved by higher levels of up to 0.25 mg/kg DMI (Lopez-Guisa and Satter, Zelenak et al. 1992).
It is suggested that both rumen and immunological function is improved independent of Vit B12 levels.

Cobalt levels in crops and forages can be very geographically specific depending on the underlying geology of the soil and interactions in the soil. Alkaline pH and the presence of Manganese means that Cobalt is unavailable to plants. Hence neighbouring fields may have different availability of Cobalt for plants and the animals that graze them. Cattle are also known to ingest soil (Pica) where minerals are low and so as discussed the levels in animals may not reflect the measured intake in feed.

Low serum Cobalt can be an indicator of low vitamin B12 and so further investigation of Vitamin B12 is indicated.

There are several strategies that could be used for improving Cobalt levels in the diet.

- Heavy Cobalt oxide oral boluses that sit in the rumen.
- Increasing the levels in supplementary feeds. All manufactured dairy pellets should be encouraged to have added cobalt.
- The use of 0.1% cobalt mineral licks.

There is virtually no risk to animals by overdosing with Cobalt.
Along with other elements, excess Cobalt does raise Cobalt levels in the milk independent of B12. As such levels in ruminants' diet should not exceed 1 mg/kg/DMI (EFSA).

Low Vitamin B12 can cause reduction in appetite, fertility and production parameters. In deficiency it can cause anaemia.

Milk and dairy products provide a significant role in providing Vitamin B12 in human diets. The significance of this in Sri Lanka and the effect on B12 levels in milk is beyond the scope of this project.

In Cobalt deficient animals, the Cobalt in milk is present as Vitamin B12. In supplemented animals or animals on a high Cobalt diet, other forms will be present in milk.

In this study the animals were low in Cobalt, so the assumption is that it is only present as Vitamin B12. The conversion to Vitamin B12 (Suttle) is to multiply by 1355/58.9.

Hence from this study the estimated Vitamin B12 levels in milk varied from 2.3-34 ug/litre. (With a caveat on the higher figures)

The Recommended Nutrient Intake is 2-2.4 ug/day. (12)

100 ml of milk or milk product at the top of this range may give adequate Vitamin B12 for human nutrition.

It may be that supplementation of cows with Cobalt will significantly increase the levels of Vitamin B12 in the milk, milk products and diet of smallholder farmers.

Iodine
Iodine is a constituent of the thyroid hormones and deficiency causes the production of physiologically inactive hormones.
Deficiency results in an increase in the size of the thyroid and perinatal mortality. Marginal low levels are associated with the reduction of fertility, immunity and production parameters.
Absolute Iodine deficiencies are rare but certain legumes and brassicas can be associated with the production of thiocyanate in the rumen preventing iodine uptake. This can be countered by providing more iodine in the diet. However, some plants produce thiouracil goitrogens that impair iodine metabolism in the thyroid. The thiouracil goitrogens are less responsive to iodine supplementation.

In coastal regions, because of atmospheric inputs from the sea, levels of Iodine in fodder are usually high.
In Sri Lanka, Iodine deficiency is still a well-recognised problem in the human population despite the routine iodisation of table salt.

The strategies for supplementation in dairy diets would need to be discussed locally.

Copper/Molybdenum

With one exception, the serum copper levels were within the normal range.
Of all the minerals, copper is the most likely to become toxic if over-supplemented.
Copper toxicosis can occur in cattle that consume excessive amounts of supplemental copper.
The very low Molybdenum levels means that any mineral supplementation or forage with high copper levels is likely to be easily absorbed and may cause toxicity.
The low fodder levels of copper and yet adequate levels in the cows may show the high bioavailability of the copper or reflect the supplementation.

Caution should be exercised in using general purpose mineral supplements especially where there is poor quality control over the levels in those supplements.

There is a growing demand for pork and pork products, however lack of market development and environmental issues has been constraining the sector (Department of Animal Production and Health, 2000). There is likely to be increasing pig production in Sri Lanka in the near future. There is a potential risk for ruminants fed fodder fertilised by pig manure with its very high copper levels.

The toxic level of copper according to the NRC is 40 mg/kg. However, this is for an American context with antagonists present and causing an acute toxicological crisis. From personal experience in the UK Copper levels below this can cause production problems and transition period problems. Copper levels from liver or kidney samples are the only definitive diagnostic test.

There are high levels of copper in the calcium supplements and in a few of the fodders.

Selenium

The selenium levels are all in the normal to high range. This reflects the pattern in the fodder, which in turn reflects the underlying geology (11). Human selenium deficiencies have been observed in studies in the southern wet areas of Sri Lanka. Whereas this is not the case in the north of Sri Lanka. Hence, levels may be different in forages and cattle further south.

Low Selenium levels have been associated with low Iodine levels in the human population and linked to chronic renal disease (12).

Next Steps and future projects

The iodine levels were not available for the forages at the time of writing this report and hence will be included in a future report.
Arsenic and Cadmium levels have been measured and the data will be written up.

Student Projects

This report brings together the main findings of the project.
The data however will be utilised for two further student analysis projects in 2020.

1. The nutritional composition of natural and artificial feedstuffs for dairy cattle in Sri Lanka. This project will look at the energy and protein levels in the fed diet.
2. Testing for correlation between trace element concentrations in blood, hair and milk in dairy cattle from Sri Lanka.

Other future projects on these data could include:

1. Comparison of serum levels of cows that are repeat-breeders.
2. Assessment of the risks in the management of copper levels in dairy cattle by comparing the levels of the different antagonists in the cattle and feed. Using the NRC model.
3. *Gliricidia* is reportedly hepato-toxic if fed in excess. Use *Gliricidia*-fed cows as a subset and compare to the rest of the cows for each mineral.
4. Heavy metal levels were measured but not commented on in this report.

Future student projects

1. A study of the variability of mineral supplements against the stated values.
2. Monitoring the effect of Cobalt supplementation on B12 levels.
3. Monitoring the effect of Iodine Supplementation on Iodine/T4 levels.

One Health Project Grant Funding Application

This project has shown low Iodine and Cobalt levels in dairy cattle. There is a problem with Iodine deficiency in the human population of Sri Lanka. This is being addressed by the traditional public health approach of iodisation of salt.
By the supplementation of dairy cattle with slow-release ruminal iodine bolus and heavy cobalt pellets, it may be possible to demonstrate that a “One Health” approach improves dairy fertility, B12 and iodine status of dairy cattle and B12 and iodine status in small holder farmers and their families.
It is known that supplementation increases the levels of B12 and Iodine in the milk.
This “One Health” approach could increase income, protein availability as well as the mineral status of the community and their dairy animals.

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Literature Review

There were two parts to the review of the knowledge available prior to the commencement of the project. The first was informal discussions with the veterinarians and academics in Sri Lanka. The second was a formal literature review of available papers. The informal discussions showed that little testing was carried out and none of those interviewed had knowledge of the mineral status of the cows in their areas. There was anecdotal evidence of cows responding to mineral supplementation, but no data had been collected. The project was supported by the DAPH.

The aim of the literature review was to establish if any surveys of mineral status in dairy cows in Sri Lanka have been published.
The first 100 search results were examined for each set of terms.
The following terms were used
Sri Lanka AND (*Bovine* OR *Dairy* OR *cow*) AND (*Selenium* OR *Cobalt* OR *Copper* OR *Iodine* OR *mineral*).

The following results were discarded.

- All the terms produced many results for human articles, water purity and chronic renal disease which is a real problem in Sri Lanka associated with high levels of Nitrates, Manganese, Selenium, Arsenic or Cadmium.
- Several results were returned where minerals were added as part of a trial.

The following relevant papers were identified.

Sri Lanka dairy selenium

Feeding Dairy Cows in the tropics
ftp://ftp3.us.freebsd.org/pub/misc/cd3wd/1004/_ag_dairy_cows_feeding_unfao_en_lp_105810_.pdf#page=59

A study on mineral status of cattle on a dairy farm in Sri Lanka.
Indian Veterinary Journal, 68,371-374. No access to the journal.

SELENIUM WORLD ATLAS (2002 UPDATED EDITION) JAMES E. OLDFIELD
Sri Lanka Soil selenium and iodine concentrations in soils in Sri Lanka are average to marginal compared to soils elsewhere. Interestingly, the highest values for selenium and iodine occur in the Wet Zone in southwest Sri Lanka, where goitre is prevalent, thus emphasizing the importance of the bioavailability of these two nutrient elements

Sri Lanka bovine selenium
No documents

Sri Lanka cow selenium

Selenium Deficiency and Toxicity in the Environment
Essentials of Medical Geology pp 375-416
Selenium (Se) is a naturally occurring metalloid element, which is essential to human and other animal health in trace amounts but is harmful in excess. Of all the elements, selenium has one of the narrowest ranges between dietary deficiency (<40μg per day) and toxic levels (>400μg per day) (WHO 1996), which makes it necessary to carefully control intakes by humans and other animals, hence, the importance of understanding the relationships between environmental exposure and health. Geology exerts a fundamental control on the concentrations of selenium in the soils on which we grow the crops and animals that form the human food chain. The selenium status of populations, animals, and crops varies markedly around the world as a result of different geological conditions. Because diet is the most important source of selenium in humans, understanding the biogeochemical controls on the distribution and mobility of environmental selenium is key to the assessment of selenium-related health risks. High selenium concentrations are associated with some phosphatic rocks, organic-rich black shales, coals, and sulfide mineralization, whereas most other rock types

contain very low concentrations and selenium-deficient environments are far more widespread than seleniferous ones. However, health outcomes are not only dependent on the total selenium content of rocks and soils but also on the amount of selenium taken up into plants and animals—the bioavailable selenium. This chapter demonstrates that even soils containing adequate total amounts of selenium can still produce selenium-deficient crops if the selenium is not in a form ready for plant uptake.

Sri Lanka Dairy Cobalt

No Documents

Sri Lanka Bovine Cobalt

No Documents

Sri Lanka Cow Cobalt

No Documents

Sri Lanka Dairy Copper

Origin and spatial distribution of heavy metals in a soil map unit of Sri Lanka.

Author(s): Sanjeevani, U. K. P. S.; Indraratne, S. P.; Vitharana, W. A. U.; Weerasooriya, R.; Rosemary, F. 2013. Proceedings of the International Symposium on Agriculture and Environment 2013, 28 November 2013, University of Ruhuna, Sri Lanka pp.197-199.

Abstract : Total concentrations and spatial distribution of heavy metals and their relationship with soil properties in soils are important in sustainable soil management. Therefore, a study was conducted to examine the total concentration of Cu, Pb, Ni, Zn and Cd and their relationships with soil properties and spatial distribution of these elements in Madawachchiya-Ranorawa-Elayapattuwa-Hurathgama-Nawagattegama soil association of the dry-zone of Sri Lanka. Soils were analyzed for organic carbon (OC), pH, EC, clay%, total Cu, Pb, Ni, Zn and Cd. Measured OC, pH, EC and clay ranged between 0.12-1.90%, 4.1-8.0, 0.02-0.41 dS/m and 2-42%, respectively. The concentrations of Cu, Pb, Ni, Zn and Cd concentrations ranged from 1.6-33.0, 2-19, 1.6-32.0, 7-71 and 0.13-1.22 mg/kg, respectively. Significant correlations were observed between total Cu, Pb, Zn and OC in the soil. Total Pb was correlated with the clay%. Significant negative correlation was observed between Zn and EC. Principal Component Analysis (PCA) showed high loadings of Cu, Ni, Zn and OC on PC1 whereas Cd and clay on PC3. Lead had high loadings on both PC1 and PC3. Soil pH and EC showed high loadings on PC2. Significant correlation among Cu, Pb, Ni and Zn indicated a common source of origin for these four metals while Cd is having different source of origin. Similar spatial distribution pattern of total Pb, Ni, Cd and OC were observed. Clay% and OC content were the two important soil properties affect on the accumulation and distribution of analyzed heavy metals in these soils.
ISBN : 9789551507251
Publisher : Faculty of Agriculture, University of Ruhuna
Location of publication : Kamburupitiya
Country of publication : Sri Lanka

Sri Lanka Bovine Copper
No Documents

Sri Lanka Cow Copper
Studies of the trace mineral status of ruminants in Sri Lanka 1983
Ranawana, S.S.E. (Veterinary Research Inst., Peradeniya (Sri Lanka))
Abstract:

Several studies have been carried out during this period. Ten growing buffalo calves were supplemented for a period of 2 months with P, S, Cu, Mn, Co, Fe, and Zn. When compared to unsupplemented control, growth rate doubled by the supplementation. Dairy cows were divided into five groups and three of them were supplemented with vitamin B12, phosphorus or copper. The other groups served as negative and positive control. Results of this study are being analyzed. A survey of 50 calves in 21 small-farmer dairies showed that they have very poor growth rates and that the majority were having low haemotocrits, haemoglobin, plasma, Cu and Zn. One hundred animals from slaughterhouse were examined and sampled to ascertain their trace mineral status. In these studies, trace mineral status was determined by measuring plasma levels of trace minerals and also by assaying for enzymes such as ceruloplasmin and alkaline phosphatase. Vitamin B12 in plasma and liver, and thyroxine in plasma was also assayed to determine the Co and I status, respectively. For the latter, thyroid histology was also studied.

Usefulness of tables of nutrient requirements to ruminant feeding in the tropics [1986]
Trung, L.T. (Philippines Univ., Los Banos, College, Laguna (Philippines). Dairy Training Research Inst.)

Abstract:
A critical analysis on the usefulness of tables of nutrient requirements, feeding standards and feed composition was made. The foremost argument against the adoption of foreign standards being differences in environment, animal and quality of feedstuffs was discussed. Other issues taken up were expression of energy value, protein utilization of ruminants, levels of feeding and nutrient availability, and associative effects of dietary feed ingredients. Examples taken from published research data showing the inapproriateness of foreign standard to ruminant feeding in the tropics were given. Finally, an alternative feeding guide was offered for ruminants in the tropics.

Sri Lanka Cow Iodine
No documents

Sri Lanka Bovine Iodine
No documents

Sri Lanka dairy Iodine
No documents

Sri Lanka dairy Mineral
Development, use and impact of feed supplementation blocks: experiences in Sri Lanka
ANF Perera14, ERK Perera, H Abeygunawardane15 - FEED SUPPLEMENTATION
http://www.fao.org/3/a-a0242e.pdf

The current status of smallholder dairy systems in Sri Lanka B.H.W.M.U.S. Bandara Department of Animal Production and Health P.O. Box 13, Peradeniya, Sri Lanka 13–16 March 2001
https://jnsfsl.sljol.info/articles/10.4038/jnsfsr.v36i0.8050/galley/6110/download/

Repeat breeding among artificially bred cattle in mid country smallholder and up-country large multiplier farms of Sri Lanka
G Perera, H Abeygunawardena, CMB Dematawewa… - 1999 - 192.248.43.136
… This also emphasizes, the need of including analysis of mineral status of animals in future studies aimed at determining exact causes of infertility and development of remedial measures for fertility improvement …

Sri Lanka cow Mineral
No documents

Sri Lanka bovine Mineral
No documents

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YGro is a social action NGO. Registered in Sri Lanka as an NGO by the Government's NGO Secretariat and approved by the Government as a Charitable Organisation. It offers training, micro enterprise and micro loans and is involved in rural poverty reduction through developmental interventions. About a third of their emphasis is working with poor dairy farmers to increase production and provide an increased income for the farmer and their family.

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