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MineralCheck

Trace element testing for optimal animal production

Introduction

The Mineral**Check** package of tests will enable veterinarians to diagnose and prevent mineral deficiencies, gross nutritional inadequacies and production limiting diseases in farmed animals.

The full Mineral**Check** package is designed to provide, by simultaneously testing animal and dietary samples, in-depth information for interpretation. However the package is also highly versatile. Each test can be used individually or with other tests relevant to the particular circumstances.

The objective of this guide is to provide information in a format which assists veterinarians to provide high quality advice to their farmer clients. For a brief summary of the number of samples to collect and reference ranges for the various species see the appendix at the end of this document.

Mineral Testing

What mineral testing can reveal

The Gribbles Veterinary laboratories' mineral reference ranges as published in this guide are primarily designed to determine if a group of animals will respond to mineral supplementation at the time of sampling.

However, there are other reasons for sampling animals which will affect the way these ranges are interpreted. The four main reasons for sampling grazing ruminants for mineral analyses are:

1. Animals are performing poorly - are they mineral deficient?
2. To safeguard against animals on the farm suffering from a mineral deficiency
3. Animals are going into a period when demand for mineral(s) is increasing and availability may be decreasing - do the animals have enough reserve of the mineral to prevent deficiency occurring?
4. Is the supplementation program adequate?

These questions will determine the type of sample required (e.g. liver or serum), the age, species and number of animals to be sampled, plus the most appropriate time of year to sample.

Strategic use of MineralCheck liver sampling at meat works

Liver sampling at meat works for mineral testing is convenient and cost effective. The age of stock at slaughter and the time of year animals are slaughtered differ for sheep, beef and deer. Even within a species, the time of slaughter varies with geographic area and farming policy. Because these variables exist, this section examines the value of Mineral**Check** liver sampling at meat works for the sheep, beef and deer farmer.

Sheep

Cobalt

Cobalt deficiency commonly occurs in the summer and autumn so checking liver concentrations in lambs slaughtered at this time is ideal. In susceptible/deficient areas, the initial sampling should be done pre-Christmas, which is achievable for many prime lamb farms. When the first draft is later, pre-Christmas on-farm sampling, preferably of livers, is required. Later drafts can be used to monitor the effectiveness of any supplements or whether adequate concentrations in December remain sufficient throughout the season (remember that B12 injections may only be effective for approximately 4 weeks in severe deficiency). Checking older classes of stock for cobalt is of limited value as adequate concentrations in them do not rule out cobalt deficiency in lambs.

Selenium

Liver selenium concentration in any class of sheep will provide information on the selenium status of the farm, provided the sheep have not been supplemented in the previous 4 months. If concentrations indicate a low or marginal status, selenium supplementation programs can then be set up. The times when selenium deficiency has greatest effect are at tupping, pre-lambing and in 3-10 month lambs. Adult ewes and lambs slaughtered about these times can be used to fine-tune a supplementation program.

Copper

In sheep there is a breed susceptibility to both copper deficiency and toxicity. The most susceptible breed for copper deficiency is Finnish Landrace. The critical period is during late pregnancy and in spring in growing lambs, but this is a time when animals are not being slaughtered on most farms. Nevertheless, some background information may be gained in animals slaughtered at other times, e.g. 4 to 8 month-old lambs and surplus hoggets. Liver biopsy in ewes prior to winter has been found to be a useful technique for assessing copper concentration to ensure adequate levels in late gestation. The Texel breed is the most susceptible to copper toxicity. Samples are also useful to determine how close liver copper concentrations are to the "toxic" range. In Otago and Southland, lamb liver copper concentrations have been found to be highest in the late autumn. Sampling of cull ewes is not recommended because too many factors can influence concentrations of minerals within the liver, e.g. Johne's disease and facial eczema.

Cattle

Selenium and copper are the trace minerals of most concern to the dairy and beef farmer.

Selenium

As in sheep, measuring liver selenium concentrations in cattle or cull cows will give useful background information on the farm's selenium status. However, for more precise monitoring if initial results are low/marginal, on-farm blood sampling maybe necessary (e.g. calves at weaning, cows pre-mating).

Copper

Copper depletion is most common in rapidly growing cattle (especially 6-12 months old) and in cows in late pregnancy and early lactation. Cows culled from the breeding herd in late autumn or early winter provides valuable information on the copper reserves of their herd mates before the increased demands of late pregnancy and lactation. If concentrations are depleted (i.e. if mean liver copper concentrations are <300 µmol/kg) and animals are supplemented at this time, then follow-up on-farm sampling will be necessary to check effectiveness of these supplements. Although liver sampling of prime cattle and heavy Friesian bulls will provide some background information on the farmers copper status, it will not reliably reflect copper status in 6 to 12-month-old growing cattle.

Deer

Copper deficiency is by far the most common mineral deficiency in deer although selenium responsive white muscle disease has been occasionally reported in fawns. Advantages and disadvantages of meat works sampling are similar to cattle. But on high performing farms, deer may reach slaughter weight by 12 months of age. Sampling at this time may provide time to treat in order to prevent enzootic ataxia.

Trace elements and minerals

COBALT/VITAMIN B12

Cobalt deficiency in ruminants is a disease characterised by loss of appetite with resultant poor growth, wasting and in severe cases death. In both sheep and cattle a watery ocular discharge has been associated with the disease. A number of diseases and conditions have been linked with low vitamin B12 status. In sheep these are polioencephalomalacia, ovine white liver disease and Phalaris staggers; in cattle infertility, metabolic diseases and depressed milk production.

Areas where severe cobalt deficiency has occurred in sheep have been identified. It is quite common in lambs on farms in the central plateau of the North Island, the Wairarapa, Southland and coastal Otago. In other areas of the country there are a number of marginally deficient soils.

Animal tests

Precise production-related reference ranges have been determined for serum and liver vitamin B12 in sheep. In cattle, deer and goats, no growth responses have yet been recorded in New Zealand.

To determine the cobalt status of animals on a farm it is suggested that animals are sampled during the most susceptible time of year, i.e. late spring, early summer in the North Island and summer- autumn in the south of the South Island. In marginal areas where the incidence of cobalt deficiency varies from year to year it is recommended to check vitamin B12 status at weaning time. Subsequent testing later in the season can be used to monitor vitamin B12 status and/or check treatment/control measures. It is important to sample those animals that are most prone to deficiency.

The order of susceptibility related to animal type is:

Lambs	>> most susceptible
Other sheep	>> less susceptible than lambs
Kids, calves, fawns	>> less susceptible than sheep
Goats, mature cattle, deer	>> least susceptible

Liver (n=5)

Liver is the storage organ for vitamin B12 but it also correlates well with treatment responses. It is the preferred test in lambs less than 2 months of age and in weaned lambs that are sampled at the beginning of the likely deficient period (November, December and early January).

Serum (n=10)

If liver samples are unobtainable, serum samples are still worth collecting from young lambs over 2 months of age. Concentrations are falsely increased in animals with liver disease (e.g. facial eczema) and if sheep are yarded for greater than 6 hours. Serum concentrations in cobalt deficient animals rise within 24-48 hours of an increase in cobalt intake.

Collect 10 serum samples or 5 liver samples

Pasture tests

If the animal tests indicate deficient or marginal cobalt status, representative pasture samples should be collected in late spring/summer from each soil type or terrain type to determine the cobalt profile of the farm. Soil contamination must be avoided as this can produce erroneously high concentrations. This should be suspected if pasture iron concentrations are reported as high.

COPPER

Copper availability is very dependent on dietary molybdenum, sulphur, iron and zinc concentrations. It is often lowest during winter and spring because this is when pasture molybdenum and iron concentrations tend to be highest. Deficiency signs include ataxia, osteoporosis, growth rate depression, infertility, reduction in fleece weight and fleece quality and hypopigmentation of wool/hair. In cattle, growth rate depression and infertility are reported to be induced by high dietary molybdenum rather than a simple copper deficiency. The copper requirements of cattle and deer are higher than those of sheep. The highest requirements for copper occur while animals are rapidly growing, during late pregnancy and in early lactation. The latter two periods are generally when dietary copper availability is lowest. There are significant species differences in the ability of the dam to translocate copper to the foetal liver. The translocation of copper is most developed in the bovine. Calves are almost always born with very good liver reserves, irrespective of the dam's status.

Sheep and goats are quite different. There is poor translocation in these species, so that signs of deficiency can happen very early in life, even before birth (congenital swayback). Different breeds of sheep differ in their ability to absorb copper. Texel sheep are more susceptible to copper poisoning while Finnish Landrace are more susceptible to copper deficiency.

Deer have not been studied in depth, but one study showed foetal and newborn deer having quite high liver copper concentrations. However, copper responsive osteochondrosis can still occur in deer of only a few weeks of age.

Animal tests

Sample types commonly selected to determine the copper status of animals are serum and liver. As an animal becomes copper depleted, liver copper is the first to fall. When this has fallen to less than 100 µmol/kg (in some animals it is much lower than this) serum copper begins to fall and finally copper at essential sites becomes low. Only when the activity of the enzymes that require copper at the essential sites are affected do production loss and deficiency symptoms occur.

Serum (n=10)

Serum copper or serum ferroxidase are both valid tests as they correlate well. This is because serum ferroxidase (or caeruloplasmin) accounts for 80-90% of copper in serum. Serum copper or ferroxidase are better than liver copper for determining if copper deficiency is the cause of a current problem. This is because they more closely reflect the amount of copper at the essential site. The serum tests reflect liver stores only when serum concentrations are low. Liver concentrations are almost always low if serum is low, but serum is not necessarily low if liver is low (depends on the degree of depletion). This means that serum is a poor indicator of liver stores and is not the recommended sample when information on storage is required, nor a recommended sample in sheep.

Notwithstanding this, low serum concentrations in 2 or more animals in a group does indicate a proportion of animals have low liver reserves (at least <100 µmol/kg). Avoid sampling animals with infections and facial eczema for instance, since both serum copper and ferroxidase increase significantly in inflammatory conditions.

Collect 10 serum samples.

Liver (n≥10)

This is the sample of choice for determining the copper status of clinically normal animals (preventive medicine). Liver biopsies in cattle and sheep can be done with local anaesthesia and are safe and relatively quick to do. Heavy sedation (e.g. xylazine) plus local anaesthesia is required for deer. Liver samples collected by the meat works from slaughtered animals give useful information.

Early winter is the best time to assess liver copper stores. This gives time to supplement before the high demands of late pregnancy and lactation. Since it may take several treatments to achieve satisfactory levels in severely depleted animals, it is important to monitor liver copper reserves during supplementation. The same animals should be sampled. The within-herd variability, especially for liver copper, is large.

Due to the variability in liver coppers, the recommended liver copper sample size is now ≥10 in all species. This will provide 75% confidence that the mean of the samples is representative of the herd as opposed to ~55% confidence for the previous recommendation of 5 liver samples.

Collect at least 10 liver samples.

Pasture tests

If animals are copper depleted, it is important to take representative pasture samples to find the cause and to determine the best way to cure it. For example, oral copper sulphate supplementation or copper sulphate in the fertiliser may be less effective at correcting an induced deficiency from high molybdenum intake compared with primary copper deficiency. Primary Cu deficiency can occur if sheep graze pastures with less than 5ppm copper and cattle less than 8ppm copper. Induced copper deficiency can occur with pasture concentrations above these values when concentrations of molybdenum, sulphur and iron in the herbage are high.

The very complex interactions between copper, molybdenum and sulphur make it impossible to give definite values for pasture molybdenum and sulphur, above which copper availability is reduced. Pasture molybdenum above 2 ppm and sulphur above 45% will probably have an effect and the higher these values the greater this effect will be.

As little as 250 mg/kg dry matter of iron produces inhibition of copper availability. Significant affects may be seen at 500 mg/kg and occurs even if the iron is in an insoluble form (e.g. Fe_2O_3) as it is in soil. The copper/iron interaction is of practical significance if:

- The animals are grazing short muddy pastures during the winter/spring.
- Silage is heavily contaminated with soil.
- The water table is high and fluctuating leading to reducing conditions and increasing plant available ferrous iron.
- Stock are grazing soil of high iron content (iron sands of North Island West Coast).

Zinc, at concentrations used to prevent sporidesmin toxicity, can impact on the copper status of cattle. One of the prophylactic effects of zinc may be to reduce copper availability. Copper supplementation should be avoided during periods of high sporidesmin challenge. Once the facial eczema season has passed, assess the copper concentration of zinc treated stock and supplement with copper if needed.

IODINE

Iodine deficient soils are found in New Zealand in large areas of Southland and Central Otago, tracts of Westland and Nelson and coastal and Inland Canterbury. In the North Island only soils in some parts of Manawatu are low in iodine. In other regions of New Zealand iodine deficiency is induced by the feeding of brassica crops like kale. As well as having a low iodine status these crops also contain glucosinolates. Glucosinolates are broken down during chewing to form inorganic thiocyanates. These compounds block the uptake of inorganic iodine by the thyroid gland. This effect can be overcome by iodine supplementation. Soil contains 10-30 times the concentration of iodine compared to pasture so animals grazing root crops in the winter may be taking in high levels of iodine because of high soil contamination.

Iodine deficiency in sheep:

Sheep are most severely affected by iodine deficiency. Clinical signs include reduced lamb survival, low birth weight lambs, and decreased wool growth in adult ewes. In a limited number of trials - weight gain response to iodine in growing sheep has not been confirmed. Increased embryo losses (up to 20% in high fecundity flocks) have been suggested. However recently a mob of half bred ewes grazing iodine deficient pastures in Central Otago was estimated at scanning to have a lambing percentage of 160% but because of poor lamb survival at lambing- this was markedly reduced to 90% at tailing. So the effects of iodine deficiency on fertility in sheep may not be as marked as the effect on birth weight and lamb survival.

Iodine deficiency in cattle:

In dairy cattle, iodine supplementation trials have shown variable results. Some have demonstrated increased milk solids, reduced services per conception and a shorter calving to conception interval, while other trials failed to demonstrate any benefits.

In beef cattle there have been anecdotal reports of low fertility in heifers and poor libido in young bulls.

Iodine deficiency in deer:

It has been suggested deer may have higher iodine requirements although goitres in neonatal deer calves has been seen occasionally. Very few deer farmers check their stock for iodine status so more work is needed in this species.

Iodine deficiency in horses:

This species appears to be extremely resistant to iodine deficiency and may have an inbuilt mechanism to prevent excessive uptake of iodine. Both serum T4 and serum inorganic iodine concentrations in normal horses grazing pastures with adequate concentrations of iodine, can be quite low compared with other species grazing the same pastures. The signs of hypothyroidism in horses can be very subtle.

Animal tests

Total thyroxine (T4) is of limited value in detecting possible iodine deficiency in the live animal as it fails to respond to changes in dietary iodine concentrations. Serum/plasma inorganic iodine (PII) testing has replaced T4 as a measure of iodine status in sheep and cattle. The inorganic iodine is the free unbound fraction of iodine in the blood and is about a third of the total blood iodine –the remainder is bound to protein.

The serum inorganic iodine concentration reflects the iodine intake of the animal over the previous 2-3 days so it can change very rapidly. Sick/ anorectic animals should not be tested. Given the relatively low variability of serum inorganic iodine across a group of animals grazing the same pasture, testing only five animals in a group would likely reflect the iodine intake of the whole group.

Inorganic iodine in serum is very stable. As the thyroid is the main storage organ for iodine, measurement of iodine reserves in live or dead animals is not practicable.

The reference range for serum inorganic iodine which is not based on production data is identical for sheep and cattle:

Adequate >45 µg/L

Marginal 20 -45 µg/L

Deficient <20 µg/L

Recently treated animals usually have serum inorganic iodine >100 µg/L

Clinical iodine deficiency (expressed as goitre in neonates) can be diagnosed in dead perinatal lambs by weighing the thyroids and lamb and comparing the thyroid weight (g) to body weight (kg) ratio. Divide the weight of both thyroid glands in grams by the weight of the lamb in kilograms. This ratio has not been validated in other species.

Thyroid: birthweight ratio:

<0.4 - iodine supplementation not required

0.4-0.8 - iodine status unclear. Additional information required- eg response to treatment.

>0.8 - iodine supplementation required

Thyroid weights of normal neonates are around 2 g in lambs: <20 g in calves: <8 g in deer calves.

When to sample

Adult Sheep -	Samples should be taken from groups of ewes pre mating and pre lambing giving enough time for corrective measures to be instituted
Adult Cattle -	Pre mating or before the peak of lactation, and pre calving especially if they are on brassica crops
Deer -	Pre calving

SELENIUM

About 30% of New Zealand's farmland is selenium deficient for grazing stock. Reference ranges indicating insufficiency are <0.03 ppm selenium for pastures and <0.5 ppm (air dry weight) for soils.

Animal tests

Selenium that is absorbed from the diet or from supplements is translocated to serum and liver within hours. There is no storage organ for selenium. Both these sample types are therefore good indicators of the current selenium status of the animal (within the last month). Glutathione peroxidase (GPx), however, changes more slowly with changing intake, as it is only incorporated into red cells during haematopoiesis. This means that GPx predominantly reflects selenium intake 3 months previous. GPx will give a reliable indication of current selenium status provided that stock have been grazing the same soil type for the last 3 months and no selenium has been supplemented in this period, either directly or through the fertiliser.

The other test sometimes measured is whole blood selenium. As this measures both the selenium in serum and in the red cell, it lies between serum selenium and GPx in its responsiveness to changes in selenium intake.

The following is the range of selenium tests available through the Gribbles Veterinary laboratory network for the different species.

	Serum Se	Whole blood GPx	Whole blood Se	Liver Se
Bovine	n=5	n=5	n=5	n=5
Ovine	n=5	n=5	n=5	n=5
Cervine		n=5	n=5	n=5
Caprine			n=5	n=5

In cattle, the initial check should be done during the winter because selenium deficiency is known to depress milk production and may affect parturition, retention of foetal membranes and conception.

In sheep, pre-mating is a good time for the initial check to avoid the effect of selenium deficiency on early embryonic loss. A pre-lamb check should also be contemplated to prevent congenital and delayed muscular dystrophy. Selenium deficiency also retards growth so that checking concentrations in growing stock is indicated in marginal or deficient areas.

Pregnant goats should also be checked before kidding in order to prevent cardiac white muscle disease. Goats appear to require higher selenium concentrations to prevent against this disease than lambs and calves. In all species, vitamin E also plays a role in cardiac white muscle disease.

In deer the only selenium responsive condition so far recorded by Gribbles Veterinary is white muscle disease in young calves.

Pasture tests

Where there is more than one soil type pasture selenium concentrations should be tested to achieve a selenium profile of the farm.

ZINC

Pasture zinc concentrations are generally quite adequate for animal requirements in the North Island. There are areas in Otago and Southland where concentrations have been reported to be inadequate. In the main, any zinc deficiency is likely to be due to reduced zinc availability rather than too low zinc intakes - causes are high dietary calcium and sulphur, excess soil ingestion, or by feeding low digestible feeds. There are no significant mobilisable stores of zinc. Most of the control of zinc in the body is through regulating the amount of zinc absorbed from the diet.

The clinical signs of zinc deficiency include excessive salivation, deterioration of hair or wool texture followed by loss of hair or wool particularly around the mouth and eyes. The skin especially around the nostrils, neck, coronet and scrotum becomes thickened, scaly and dry, cracking readily. The animal may walk stiffly. Reproduction function can be impaired in sheep and cattle with poor testicular growth and development. Reduced growth rate can occur in association with the above signs or on its own.

Animal tests

Serum (n=10) is the preferred test for determining the zinc status of animals. In cattle and sheep serum zinc concentrations <7 µmol/l may be associated with clinical signs of zinc deficiency.

When sampling animals to determine their zinc status:

- Do not sample animals known to have inflammatory diseases (including facial eczema), or animals within two weeks of parturition as these processes depress serum zinc concentrations by up to 50%.
- Store vacutainers in an upright position at all times as there is significant leakage of zinc from the stopper into blood if the two are in contact (initial values can double within 24 hours of such contact).

Pasture tests

Primary zinc deficiency is likely to occur only where pasture zinc concentrations are consistently below 20 mg/kg. Pasture zinc concentrations may need to be higher than this in situations of reduced zinc availability, but this has been poorly defined under New Zealand grazing conditions. Surveys have found that pasture zinc concentrations in the North Island range from 25 - 50 mg/kg DM and from 7 - 50 mg/kg DM in the South Island.

The role of zinc in deer and goat production and health under New Zealand conditions is largely unknown.

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Appendix: Trace Element Reference Ranges

		Copper			Selenium				Cobalt/ Vit. B12		Zinc	Iodine		
Sample Unit		Serum Cu µmol/L	Serum Fx U/L	Liver Cu µmol/kg	Whole bld nmol/L	Serum nmol/L	Whole bld GPx KU/L	Liver nmol/kg	Serum pmol/L	Liver nmol/kg	Serum µmol/L	Serum T4 nmol/L	Plasma I_2 ng/mL	Urine I_2 µg/L
Sample No.		10	10	5	5	5	5	5	10	5	10	10	10	10
Cattle	L	<4.5	<7	<45	<130	<85	<0.5	<600		<75	<7.0		<20	<50
	M	4.5-7.0	7-14	45-95	130-250	85-140	0.5-2.0	600-850		75-220	7-12		20-80	50-150
	A	>7.0	>14	>95	>250	>140	2.0-25	>850		>220	12-18.5	>35	>80	>150
	E			>2,800			>3,000	>10,000			27-92			
Sheep	L	NR	NR	<65	<130	<52	<1.0	>250	<220	<280	<7.0		<20	<50
	M			65-300	130-250	52-100	1.0-3.0	250-450	220-500	280-375	7.0-9.0		20-80	50-150
	A			>300	>250	>100	>3.0	>450	>500 lambs >300 adults <300 low	>375 lambs >200 adults	9.0-18.5	>40 adult >72 lamb	>80	>150
	E			>2,800	>5,000			>15,000			27-92			
Deer	L	<5		<60	<100	NR	NI	<270	<336	<280	NI	50-130	<20	<50
	M	5-8		60-100	100-200								20-80	50-150
	A	>8	11-32	>100	>120		>3	>440					>80	>150
Goats	L				NI	NR	NI	<500		NI	NI	>68	<20	<50
	M							500-1100					20-80	50-150
	A	11-25	23-53	>160				>1100					>80	>150

Key: NR = Not recommended, NI = No information, L = Low, M = Marginal, A = Adequate/ Normal, E = Excessive