Trace element case studies for cattle and sheep

Methodology

A total of seven suckler beef and sheep farms, four in England and three in Wales, were identified for the study (see below for a summary of farm size and livestock numbers). Farmers were asked to provide background information including basic performance data and details of all trace element inputs into their animals over a year.

Case study		Area (ha)	Breeding ewes	Suckler cows
1	Lleyn peninsula	280	850	200
2	Bala, Gwynedd	140	700	35
3	Powys	150	760	22
4	Shropshire	518	800	240
5	Northumberland	650	1200	130
6	Warwickshire	465	1700	160
7	Somerset	530	430	60

Sample collection and analysis

Forage samples

On each farm four grazing/conservation fields were sampled in May/June and September. Samples were taken from representative areas with care taken to minimise contamination of the sample by soil. Soil contamination can lead to anomalously high levels of some trace elements (such as iron and cobalt) in forage samples.

Forage samples were sent for analysis to NRM laboratories where they were analysed for cobalt (Co), selenium (Se), copper (Cu), iron (Fe), sulphur (S), molybdenum (Mo), zinc (Zn) and iodine (I).

Discussions with NRM laboratory staff highlighted that the technique used for routine trace element analysis can be unreliable for selenium, especially at the lower levels. As a result selenium was analysed by Atomic Fluorescence Spectroscopy (AFS) which although very accurate is also more expensive. The laboratory also highlighted that the iodine result produced by routine analysis can not be considered to be reliable. The wider industry is aware of the limitations and the laboratory has suggested to its clients that they could set up a more accurate method for iodine but this would be considerably more expensive and so far clients have stuck with the cheaper method.

Eurofins Laboratory was approached to carry out iodine analysis by an alternative (more accurate) method. The high cost of the technique meant that samples were restricted to a bulked sample from each farm in the spring and autumn. The procedure involved an initial extraction followed by ICP-MS which has proved accurate and reliable in samples analysed for the food industry. Unfortunately despite this being an accepted procedure the results achieved by this method were also unreliable. Despite much research the laboratory has not been able to explain why this procedure could not cope with the determination of iodine in herbages.

In calculating the trace element inputs on farms in this study the NRM figures have been used to give a broad indication of iodine content of the forage but the figures do need to be treated with extreme caution.

Blood and liver samples

Blood samples were taken in the spring and the autumn by the farm's own vet and sent to the VLA in Shrewsbury for analysis. The aim was to sample eight ewes and eight lambs plus six cows and six calves for copper, cobalt (vit B_{12}) and selenium (GSH-Px) with half this number being analysed for thyroxine (T_4) to give an indication of iodine status.

Measuring selenium in blood is costly, and most UK labs measure a selenium containing enzyme, glutathione peroxidise, to determine blood selenium levels. Blood iodine levels also cannot be measured directly. This study chose to use the iodine containing enzyme thyroxine to indicate blood iodine status. Cobalt is not absorbed into the blood of ruminants, but is converted to vitamin B12 in the rumeno reticulum. Blood and liver vitamin B12 levels are used to assess cobalt status.

Where finished stock were sold deadweight the aim was to get liver samples from six lambs and six finished cattle. These liver samples were analysed by VLA Shrewsbury for copper, selenium, iron, manganese and zinc.

Sources of trace elements

The study aimed to capture all the trace elements supplied to the stock and included:

- Forage
- Compound feeds (including feed blocks)
- Straight feeds
- In feed minerals
- Free access mineral and trace element buckets/licks
- Mineral/vitamin drenches
- Trace element boluses
- Injections
- Anthelmintic products containing Se and Co
- Pasture dressing.

Assumptions used to calculate the trace element profiles

The trace element profiles are intended to give a very rough indication of the likely adequacy of the total diet across the year for the breeding stock. In many cases the trace element content of some, particularly straight, feedstuffs are not known and standard data from a number of sources has been used to provide a 'best estimate'. Where farmers have fed root crops *in situ* the levels of trace elements ingested will be academic due to the high levels of soil ingested.

Some specific assumptions have been applied to the data:

- In each case the recommended daily allowance or requirement and estimated total daily intakes have been calculated using average dry matter intakes of 2.5% of live weight for ewes and 2% for suckler cows and are assumed to remain constant throughout the year.
- Total daily allowances of cobalt, selenium and iodine have been based on information produced for the ARC (1980) technical review on the nutrient requirements of ruminant livestock. In reality the amount necessary to prevent deficiency in the animal may be lower.
- To simplify the calculation, the daily allowances for Co, Se and I have been assumed to be constant throughout the year irrespective of the physiological status of the animal.
- Copper requirements (rather than allowances) are based on information provided by The Mineral Nutrition of Livestock (3rd edition) and have been calculated to take into account:
  - the true availability of Cu in the forage which is influenced by levels of Mo, S and Fe.
  - the higher availability of copper from concentrate feeds
  - the increased copper requirements of ewes and cows in late pregnancy.
- The daily amount of trace element released from boluses has been assumed to be constant throughout the active life of the product although in reality roughening of the surface means that (for some products) the rate will increase over time
- Oral drenches which typically contain high levels of trace elements have been spread over a seven day period for all elements.
- The manufacturers declared analysis has been used wherever possible

Case Study 1

Richard Parry farms 280ha on the Lleyn peninsula. The farm is split into 2 holdings, one at 15 to 60 m above sea level and the other at 180 to 490 m above sea level (133 ha). The majority of the farm is owned with 80 ha rented near the lowland farm. The higher altitude farm has 60 ha of unimproved land and all other land is improved. A third of the lower altitude farm is improved every year. Swedes, maize, oats and barley are grown on 24 ha to provide winter feed.

Sheep

The flock consists of 850 breeding ewes and 250 ewe lambs are retained every year. Richard is gradually changing his flock from Texel cross Welsh ewes to 300 Lleyns and 530 Suffolk cross Lleyns. Texel rams are used on the Suffolk cross Lleyn ewes. Ewes are lambed early indoors, from mid January to the end of February and turned out onto the swedes as soon as they have lambed. The January lambing ewes are housed at the end of November and the February lambing ewes are housed a month later.

Lambs are sold finished on to the Waitrose scheme or to Morrisons from April to June. All remaining lambs are weaned at 12-14 weeks old in early May and housed to finish on creep feed. Rarely more than 200 lambs are housed and all lambs are finished and sold before the end of June. Richard achieved 140% lambs reared last year and mostly scans at 150-160%.

Cattle

The farm also has 200 Stabiliser cows. The majority (120) are spring calving (starting in March and continuing for nine weeks) and the remainder calve in July and August. 60% of the cows calve in the first cycle, 30% in the second cycle and 6% in the third cycle. Around 4% of the herd is barren each year. Calves are weaned at around six months of age and unless they are retained as replacements, are fattened and sold to St Merryn in Merthyr (bull beef) or to Woodheads (heifers). Most of the cattle on the farm are housed for six months and graze for six months. Late calving cows are fed high magnesium rolls from late September to November. Cows are overwintered on maize and grass silage diet. Weaned calves are fed silage and distiller’s wheat grains for fattening.

Trace element sampling results

On average trace element levels in the grass were reasonably satisfactory with sight variation between fields and season. Grass copper results were marginally low for cattle and sulphur levels were slightly raised which may affect copper availability. There were marginally low cobalt and selenium levels on selected fields. Autumn grass results were overall better than spring grass results.

Table 1 Farm on Lleyn peninsula Grass results

	Spring	**Autumn**	**Farm Average**	**Typical Average Level in Pasture**	**Satisfactory Pasture Levels to Avoid Deficiency Risk**
					More than
Copper (mg/kg)	7.70	8.60	8.2	9	8
Cobalt (mg/kg)	0.14	0.22	0.18	0.1	0.1
Selenium (mg/kg)	0.05	0.08	0.07	0.07	0.05
Zinc (mg/kg)	30.48	40.88	36	51	25
Minerals affecting availability of copper					*Less than*
Molybdenum (mg/kg)	0.52	0.47	0.5	1.3	1.5
Sulphur (%)	0.21	0.22	0.22	0.15	0.2
Iron(mg/kg)	269	539	405	150	500

The trace element profile for cobalt, selenium and iodine throughout the year has been plotted using the forage results (above) and the declared analyses of other feeds and supplements offered. The results are presented in the Appendix (Figures A1 and A2) and in each case the recommended daily allowance (Allowance) and estimated total daily intakes (Total intake) have been calculated. The graphs indicate that for ewes the estimated supply of all three trace elements is close to the recommended allowance throughout the year with two distinctive peaks relating to oral drenches of a multi-vitamin/mineral supplement given pre-tupping in July 2009 and pre-lambing in January 2010. The cows received a bolus containing Cu, Co, Se and I in May raising trace element supply well above requirements for six months although supply tended to be slightly below requirements over winter.

Predicted gross dietary copper requirements are influenced by interactions with molybdenum, sulphur and iron that affect the amount of absorbable copper in the diet. The graphs in the Appendix (Figure A3) show the contribution of forage as well as the estimated total dietary intake of copper. For ewes copper supply is close to requirements throughout the year with peaks corresponding to the oral drench whilst for cattle the bolus given in May increases supply well above requirements.

Spring blood results for both cattle and sheep at Mr Parry's farm were satisfactory (Table 2 & 3) with a few animals outside the reference range. Two cows had copper levels above the reference range. However, with copper, the blood levels do not always reflect the amount of copper in the body. Blood copper levels may be elevated when the liver is damaged, for example by liver fluke, releasing stored copper into the blood. So, blood copper may be elevated whilst liver copper stores are within the normal range. One ewe had high copper levels (28.9 umol/l) and T_4 values were slightly above the reference range in ewes and lambs, but this is unlikely to be of significance.

Table 2 Cattle blood results

Cows	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	18.07	18.88
Vit B_{12} (Cobalt) (pmol/l)	>100	187.17	186.67
GSH-Px (Selenium) (U/ml RBCs)	> 30	157.72	85.40
T_4 ((nmol/l)	26 to 84	54.32	46.43

Calves	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	17.62	12.93
Vit B_{12} (Cobalt) (pmol/l)	>100	347.83	227.50
GSH-Px (Selenium) (U/ml RBCs)	> 30	160.08	75.38
T_4 (nmol/l)	26 to 84		62.37

Richard decided to bolus all the sheep and cattle this year due to previous blood tests. Cattle blood tests have previously shown low selenium levels and there is a high abortion rate in the cattle (5%). The bolused animals will no longer receive a multivitamin drench or free access minerals. Richard hopes to have a better return on the inputs. Boluses have cost more than minerals, but he would like to assess whether they will give him a better return. All ewes were given a copper bolus pre tupping and the aim is to do the spring calving cattle with a multi-trace element bolus in January, summer calving cattle in April, calves will be bolused when weaned at housing and the younger calves in January. The number of barren cows has decreased and the scanning percentage of the ewes has increased to 164% (158% in previous year) although this may be due in part to a change in ewe breed.

Following this, autumn blood samples were overall satisfactory for all cows, calves, ewes and lambs.. ~~A~~ few animals were outside the normal rangein autumn sampling; two cows had high copper levels and one lamb had slightly low T_4~~,~~ these are not significant.

Table 3 Sheep blood results

Ewes	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	18.45	17.25
Vit B_{12} (cobalt))pmol/l)	>188	658.83	707.17
GSH-Px (Selenium) (U/ml RBCs)	> 50	128.77	113.65
T_4 ((nmol/l)	35 to 75	81.28	

Lambs	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	12.83	14.97
Vit B_{12} (cobalt) pmol/l)	>188	697.83	1415.17
GSH-Px (Selenium) (U/ml RBCs)	> 50	111.32	93.32
T_4 ((nmol/l)	35 to 75	124.82	41.32

Liver samples were taken from slaughtered lambs for trace element analysis in the spring and all results were satisfactory.

Summary

- Previous cattle blood samples have highlighted Se problems
- Forage analysis shows some marginally low Cu levels and some individual fields marginal for Se and/or Co. Sulphur levels slightly above recommended maximum.
- Blood samples this year show:
    - satisfactory levels in all stock

Changes made/future actions

- Sheep – switch from an oral drench for ewes to a copper bolus pre-tupping
- Cattle - switch from free access minerals to multi-trace element bolus

Case Study 2

Huw Roberts runs a 140 ha upland farm near Bala. The farm yard sits at 300 m above sea level with the fields ranging from 175 to 475 m. The majority of the grassland has been improved over time with only about 10 ha unimproved. He aims to reseed around four or five hectares each year with long term leys and occasionally includes rape to improve lamb finishing.

Sheep

The farm carries over 700 breeding ewes and 35 suckler cows. The majority of the ewes on the farm are pure Welsh (670) and some Cheviot cross Welsh (65). 400 Welsh ewes are put to Welsh rams and the remaining Welsh ewes are put to the Cheviot, the Cheviot crosses are put to Suffolk rams. Ewes scan at about 150% and all ewes are lambed outdoors from mid March to the end of April. Lambs are sold from the end of May onwards. Many Suffolk cross lambs are sold at Bala fat stock sales from May to weaning with weights varying from 30-35kg liveweight. All remaining lambs are weaned in the first week of August and sold direct to Randall Parker Foods at Llanidloes between September and November (with an average deadweight of 16kg in 2009). Lamb creep is offered to some of the early lambs (50) and some of the late lambs (50). Huw achieves a rearing percentage of 135%.

Last year ewes were fed from December due to the weather and sugar beet nuts were given at a rate of 0.2kg/head until scanning in late January. Big-bale silage is also offered to the ewes. After scanning twin bearing ewes are fed compound feed starting at 0.2kg and working up to 0.55kg split into two feeds each day. Singles are fed very little concentrate with 0.1kg offered a couple of weeks before lambing. All ewes have free access to Crystalyx extra high energy feed buckets from February to the end of April. Lambs are supplemented with a multi-vitamin/trace element drench at 4-6 week intervals throughout the summer.

Cattle

There are 35 Welsh Black cows and 12 in calf heifers on the farm. Half the cows are bred pure and half are crossed with a Charolais. The herd calves in the autumn starting in September (over about 6 weeks). Cows and calves are housed from late October to mid May each winter. Whilst inside cows are fed grass silage plus sugar beet nuts to improve body condition for bulling and calves are fed a calf mix. Calves are weaned in August and fed a beef nut at a rate of 3 kg/head when housed.

Trace Element Results

Overall the average results for the grass samples show copper levels below minimum levels for cattle, in particular in the autumn. High levels of sulphur and iron also compromise copper availability to the animal. Selenium was slightly low in one grass sample (reseed) in the spring. Another field was low in cobalt in the autumn (0.05).

Table 4 Bala farm grass results

	Spring	Autumn	Farm Average	Typical Average Level in Pasture	Satisfactory Pasture Levels to Avoid Deficiency Risk
					More than
Copper (mg/kg)	8.25	6.93	7.6	9	8
Cobalt (mg/kg)	0.30	0.19	0.14	0.1	0.1
Selenium (mg/kg)	0.10	0.09	0.09	0.07	0.05
Zinc (mg/kg)	38.65	39.73	39	51	25
Minerals affecting availability of copper					*Less than*
Molybdenum (mg/kg)	0.96	1.01	1	1.3	1.5
Sulphur (%)	0.25	0.25	0.25	0.15	0.2
Iron(mg/kg)	831.50	730.75	781	150	500

The trace element profile for cobalt, selenium and iodine throughout the year has been plotted using the forage results (above) and the declared analyses of other feeds and supplements offered. The results are presented in the Appendix (Figures A4 and A5) and in each case the recommended daily allowance (Allowance) and estimated total daily intakes (Total intake) have been calculated. The graphs indicate that the predicted supply of all three trace elements should meet the requirements of ewes and suckler cows throughout the year, with the exception of Se intakes for ewes which are marginally low in some months (see Figure 1 below), and it would be expected that both would have blood results above the minimum for cobalt, selenium and iodine.

Supply to ewes is seasonal with a peak around lambing associated with supplementary feed whilst supply to the suckler cows is generally more constant throughout the year. The pattern of selenium intake for ewes is reflected in the blood results with GSH-Px levels, high in June and lower in the autumn following a period of no supplementation (Table 6.)

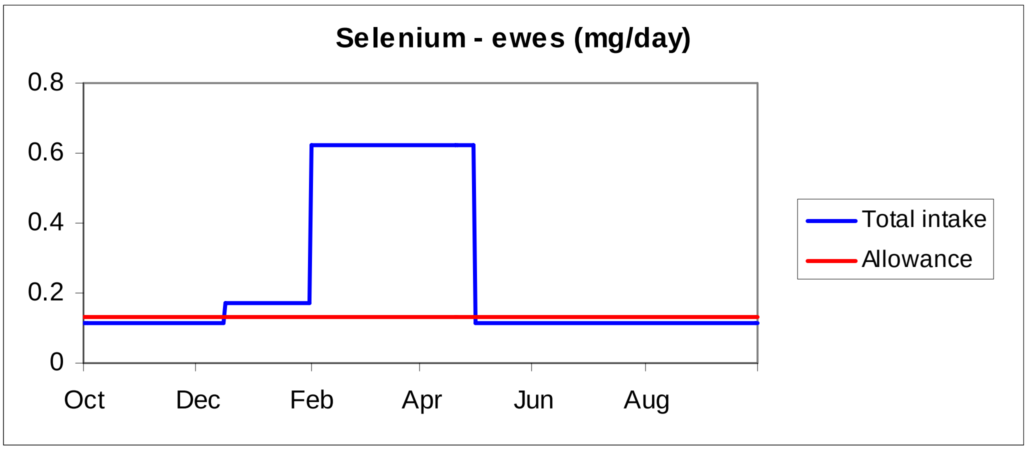


Figure 1. Annual Se profile for breeding ewes

Predicted gross dietary copper requirements are influenced by interactions with molybdenum, sulphur and iron that affect the amount of absorbable copper in the diet. Due to the higher availability of copper in compound feeds the overall gross requirement for forage plus concentrate diets can be reduced e.g. breeding ewes receiving supplementary feed around lambing. The graphs in the Appendix (Figure A6) show the contribution of forage as well as the estimated total dietary intake of copper. For cattle in particular (see below Figure 2) it can be seen that forage alone is insufficient to meet requirements although total dietary supply appears adequate.

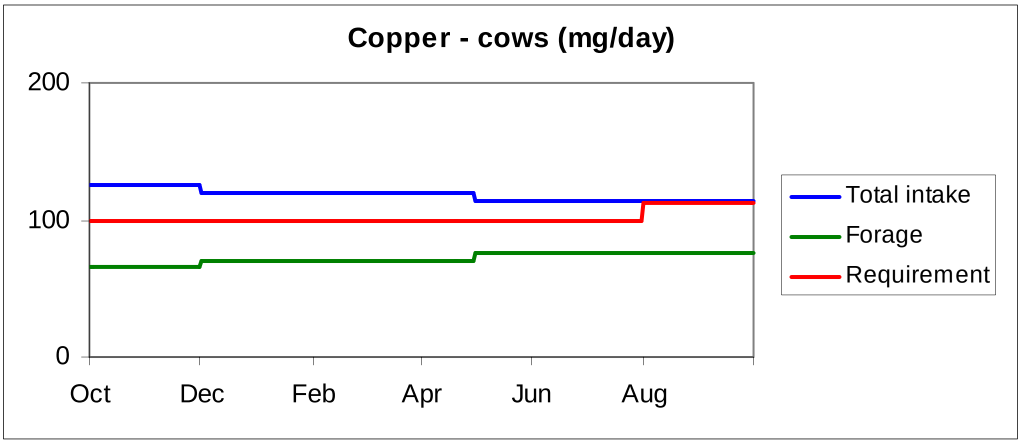


Figure 2. Annual copper profile for suckler cows

Despite the estimated copper supply being adequate, cattle blood results show low copper in the majority of the cattle in the spring and the autumn. It should be noted however that blood copper is not the most accurate way to predict copper deficiency, liver samples being a better guide. Young calves (7 months old) had levels within the reference range and only one of the cows and older calves (20 months) had levels of copper within the reference range in the spring. Low copper levels persisted to be a problem in the autumn blood sampling of the cattle with five of the eight bulling heifers showing low levels. Some of these had received a copper bolus.
Three calves showed levels of T_4 slightly above the reference range, but these results are unlikely to be of significance Cobalt levels were satisfactory in the cattle. Selenium levels in the cattle in the autumn are a slight concern, despite only one cow with levels below the reference range several cows have values only just within the reference range. GSH-Px is an enzyme in red blood cells, and as red blood cells can survive in the circulation for up to 6 weeks, GSH-Px levels are considered to be slightly historic. So animals could well be selenium deficient with these sorts of GSH-Px levels.

Table 5 Cattle blood results

	Reference Range	Cows Spring	Cows Autumn	Calves Spring
Copper (umol/l)	9 to 19	7.91	8.01	10.1
Vit B_{12} (Cobalt) (pmol/l)	>100	155.50	163.50	223.75
GSH-Px (Selenium) (U/ml RBCs)	> 30	60.69	41.11	71.85
T_4 (nmol/l)	26 to 84	64.46	46.68	93.05

All ewe and lamb blood results were satisfactory in the spring (Table 3). In the autumn, blood sampling showed that three of the eight ewes were deficient in selenium although the overall average is greater than the reference range minimum. All lamb liver samples were within the reference range.

Table 6 Sheep blood results

	Reference Range	Ewes Spring	Ewes Autumn	Lambs Spring
Copper (umol/l)	9 to 19	14.04	15.38	21.08
Vit B_{12} (Cobalt) (pmol/l)	>188	527.38	355.00	587.50
GSH-Px (Selenium) (U/ml RBCs)	> 50	283.03	67.06	170.40
T_4 (nmol/l)	35 to 75	66.41	81.45	70.98

The cattle blood results appear to have confirmed the copper issue Huw suspected on his farm. Liver samples would provide a better assessment of copper deficiency but were unavailable on this farm. Huw has been offering minerals to the cattle but this appears to be insufficient for some of them. Intakes of free access mineral blocks are extremely variable and Huw is considering whether he is better spending money on boluses that ensure all animals receive their requirements.

Summary

- Forage analysis shows some fields with low Cu levels and raised sulphur and iron levels
- Individual fields with low Co or Se levels
- Blood samples this year show:
    - Some copper levels below the reference range in cows and bulling heifers but no liver samples available to assess Cu deficiency further.
    - Breeding ewes and lambs satisfactory in the spring but some ewes low in selenium in the autumn

Changes made/future actions

- Cattle - considering switching from a free access high copper mineral block to a trace element bolus

Case Study 3

Keith William runs a 150 ha upland farm in Mid Wales. The farm sits on clay soils at 260 to 350 m above sea level. Some of the higher ground has peat soils. The majority of the farm (75%) was improved in the late 80's and very little grassland improvement has been carried out until recently. 12 ha were overseeded in 2009 and another 3 ha were improved in 2010. Half was overseeded and the other half was reseeded with red clover for comparison.

Sheep

There are 760 breeding ewes, including 200 pure Welsh, 500 Mules and Texel cross Mules and some pedigree Texels. Keith purchased some Lleyn rams last year and has used them on the Welsh ewes to produce replacements. The majority of the ewes are lambed indoors. Lambing starts in the last few days of March and the majority of ewes have lambed within three weeks. Ewes are scanned at 140% and losses are low with 127% lambs reared. Around 100 ewe lambs are also lambed.

One draw of finished lambs is taken before lambs are weaned in late July/early August. The majority of lambs are sold finished in September and October direct to the abattoir with many going through the Waitrose scheme. Last year the lambs on the Waitrose scheme averaged 17.8 kg dead weight. Due to the buoyant store trade in 2009, 200 lambs were sold store at 35 kg liveweight. Mineral and vitamin drenches supplements have typically been given to the ewes pre tupping and pre lambing due to a known selenium deficiency on the farm.

Lambs are also given mineral supplements (multivitamin drench) in early May and some of the poorer lambs are given a further supplement in September (often around 150 lambs). This year all lambs were given mineral supplements in the form of a multivitamin drench at weaning due to their condition.

Cattle

Keith also runs a herd of spring calving Welsh Black cattle. There are up to 60 cattle on the farm at any time including 22 breeding cows. The calves are finished on the farm and sold at around 30 months to the Waitrose scheme or to a local butcher. Each year about 20 calves are produced from 22 cows. The bull is put in with the cows for 12 weeks and anything that is barren is sold (one sold last year). All cattle are housed from early December to the end of April on a grass silage based diet. Some of the finishing cattle are housed earlier in November and fed a finishing concentrate. The younger calves are fed 0.7kg sheep concentrate over the winter months (3.5 months) with ad lib forage.

Trace element sampling

On average trace element levels in grass showed low levels of copper and high levels of sulphur affecting copper availability. Spring grass results showed high molybdenum and sulphur in all improved land. The molybdenum levels had decreased by the autumn to within the acceptable limits. Cobalt was marginally low in one field in the spring at 0.07mg/kg and selenium was marginally low in one field in the spring at 0.03mg/kg.

Table 7 Mid Wales farm grass results

	Spring	Autumn	Average	Typical Average Level in Pasture	Satisfactory Pasture Levels to avoid deficiency risk
					More than
Copper (mg/kg)	8.13	7.3	7.7	9	8
Cobalt (mg/kg)	0.13	0.11	0.12	0.1	0.1
Selenium (mg/kg)	0.06	0.05	0.06	0.07	0.05
Zinc (mg/kg)	36.48	44.38	40	51	25
Minerals affecting availability of copper					*Less than*
Molybdenum (mg/kg)	1.81	1.13	1.5	1.3	1.5
Sulphur (%)	0.24	0.27	0.3	0.15	0.2
Iron(mg/kg)	397.5	351.75	375	150	500

The trace element profile for cobalt, selenium and iodine throughout the year has been plotted using the forage results (above) and the declared analyses of other feeds and supplements offered. The results are presented in the Appendix (Figures A7 and A8) and in each case the recommended daily allowance (Allowance) and estimated total daily intakes (Total intake) have been calculated. Overall cobalt and iodine supply appears to be adequate for both ewes and cows with peaks in intake for ewes corresponding with administration of the trace element drench. Selenium intake is marginally below requirements for both cattle and sheep for the majority of the year (Figures 3 and 4 below) resulting in low blood GSH-Px (Se) at certain times of the year (see Tables 8 and 9).

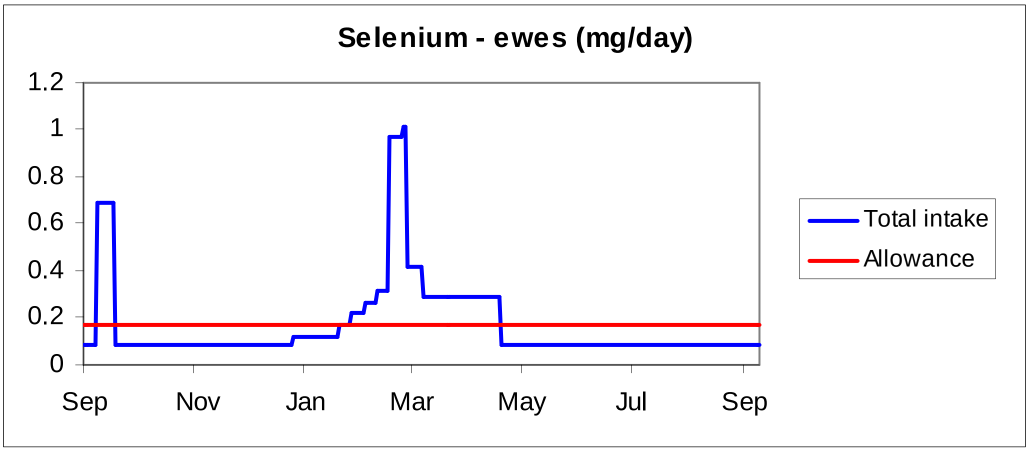


Figure 3. Annual Se profile for breeding ewes

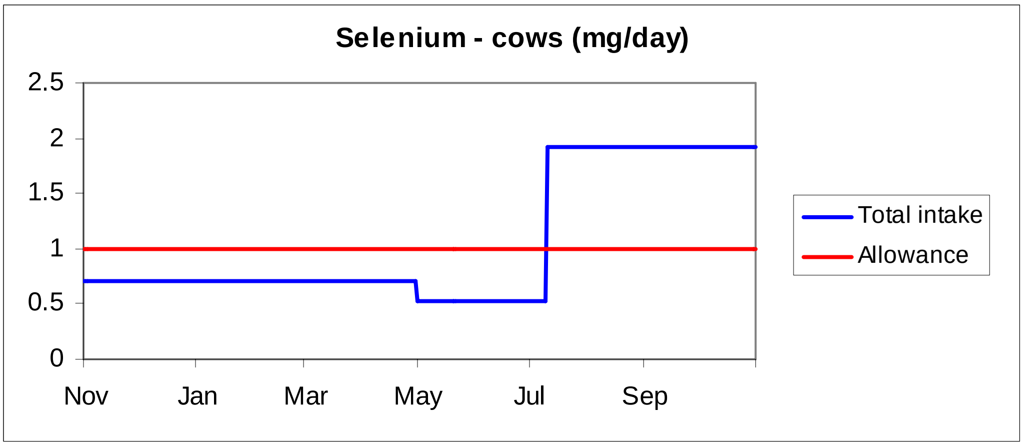


Figure 4. Annual Se profile for suckler cows

Predicted copper requirements are influenced by interactions with molybdenum, sulphur and iron that affect the amount of absorbable copper in the diet. Due to the higher availability of copper in compound feeds the overall gross requirement for forage plus concentrate diets can be reduced e.g. breeding ewes receiving supplementary feed around lambing. The graphs in the Appendix (Figure A9) show the contribution of forage as well as the estimated total dietary intake of copper.
For cattle, total copper intake is below requirement until mid-July when they received a copper bolus (Figure 5), whilst for ewes intakes are above requirements around lambing when ewes receive compound feed.

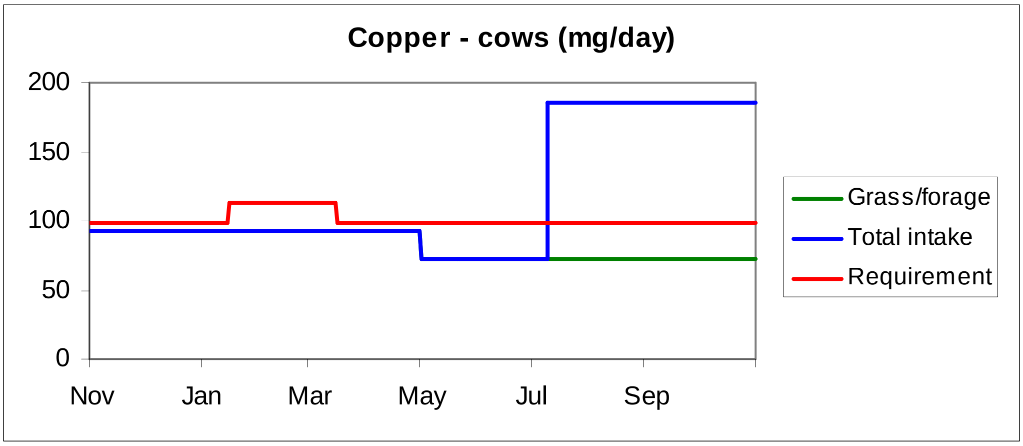


Figure 5. Annual copper profiles for suckler cows

The cattle blood results were of particular concern in the spring with the average copper level in cows at 4.7 umol/l and calves at 8 umol/l. Only 2 calves were within the recommended range and all breeding cows were below the recommended range. All cattle sampled in the spring (cows and calves) were also below the recommended range for selenium.

Table 8 Cattle blood results

Cows	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	4.72	12.97
Vit B_{12} (Cobalt) (pmol/l)	>100	221.33	160.00
GSH-Px (Selenium) (U/ml RBCs)	> 30	11.22	38.87
T_4 (nmol/l)	26 to 84	72.73	44.77

Calves	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	8.05	11.23
Vit B_{12} (Cobalt) (pmol/l)	>100	449.50	166.33
GSH-Px (Selenium) (U/ml RBCs)	> 30	11.08	34.93
T_4 (nmol/l)	26 to 84	128.23	56.90

These results and the colour of the coats of the young calves persuaded Keith to give all the cows and young calves copper boluses and slow release selenium injections. Consequently autumn cattle blood results were overall satisfactory with only one calf and one cow slightly deficient in selenium. Figure 6 shows the spring and autumn Copper levels in the cattle blood results. The greyed out area shows how the autumn levels are just in the reference range. Figure 7 shows the Selenium levels in the cattle blood results. The red line is the reference range > 30 u/ml which shows the autumn selenium levels are just above the reference range.

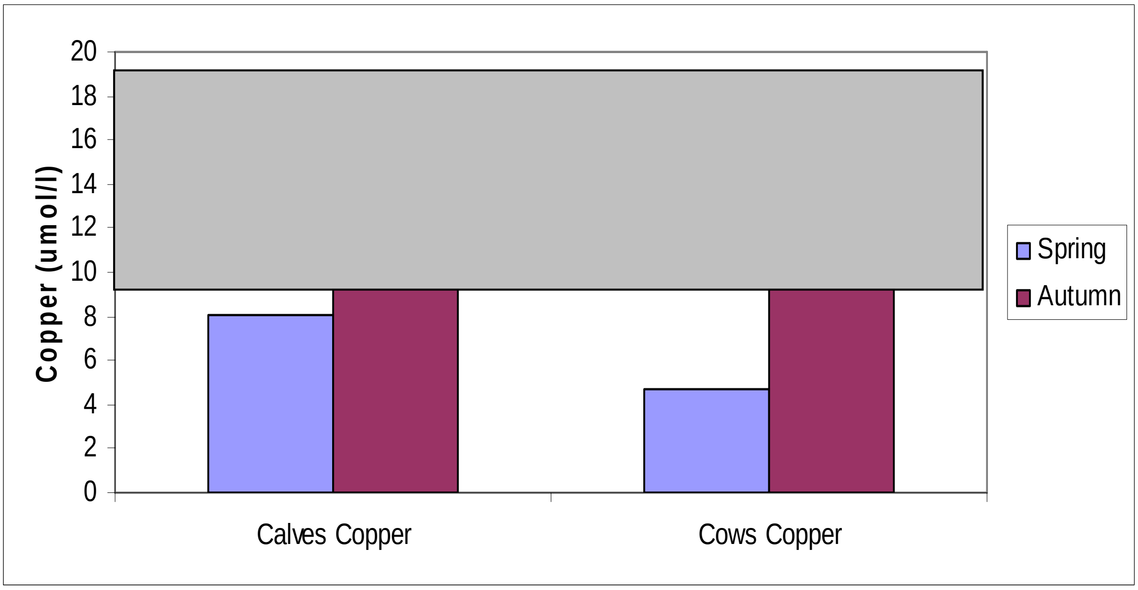


Figure 6 Mid Wales Cattle copper blood levels

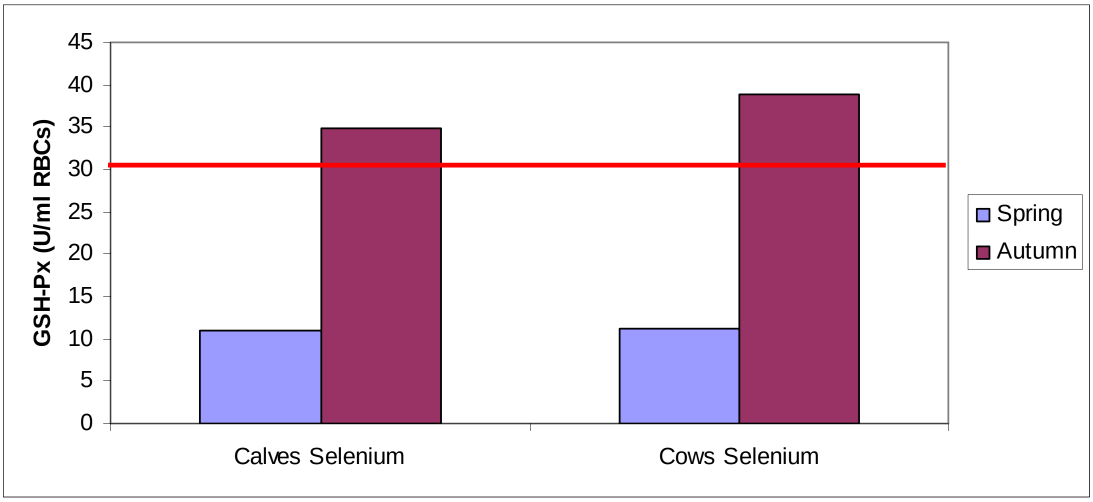


Figure 7 Mid Wales Cattle selenium blood levels

Half the finishing cattle were given a trace element bolus and weight gains were compared to those that had not been given boluses. The finishing cattle averaged 371kg when treated. The non bolused animals on average gained 70kg (daily weight gain of 0.80 kg/day) and the bolused animals gained 76.5kg (daily weight gain of 0.88 kg/day) over 87 days.

Cattle liver samples showed low iron levels and slightly low zinc levels. The only heifer that was sampled showed copper and selenium deficiency. This animal was not fed any concentrates while the steers had been fed concentrates. These slaughtered animals had not been given a bolus because they were nearly ready for slaughter when the other finishing cattle were bolused.

Spring blood results for the ewes were satisfactory (Table 9). Liver samples from lambs showed that 5 of 6 lambs were selenium deficient. White muscle disease has been a problem on this farm in the past and is the reason that lambs are given mineral supplements. These lambs had been given a multivitamin drench 3 weeks before slaughter. An alternative method of supplementation needs to be considered.

Autumn blood sampling showed all ewes and lambs to be deficient in selenium. Seven of the eight lambs were also slightly deficient in cobalt in the autumn and all ewes had slightly low levels of T_4.

Table 9 Sheep blood results

Ewes	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	11.85	14.11
Vit B_{12} (Cobalt) (pmol/l)	>188	589.50	1285.71
GSH-Px (Selenium) (U/ml RBCs)	> 50	115.54	20.34
T_4 (nmol/l)	35 to 75	54.53	30.55

Lambs	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	16.79	18.86
Vit B_{12} (Cobalt) (pmol/l)	>188	392	159.50
GSH-Px (Selenium) (U/ml RBCs)	> 50	190.5	24.54
T_4 (nmol/l)	35 to 75	90.57	57.28

The results have highlighted to Keith the extent of the copper and selenium deficiencies on his farm. Consequently he has treated both cattle and sheep differently this year compared to previous years with additional supplementation. Keith plans to monitor this carefully over the next few years, in particular the cost benefits.

Summary

- Forage analysis shows some fields with low Cu and raised S and Mo
- Individual fields with low Co or Se levels
- Blood samples this year show:
    - Low copper and selenium in cows and calves in spring.
    - A liver sample from a heifer that did not receive concentrate feed showed low Cu and Se.
    - Cu and Se acceptable in autumn following supplementation
    - Breeding ewes and lambs overall satisfactory in the spring
    - Breeding ewes and lambs low Se in autumn
    - Lambs slightly low in Co in autumn and ewes slightly low T_4 values

Changes made/future actions

- This year cows and young calves have received a copper bolus and slow release selenium injection.
- Trialled a multi-trace element bolus with some finishing cattle to assess cost effectiveness
- Sheep currently receive an oral drench of a multi-vitamin & trace element drench – the low Se levels in the autumn mean that an alternative method of supplementation should be considered.

Case Study 4

James Evans farms in partnership with his father and brother on two holdings in Shropshire. The farm is an upland farm extending to around 518 ha much of which is in the LFA and is managed under a contract farming arrangement. The farm sits on sandy, clay loam soils at 120 – 365 m above sea level and receives around 900 mm rain annually. No grassland improvement has been carried out in the last ten years and around 160 ha are classified as rough grazing. Conserved forage is made on around 80 ha of grassland.

Sheep

The farm carries a total of 800 breeding ewes. In the past these have been Welsh Mules but James is moving to Lleyn ewes, with around 300 lambed in 2010. Following tupping on grass, ewes spend December to February on stubble turnips. This year Lleyn ewes were lambed outside from the third week of March receiving feed buckets rather than being trough fed. Typically ewes scan at around 180% with 160% reared. Lambs are weaned at 16 weeks of age in July and finished lambs are sold off grass from 1st August. Some late finishing lambs are finished off turnips. Lambs are sold dead weight at an average of 19 kg carcass weight. A proportion of lambs are sold as stores.

Cattle

The farm also carries spring and autumn calving herds of suckler cows. The 160 strong spring herd consists of purebred Stabiliser and Limousin cross Holstein cows all put to Stabiliser bulls whilst a further 80 Stabiliser and Limousin cross cows calve in the autumn. The aim is to move to Stabiliser cows in both herds. The spring calving cows are typically housed in early November and overwintered on a grass silage and straw ration and fed 100g/head of a specially formulated mineral. All cows receive a multi-trace element/vitamin bolus in early March before being turned out to grass as they calve. Calving spread is around 12 weeks with 96 calves per 100 cows being reared typically. Calves do not receive creep feed until the autumn; they are weaned at 6 – 8 months and are sold as stores.

Trace element sampling

Analysis of four grass fields showed all to be low in cobalt and selenium although levels were slightly higher in the autumn. On average copper levels were adequate and only moderate levels of antagonists were present although individual fields did show elevated sulphur and molybdenum.

Table 10 Shropshire Farm Grass Results

	Spring	Autumn	Shropshire Farm Average	Typical Average Level in Pasture	Satisfactory Pasture Levels to avoid deficiency risk
					More than
Copper (mg/kg)	9.53	9.18	9.35	9	8
Cobalt (mg/kg)	0.046	0.088	0.067	0.1	0.1
Selenium (mg/kg)	0.023	0.038	0.031	0.07	0.05
Zinc (mg/kg)	36.73	60.03	48.38	51	25
Minerals affecting availability of copper					*Less than*
Molybdenum (mg/kg)	1.46	1.20	1.33	1.3	1.5
Sulphur (%)	0.19	0.21	0.20	0.15	0.2
Iron(mg/kg)	107.25	312.0	209.63	150	500

The trace element profile for cobalt, selenium and iodine throughout the year has been plotted using the forage results (above) and the declared analyses of other feeds and supplements offered. The results are presented in the Appendix (Figures A10 and A11) and in each case the recommended daily allowance (Allowance) and estimated total daily intakes (Total intake) have been calculated. The graphs indicate that the predicted supply of all three trace elements should fully meet the requirements of suckler cows throughout the year. The profiles for ewes show adequate levels of cobalt and iodine but selenium levels are below the recommended allowance for around eight months of the year. The prolonged period of low selenium intake between May and September leaves ewes vulnerable to deficiency at the end of the summer (Figure 8) and is reflected in the blood samples taken in September.

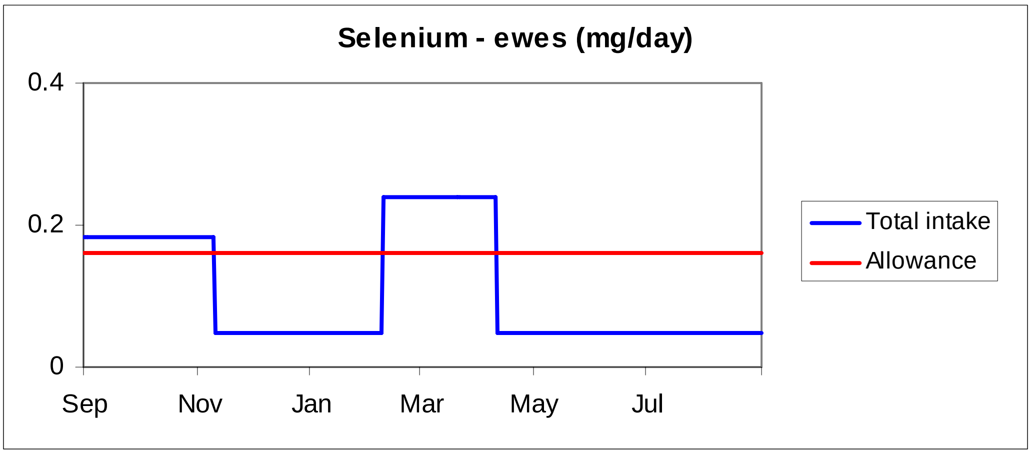


Figure 8. Annual Se profile for breeding ewes

Predicted copper requirements are influenced by interactions with molybdenum, sulphur and iron that affect the amount of absorbable copper in the diet. The graphs in the Appendix (Figure A12) show that copper intakes for cows and sheep exceed requirements throughout the year. It can be seen however for cows that forage alone does not meet requirements for around six months of the year.

Blood results for cows and calves were satisfactory for all tests in the spring. In the autumn, although average results were satisfactory, half of the calves sampled were low in copper and one was low in selenium. At the time of the blood sampling calves had not received any creep feed. The results for the cows remained satisfactory for all tests.

Table 11 Cattle blood results

Cows	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	14.4	15.3
Vit B_{12} (Cobalt) (pmol/l)	>100	141	127
GSH-Px (Selenium) (U/ml RBCs)	> 30	127	76
T_4 (nmol/l)	26 to 84	53.9	54.7

Calves	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	12.1	9.9
Vit B_{12} (Cobalt) (pmol/l)	>100	198	142
GSH-Px (Selenium) (U/ml RBCs)	> 30	93	44
T_4 (nmol/l)	26 to 84	82.1	69.7

Blood sampling of ewes and lambs showed all results to be above the minimum in the spring. By the autumn, selenium levels in the majority of sheep were below the minimum and the decision was taken to supplement all the breeding ewes with a multi-trace element bolus. Liver samples taken from finished lambs in September confirmed the low selenium levels in some animals. Results for the other elements were satisfactory for ewes and lambs.

Table 12 Sheep blood results

Ewes	Reference Range	Spring	Autumn	Post bolus
Copper (umol/l)	9 to 19	14.3	14.6	17.6
Vit B_{12} (Cobalt) (pmol/l)	>188	382	414	1257
GSH-Px (Selenium) (U/ml RBCs)	> 50	119	28.1	114.5
T_4 (nmol/l)	35 to 75	79.4	36.1	

Lambs	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	16.0	13.6
Vit B_{12} (Cobalt) (pmol/l)	>188	362	271
GSH-Px (Selenium) (U/ml RBCs)	> 50	120	49
T_4 (nmol/l)	35 to 75	132.5	48.0

Ewes were bolused in late September with a multi-trace element bolus and then blood sampled around a month later. The results showed levels of cobalt and selenium to have increased by three to four times (Table 12). James will monitor the performance of the flock to assess the cost-effectiveness of the treatment.

Summary

- Forage analysis shows all fields to be low in Co and Se
- Individual fields with marginally low Cu and/or raised S and Mo
- Blood samples this year show:
    - All cattle and sheep results satisfactory in the spring
    - Some Cu levels in calves below the reference range in the autumn
    - Breeding ewes and lambs low Se in autumn
    - Breeding ewes satisfactory following administration of trace element bolus

Changes made/future actions

- This year breeding ewes have been given a multi-trace element bolus pre-tupping – cost effectiveness to be monitored

Case Study 5

Simon Bainbridge farms 650 Ha near Morpeth in Northumberland. It is an organic farm that sits on sandy loam soils at 200 – 260 m above sea level and receives around 1200 mm of rainfall annually. The majority of the land is classed as rough grazing but around 80 ha are used for grass silage and a further 60 ha for arable crops. Crops grown include barley and red clover. In 2010 a pasture dressing was applied to the red clover and grass silage fields in May. This contains a wide range of minerals and trace elements (see Table 14) and is applied as a granule/dust using a lime spreader.

Sheep

In total there are around 1200 Swaledale and North Country Mule ewes on the farm. Swaledales are either bred pure or put to Blue Faced Leicester rams and the Mules are put to Suffolk rams. In October/November prior to tupping all ewes receive a trace element bolus containing Co, Se and Cu but do not receive any other supplements during tupping. Ewes are offered hay and organic feed buckets over winter and twin bearing Mules are housed from mid/late February until April on a TMR ration of silage, wholecrop barley and some purchased protein. A specially formulated mineral supplement that includes copper is mixed into the diet. All ewes lamb at grass from mid-April and do not receive any supplements. The Swaledale ewes typically scan at around 150% and the Mules at 180 % with around 150% reared overall. Lambs are weaned at around 14 – 16 weeks of age and are sold finished between August and the following April. At weaning Swaledale and Mule lambs are given a trace element bolus (Co, Se and Cu) whilst the Suffolk cross lambs receive monthly injections of vitamin B_{12}. Lambs are finished on silage aftermaths and red clover. Later finishing lambs move on to rape or turnips before being finished indoors.

Cattle

The farm also carries 130 Aberdeen Angus and continental cross suckler cows. A total of 65 calve down in the autumn (from 20th September) and 55 in the spring (from 20th March). Cattle are housed from the end of October and are fed a TMR ration based on silage and straw with specially formulated high copper minerals. Autumn calvers also receive some home grown barley. All cows receive a trace element bolus containing Co, Se and Cu pre-turnout in May. Spring born calves are weaned at 7 months and autumn born calves at 11 months of age. Finished cattle are sold dead weight with some stock supplying a local farm shop.

Trace element sampling

Three grass fields and one of red clover were sampled and average results for the four fields are shown below in Table 13. The spring results identified low copper levels in all fields although minerals affecting copper availability were also low. Additionally all fields were below recommended levels for cobalt and one field was low in selenium. Selenium levels were however high in two fields that had received the pasture dressing raising the overall average. With the exception of selenium, levels of all trace elements were higher at the autumn sampling than in June and although copper levels were at satisfactory levels, sulphur and molybdenum had also increased, reducing copper availability.

Table 13 Northumberland Grass results

	Spring	**Autumn**	**Farm Average**	**Typical Average Level in Pasture**	**Satisfactory Pasture Levels to avoid deficiency risk**
					More than
Copper (mg/kg)	6.33	11.43	8.88	9	8
Cobalt (mg/kg)	0.048	0.103	0.075	0.1	0.1
Selenium (mg/kg)	0.44	0.11	0.27	0.07	0.05
Zinc (mg/kg)	33.10	47.18	40.14	51	25
Minerals affecting availability of copper					*Less than*
Molybdenum (mg/kg)	0.54	1.84	1.19	1.3	1.5
Sulphur (%)	0.16	0.32	0.24	0.15	0.2
Iron(mg/kg)	79.2	315.75	197.48	150	500

There was some variation between fields with the red clover typically having higher levels of cobalt and selenium than the grass fields and dressed fields higher than the undressed. Quantities of minerals and trace elements applied to these fields are shown below in Table 14 and a comparison of copper, cobalt and selenium levels in forage for dressed *vs* undressed fields is shown in Table 15.

Table 14. Levels of minerals and trace element applied.

Major minerals			Trace Elements	
	Kg/ha			g/ha
Calcium	300		Silicon	150
Phosphorus	11		Manganese	750
Potassium	11		Copper	750
Magnesium	45		Zinc	750
Sodium	64		Boron	300
Sulphur	23		Iodine	80
			Selenium	60
			Cobalt	50

Table 15 Comparison of trace element levels in pasture (mg/kg)

	Top dressed in May (red clover and grass silage)		No top dressing (grazing)	
	Spring	Autumn	Spring	Autumn
Copper	6.8	13.2	5.9	9.7
Cobalt	0.06	0.13	0.04	0.08
Selenium	0.83	0.16	0.05	0.06

The trace element profile for cobalt, selenium and iodine throughout the year has been plotted using the forage results (above) and the declared analyses of other feeds and supplements offered. The results are presented in the Appendix (Figures A13 and A14) and in each case the recommended daily allowance (Allowance) and estimated total daily intakes (Total intake) have been calculated. The graphs indicate that the predicted supply of all three trace elements should fully meet the requirements of suckler cows throughout the year and the expectation would be that blood results would be above the minimum for cobalt, selenium and iodine. Supplies of selenium and iodine appear to be above requirements for ewes throughout the year but cobalt supply is marginally low throughout the summer grazing period (Figure 9).

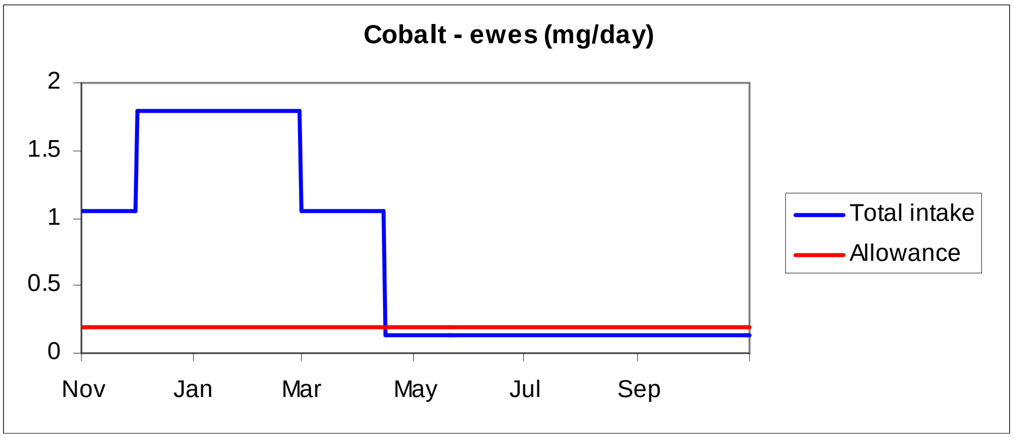


Figure 9. Annual Co profile for breeding ewes

Predicted copper requirements are influenced by interactions with molybdenum, sulphur and iron that affect the amount of absorbable copper in the diet. The graphs in the Appendix (Figure A15) show that total copper supply for the cows is above requirements throughout the year. The supply for ewes is above requirements over the winter feeding period but falls to closely match requirements over the summer. Blood samples for cows and ewes should be above the recommended minimum based on these intakes.

Cattle blood results were satisfactory for all tests for both cows and calves in the spring. However, in the autumn blood samples for cows remained satisfactory but the majority of calves had copper levels below the reference range. Levels for other tests were satisfactory although the practice vets considered selenium levels in calves to be marginal and likely to respond to supplementation.

Table 16 Cattle blood results

Cows	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	13.2	11.4
Vit B_{12} (Cobalt) (pmol/l)	>100	182	166
GSH-Px (Selenium) (U/ml RBCs)	> 30	98	91
T_4 (nmol/l)	26 to 84	52.7	48.6

Calves	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	11.7	5.6
Vit B_{12} (Cobalt) (pmol/l)	>100	312	210
GSH-Px (Selenium) (U/ml RBCs)	> 30	53	40
T_4 (nmol/l)	26 to 84	77.5	69.2

Blood sampling of Mule ewes in June showed two out of six to be marginally low in Co but with satisfactory levels for all other tests. Four out of the six Suffolk cross lambs were low in Cobalt (vitamin B_{12}) and two lambs had slightly raised T_4 levels. Lambs were weaned in July and received either a trace element bolus (for Swaledale and North Country Mule lambs) or monthly injections of vitamin B_{12} (for Suffolk cross lambs). The second sampling took place in October and all ewes had satisfactory levels for all blood tests. Sampling of Suffolk cross lambs revealed six of the eight sampled to have cobalt levels below the reference minimum.

Table 17 Sheep blood results

Ewes	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	14.6	17.0
Vit B_{12} (Cobalt) (pmol/l)	>188	236	709
GSH-Px (Selenium) (U/ml RBCs)	> 50	245	160
T_4 (nmol/l)	35 to 75	58.5	48.1

Lambs	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	14.6	17.0
Vit B_{12} (Cobalt) (pmol/l)	>188	197	158
GSH-Px (Selenium) (U/ml RBCs)	> 50	255	270
T_4 (nmol/l)	35 to 75	83.4	56.1

Blood sampling of suckler cows has confirmed the benefits of the trace element bolus given at turnout and this will continue. Results for the young calves revealed some low copper and marginal selenium results. As a result the decision has been taken to give a trace element bolus containing Co, Se and Cu to autumn born calves at turn out and spring born calves in mid-summer once they are at least 2 months old and weigh over 100 kg.

The blood results for lambs highlighted the cobalt issues on the farm. The Swaledale and Mule lambs will continue to receive a bolus whilst the Vit B_{12} injections will continue for the terminal sire cross lambs. This decision is based largely on the relative costs of the two treatments. Typically all ewes have received a bolus pre-tupping but this year this will only be given to the hill ewes. The mule ewes will be housed for longer this winter and will receive adequate trace elements in their winter ration.

The practice of formulating bespoke minerals based on forage analysis will continue. This is particularly relevant for this farm which, as an organic unit, has to justify any supplementation it provides.

Summary

- Forage analysis shows fields to be low in Cu in spring and Co throughout the year.
- Pasture dressing effective in raising trace element levels in forage
- Blood samples this year show:
    - All cattle results satisfactory in the spring
    - Some low Cu and marginal Se levels in calves in the autumn
    - Overall breeding ewes satisfactory in spring and autumn
    - Suffolk cross lambs low Co levels in June and October

Changes made/future actions

- Suffolk cross lambs to continue with injection of B12 as more cost-effective than a bolus – could consider reducing the interval between injections to three weeks.
- Swaledale and mule lambs to continue with a trace element bolus.
- Autumn born calves will receive a bolus containing Co, Se and Cu at turn out in spring
- Spring born calves to receive a bolus mid-summer once they are at least 2 months of age and weigh over 100kg.

Case Study 6

Richard Smith farms 465 Ha near Leamington Spa. The farm sits on heavy clay soils at 180 m above sea level. All the land has been improved in the last 10 years and around 80 ha are used for forage conservation. The swards are generally productive and have high clover content.

Sheep

The farm carries around 1700 North Country Mule ewes that are put to Suffolk, Texel and Charollais rams. Ewes lamb outside from the end of March over three to four weeks and receive 0.5 kg per day of compound feed over this period. Richard does not pregnancy scan his ewes but generally ewes rear around 180%. The first draw of finished lambs is at the end of July before weaning in early August. Creep feed is offered to lambs from late July and around 90% of lambs are sold finished at an average dead weight of 19.7 kg between July and February. The sheep are offered a free access mineral specially formulated to include copper from the end of December to the end of June.

Cattle

The farm also carries 160 suckler cows put to Simmental bulls. The majority of these are spring calving. Cows are typically housed from the end of November until turnout in May and are fed a silage based diet supplemented with high energy feed blocks. The youngstock typically receive a free access mineral although Richard intends to bolus some animals this year. Generally around 95 calves are reared per 100 cows and they are all sold as store cattle.

Trace element sampling

Overall grass results were consistent between fields and seasons with the exception of selenium and indicate copper and cobalt levels below the minimum recommendation for all samples. In addition sulphur and molybdenum levels were raised, affecting availability of copper to the animal. All samples had high selenium levels in the spring but appeared to be deficient in the autumn.

Table 18 Leamngton spa Farm Grass Results

	Spring	Autumn	Farm Average	Typical Average Level in Pasture	Satisfactory Pasture Levels to avoid deficiency risk
					More than
Copper (mg/kg)	7.45	6.98	7.21	9	8
Cobalt (mg/kg)	0.037	0.048	0.042	0.1	0.1
Selenium (mg/kg)	0.97	0.03	0.50	0.07	0.05
Zinc (mg/kg)	30.83	29.55	30.19	51	25
Minerals affecting availability of copper					*Less than*
Molybdenum (mg/kg)	3.09	4.63	3.86	1.3	1.5
Sulphur (%)	0.23	0.26	0.25	0.15	0.2
Iron(mg/kg)	120.58	150.25	135.41	150	500

The trace element profile for cobalt, selenium and iodine throughout the year has been plotted using the forage results (above) and the declared analyses of other feeds and supplements offered. The results are presented in the Appendix (Figures A16 and A17) and in each case the recommended daily allowance (Allowance) and estimated total daily intakes (Total intake) have been calculated. The graphs indicate selenium levels above requirements for both cows and ewes throughout the year. Cobalt and iodine intakes are above requirements for 3-6 months of the year and generally close to requirements for the rest of the year (e.g. Figure 10).

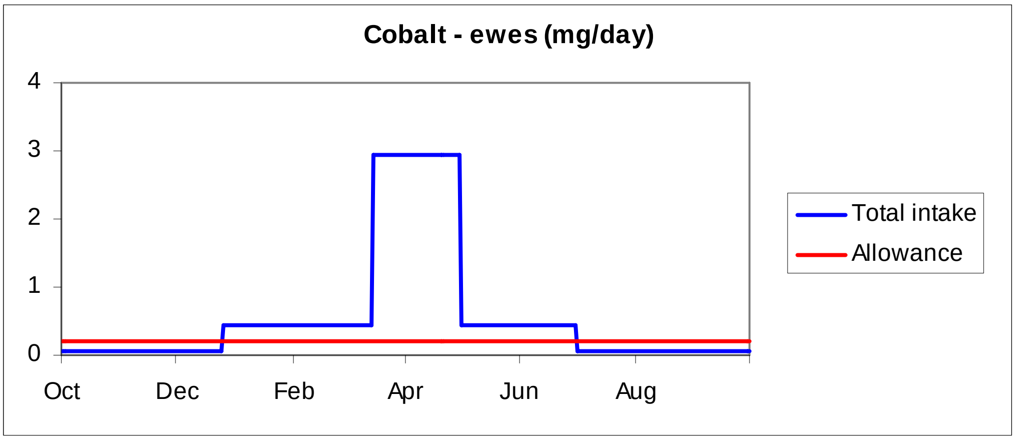


Figure 10. Annual Co profile for breeding ewes

Predicted copper requirements are influenced by interactions with molybdenum, sulphur and iron that affect the amount of absorbable copper in the diet. The graphs in the Appendix (Figure A18) show the contribution of forage and the estimated total dietary intake of copper. For cattle, total copper intake is marginally low for the majority of the year (Figure 11) although intakes in spring are above requirements when cattle have access to high magnesium buckets. For ewes total intakes are above requirements around lambing but are below theoretical requirements for the rest of the year.

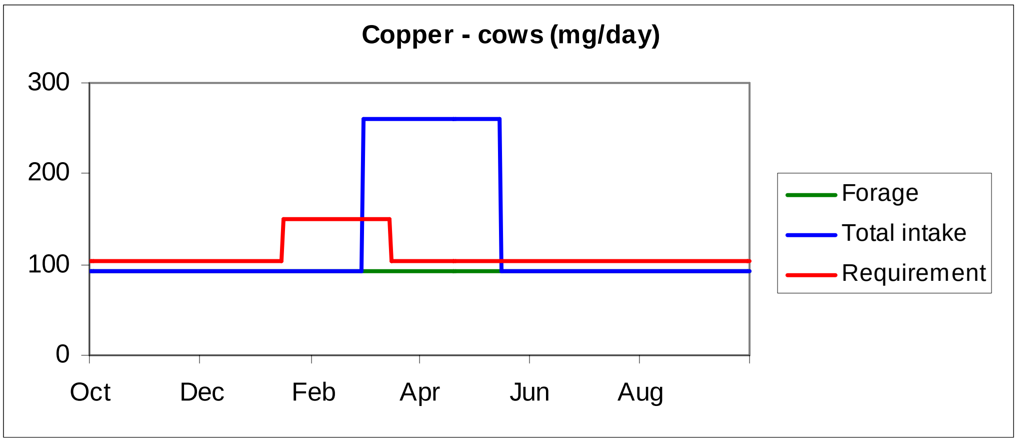


Figure 11. Annual copper profiles for suckler cows

Cattle blood results show low copper in half of the cows in the spring with other tests within the normal range. The results for calves were within the reference range for all tests with the exception of two slightly raised T_4 tests. Low copper blood results remained an issue in the autumn with the majority of the cows and two calves below the minimum. The results for all other tests were satisfactory.

Table 19 Cattle blood results

Cows	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	9.75	8.2
Vit B_{12} (Cobalt) (pmol/l)	>100	165	182
GSH-Px (Selenium) (U/ml RBCs)	> 30	72.4	60.1
T_4 (nmol/l)	26 to 84	45.3	44.8

Calves	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	13.3	10.8
Vit B_{12} (Cobalt) (pmol/l)	>100	208	316
GSH-Px (Selenium) (U/ml RBCs)	> 30	76.4	93.8
T_4 (nmol/l)	26 to 84	88.0	81.8

Overall blood results were satisfactory for ewes and lambs in May and September with a few animals outside the recommended range. In the spring one lamb was marginally low for cobalt (vitamin B_{12}) and two had slightly raised T_4 levels, whilst in the autumn two ewes and two lambs had marginally low copper levels and two ewes slightly low T_4 results. Liver samples taken from finished lambs in July showed three out of six to have a marginal selenium deficiency but all liver copper levels were within the reference range. Creep feed introduced from the end of July would provide sufficient selenium for later finishing lambs.

Table 20 Sheep blood results

Ewes	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	13.6	10.0
Vit B_{12} (Cobalt) (pmol/l)	>188	561	613
GSH-Px (Selenium) (U/ml RBCs)	> 50	137	189
T_4 (nmol/l)	35 to 75		39.7

Lambs	Reference Range	Spring	Autumn
Copper (umol/l)	9 to 19	13.1	12.0
Vit B_{12} (Cobalt) (pmol/l)	>188	588	289
GSH-Px (Selenium) (U/ml RBCs)	> 50	194	196
T_4 (nmol/l)	35 to 75	73.3	44.8

The blood sampling did highlight some low copper values in the cattle (particularly the calves in autumn) and as a result Richard intends to discuss this with his own vet with a view to developing an appropriate action plan. Currently Richard is happy with the results from the sheep and has no immediate plans to alter their trace element supplementation.

Summary

- Forage analysis shows all fields to be below recommendation for Cu with raised S and Mo
- All fields below recommendation for Co throughout year and low in Se in autumn
- Blood/liver samples this year show:
    - Some cattle blood Cu levels below the reference range in spring and autumn
    - Some marginally low blood Cu in breeding ewes and lambs in the autumn
    - Some lambs slaughtered before creep feeding started marginally deficient in Se

Changes made/future actions

- No plans to alter sheep supplementation, although, as free access minerals containing copper are being offered to sheep, it would be advisable to periodically check liver copper levels to ensure there is no risk of copper toxicity
- Supplementation for cattle to be discussed at next health review meeting

Case Study 7

Chris Salisbury farms 530 Ha near Taunton in Somerset. The home farm extends to 284 ha and sits on clay soils at 50 m above sea level and receives around 660 mm of rainfall annually. Around 40 ha are used for forage conservation. Much of the grassland is permanent pasture based around perennial ryegrass and white clover with some recent reseeds. There is a further 246 ha of woodland that is grazed by cattle as part of a share farming arrangement. This land sits on clay and glacial spoil at between 100 – 310 m and receives around 1000 mm of rainfall. This area has been woodland for the last 50 to 60 years but in the last four years some areas have been cleared allowing natural regeneration.

Sheep

The farm carries around 430 Lleyn ewes and ewe lambs put to Texel and Charollais rams. This year the ewes scanned at 180% and ewe lambs at 150%. The ewes lambed indoors this year from mid-February and the ewe lambs outside in May. Ewes were housed shortly before lambing in 2010 but the intention is to move towards outdoor lambing for the whole flock. Ewes have access to a mineral bucket all year supplemented with feed blocks/buckets and compound feed in late pregnancy and early lactation. Lambs are weaned between 12 – 16 weeks of age and are all sold live weight at 35 – 42 kg. The majority of lambs are sold between June and October depending on grass supply.

Cattle

The farm also carries around 60 Longhorn suckler cows bred pure that are managed on a share farming basis with the Forestry Commission. Currently the majority of cows calve in the spring although the herd calves all year round. Currently reproductive performance is disappointing with only 40 calves produced from 60 cows. Conception rates to natural service should run at around 90% and Chris feels that the physically difficult environment of the woodland is a factor. The aim is to wean calves at around 6 months of age and rear them all for finishing at 30 to 36 months at a weight of 500 – 600 kg. Cattle are normally removed from the hill in October and overwintered on silage with free access to cattle minerals and some compound feed in early winter. They are turned out in early May to the woodland and although they have access to minerals very little is taken. In 2010 the cattle remained on the hill until September before being taken off for overwintering away from the farm. The original intention was to build the suckler herd up to 100 cows but the share farming agreement came to an end in the autumn and currently plans for an alternative cattle enterprise are in their infancy.

Trace element sampling

Grass results from the home farm show all three fields to be low in cobalt and two fields low in selenium in the spring although levels were higher in the autumn. Overall copper levels were below the minimum for cattle with sulphur and molybdenum above the recommended level indicating that copper availability would be compromised in the animal. The wooded area, whilst having moderate sulphur content had extremely high molybdenum levels and copper below the minimum for cattle. The high molybdenum levels are a particular feature of the 'teart' pastures in this area of Somerset.

Table 21 Somerset Farm Grass Results

	Spring	**Autumn**	**Farm Average**	**Woodland Average**	**Typical Average Level in Pasture**	**Satisfactory Pasture Levels to Avoid Deficiency Risk**
						More than
Copper (mg/kg)	8.13	7.83	7.98	7.60	9	8
Cobalt (mg/kg)	0.06	0.14	0.10	0.12	0.1	0.1
Selenium (mg/kg)	0.04	0.12	0.08	0.07	0.07	0.05
Zinc (mg/kg)	25.4	40.9	33.2	51.3	51	25
Minerals affecting availability of copper						*Less than*
Molybdenum (mg/kg)	4.35	7.08	5.71	19.01	1.3	1.5
Sulphur (%)	0.27	0.26	0.27	0.18	0.15	0.2
Iron(mg/kg)	302.3	620.0	461.2	274.5	150	500

The trace element profile for cobalt, selenium and iodine throughout the year has been plotted using the forage results (above) and the declared analyses of other feeds and supplements offered. The results are presented in the Appendix (Figures A19 and A20) and in each case the recommended daily allowance (Allowance) and estimated total daily intakes (Total intake) have been calculated. The graphs indicate that total intakes for cattle and sheep to be at or above the required levels for the majority of the year. The exception is selenium for the cows which does fall below recommendations particularly during the summer (Figure 12).

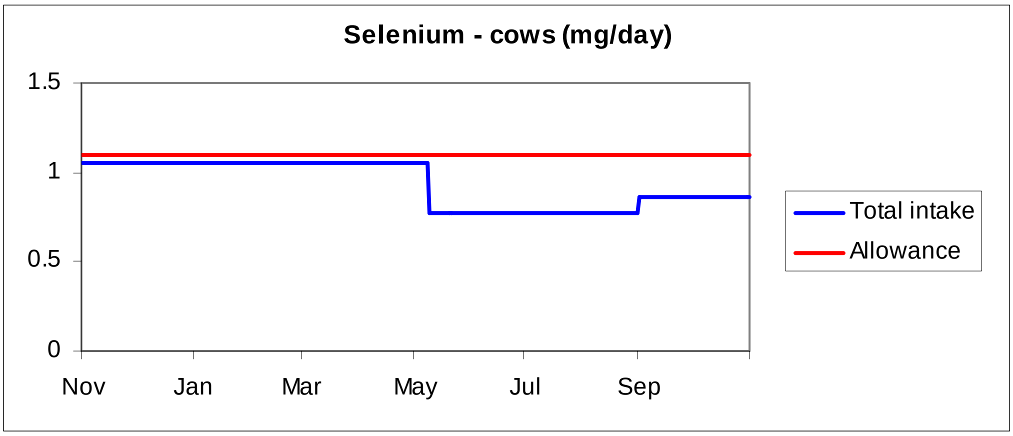


Figure 12. Annual, Se profile for breeding suckler cows

Predicted copper requirements are influenced by interactions with molybdenum, sulphur and iron that affect the amount of absorbable copper in the diet. Due to the higher availability of copper in compound feeds the overall gross requirement for forage plus concentrate diets can be reduced e.g. where ewes receive supplementary feed around lambing. However the converse is true where animals graze molybdenum rich pastures (e.g. cattle grazing in the woodland). The graphs in the Appendix (Figure A21) and below show the contribution of forage and the estimated total dietary intake of copper. For cattle, total copper intake is close to requirements over winter with the exception of late pregnancy. Following turnout, intakes are significantly below requirement until July when cattle received a copper bolus. Total copper intakes for ewes are above requirements around lambing when ewes receive compound feed but typically are about 75% of requirement for the remainder of the year.

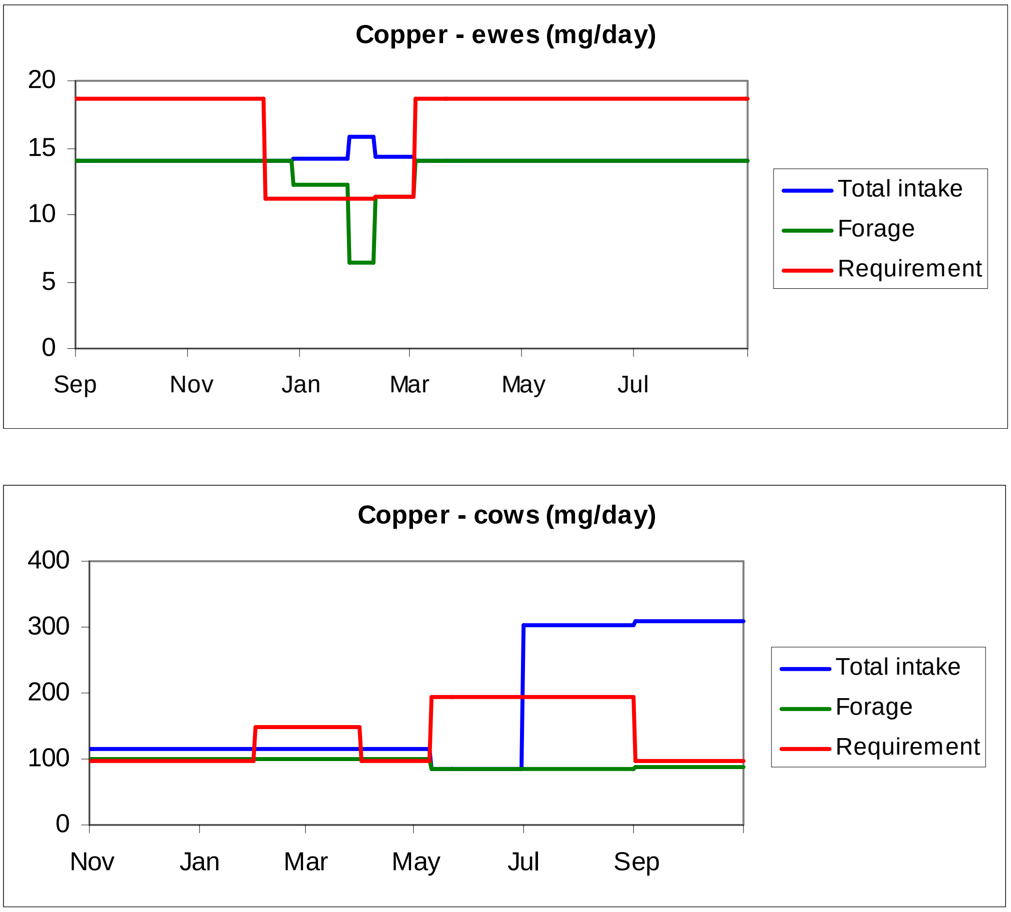


Figure 13. Annual copper profiles for breeding ewes and cattle

Cattle blood results at turnout in the spring showed low copper in five out of six cows (with the other slightly above the normal range) with other tests being satisfactory.   Blood results for calves were within the reference range for all tests with the exception of one calf with very low copper levels. The lack of autumn blood samples means it is not possible to measure the effect of the copper boluses or assess whether the lower selenium levels over the summer resulted in low levels in animals.

Table 22 Cattle blood results

Cows	Reference Range	Cows spring	Calves spring
Copper (umol/l)	9 to 19	7.7	11.6
Cobalt (Vit B12) (pmol/l)	>100	176	223
GSH-Px (Selenium) (U/ml RBCs)	> 30	63	61.8
T_4 (nmol/l)	26 to 84	60.5	59.4

The overall results of blood sampling of ewes in May showed two out of eight to have copper levels slightly above the reference range and two (from four) to have raised T_4, other tests showed Co and Se levels to be within the reference range. Two lambs had blood Cu levels below the reference range and three had raised T_4 levels.

Table 23 Sheep blood results

Ewes	Reference Range	Ewes spring	Lambs spring
Copper (umol/l)	9 to 19	15.6	10.6
Vit B_{12} (Cobalt) (pmol/l)	>188	684	609
GSH-Px (Selenium) (U/ml RBCs)	> 50	203	207
T_4 ((nmol/l)	35 to 75	73.5	89.5

Historically the farm was run as a dairy unit only converting to suckler cattle and sheep in the last five years. As far back as 1976 copper was a significant issue for the farm resulting in cattle losses, and at the time a high copper mineral was prescribed for the dairy herd which was fed for a number of years. In 2003 however it was discovered from liver samples that the copper levels had become too high and as a result the farm reverted to feeding a standard cattle mineral. When the Longhorn enterprise started Chris was unaware of the exceptionally high levels of molybdenum in the woodland and continued with the standard mineral. The forage and blood samples taken in 2010 highlighted the issues with the hill grazing and the decision was taken to bolus all cattle for copper. If the suckler enterprise had continued offering a bolus at turnout would match copper supply to requirements more closely. Although the trace element profile for ewes suggests that copper could be an issue Chris and his vet have chosen to monitor ewes carefully (blood sampling would be recommended) rather than offer additional copper routinely.

Summary

- Fields on the home farm have raised S and Mo levels with some fields marginally below the recommended Cu level.
- Woodland grazing had extremely high Mo levels
- Blood/liver samples this year show:
    - Low blood Cu levels in cows
    - Sheep results were satisfactory overall

Changes made/future actions

- If the share farming agreement had continued the cattle grazing the woodland would receive a Cu bolus at turnout in spring

Overall summary

The study has highlighted the potential benefits of establishing the trace element status of livestock farms. The approach taken here was to assess the trace element content of grazed forage in conjunction with targeted blood and liver sampling in cattle and sheep.

Forage

- Establishing a reliable iodine value for forage proved to be difficult in this study although standard industry techniques gave a broad indication.
- On some farms there was significant variation in the trace element content of different fields/areas of the farm eg Case study 7. Sampling a good cross section of available grazing and conservation fields can help target supplementation.
- On the majority of case study farms overall levels of trace elements tended to be higher in autumn forage samples.
- The potential for pasture dressing to raise the trace element content of forage was demonstrated in Case Study 5.

Blood and liver samples

Cattle

- None of the cattle blood samples taken had levels of cobalt (Vit B_{12}) or T_4 below the reference range.
- Around a third of cattle blood samples (affecting six of the farms) had Cu levels below the reference range with twice as many cows as calves affected. Liver samples give a more accurate indication of copper deficiency but were only available from cattle on two farms.
- 13% of cattle blood samples were below the reference range for selenium although the vast majority were from one farm (Case study 3).

Sheep

- Very few (5%) of sheep blood samples had copper levels below the reference range and these were split fairly evenly between ewes and lambs and spring/autumn. Twice as many samples (10%) showed marginally high copper levels.
- 12% of sheep blood samples were below the reference range for cobalt (Vit B_{12}) with the vast majority affecting lambs. It was only a problem for one farm in spring and two in the autumn.
- Selenium (GSH-Px) levels in the spring were all satisfactory. In the autumn however 36% of samples were below the reference range affecting the breeding ewes on three farms and lambs on two. Liver samples of finished lambs from the two farms showed a marginal deficiency supporting the blood results.

- T_4 levels were marginally low in around 10% of samples, affecting twice as many ewes as lambs. The vast majority of these were sampled in the autumn with four farms affected.

Methods of supplementation

- The farms studied employed a wide range of supplementation methods including free access minerals, trace element boluses, oral drenches and injections.

- Over the life of the study two of the farms had either changed or were considering changing their supplementation method.
    - The first was using drenches for sheep and FA minerals for cattle but had changed to boluses this year
    - The second was considering changing from FA mineral blocks to boluses to ensure all cattle receive their requirements.

- Following blood sample results from this study four farmers have given or will give additional supplementation:
    - Pre-tupping bolus for breeding ewes (Case study 4)
    - Copper bolus and slow release Se injections for cows and calves (Case study 3)
    - Co, Se and Cu bolus for calves (Case study 5)
    - Copper bolus for cattle at grass (Case study 7)

Appendix

Case Study 1

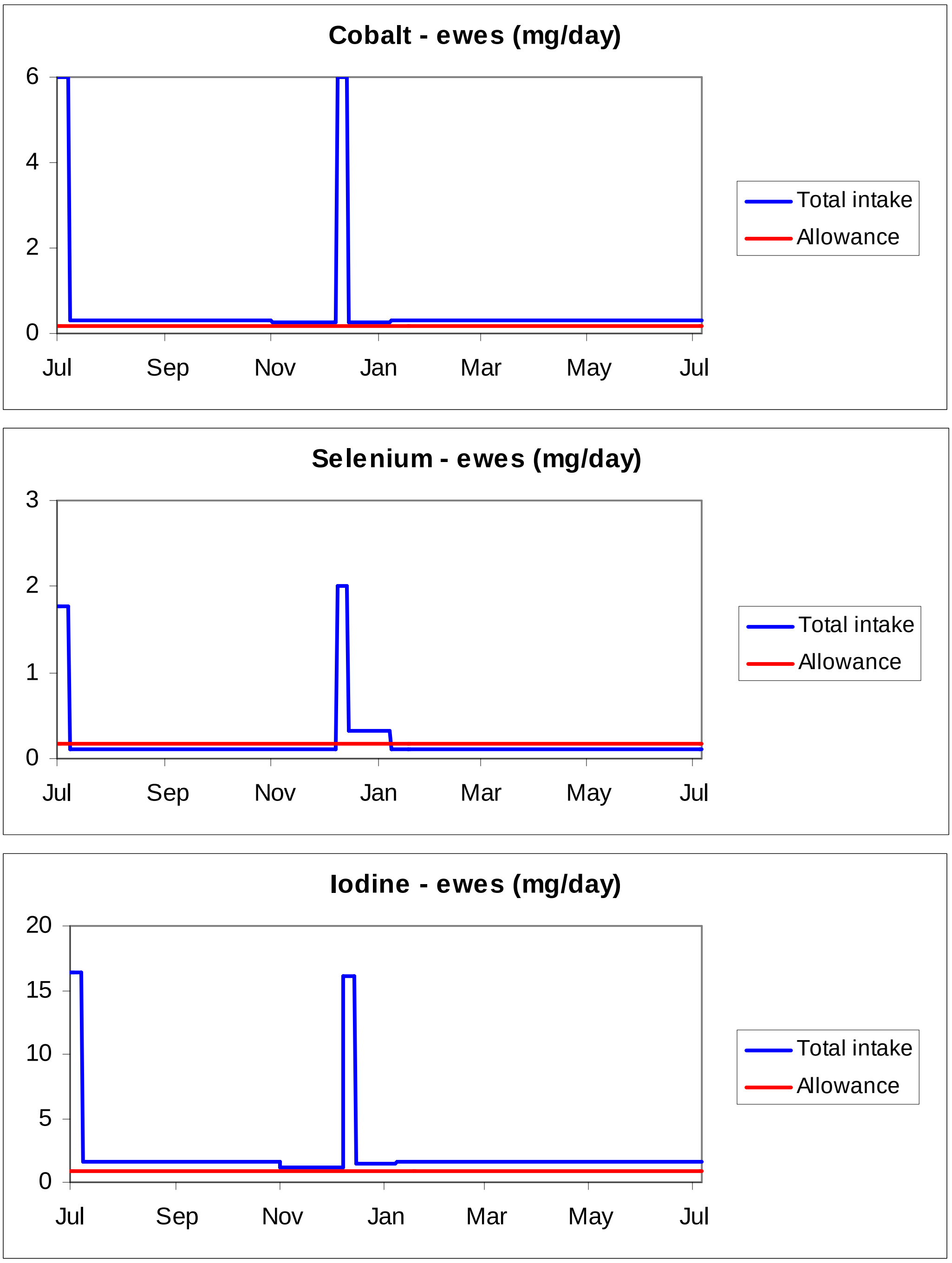


Figure A1. Annual Co, Se and I profiles for breeding ewes

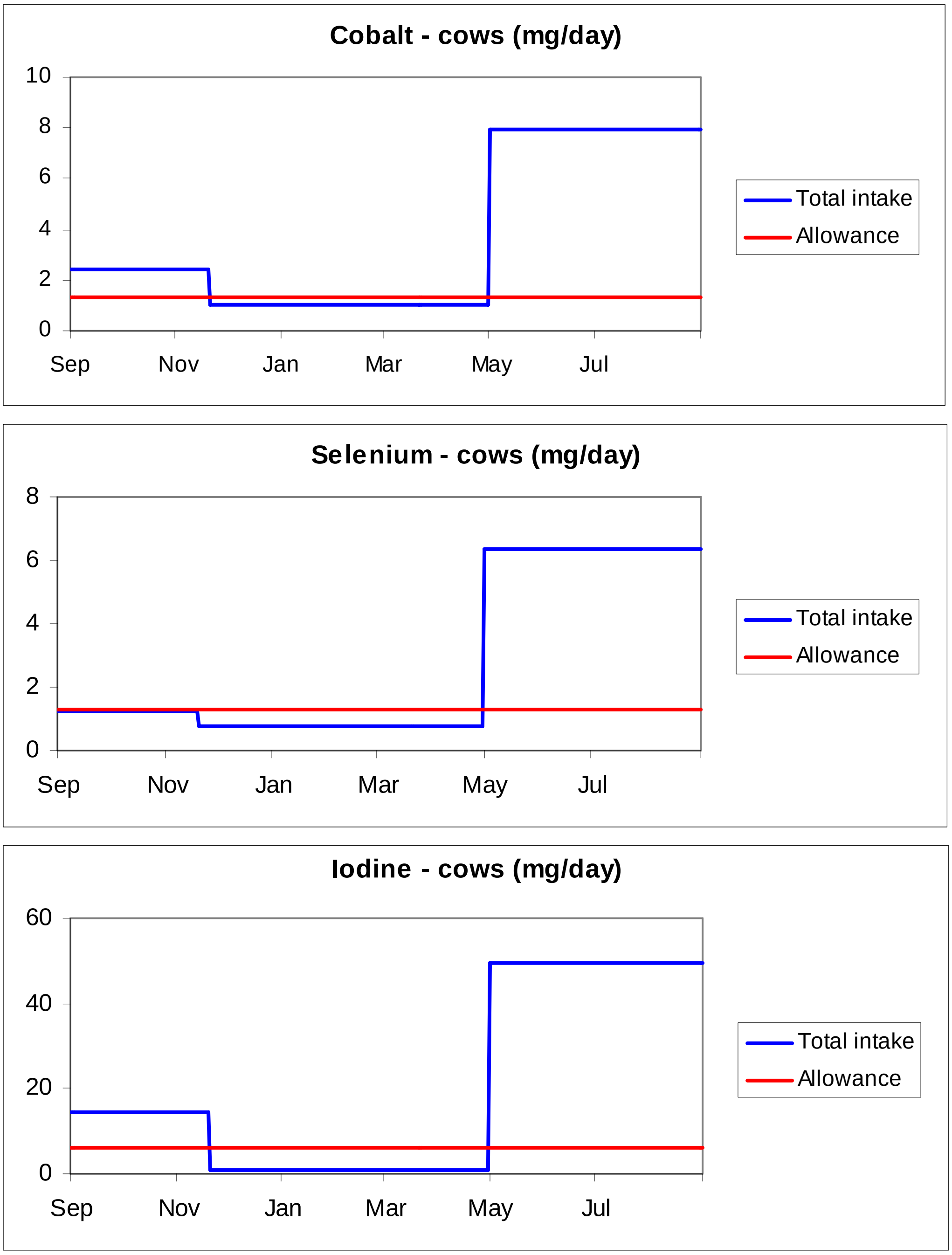


Figure A2. Annual Co, Se and I profiles for breeding suckler cows

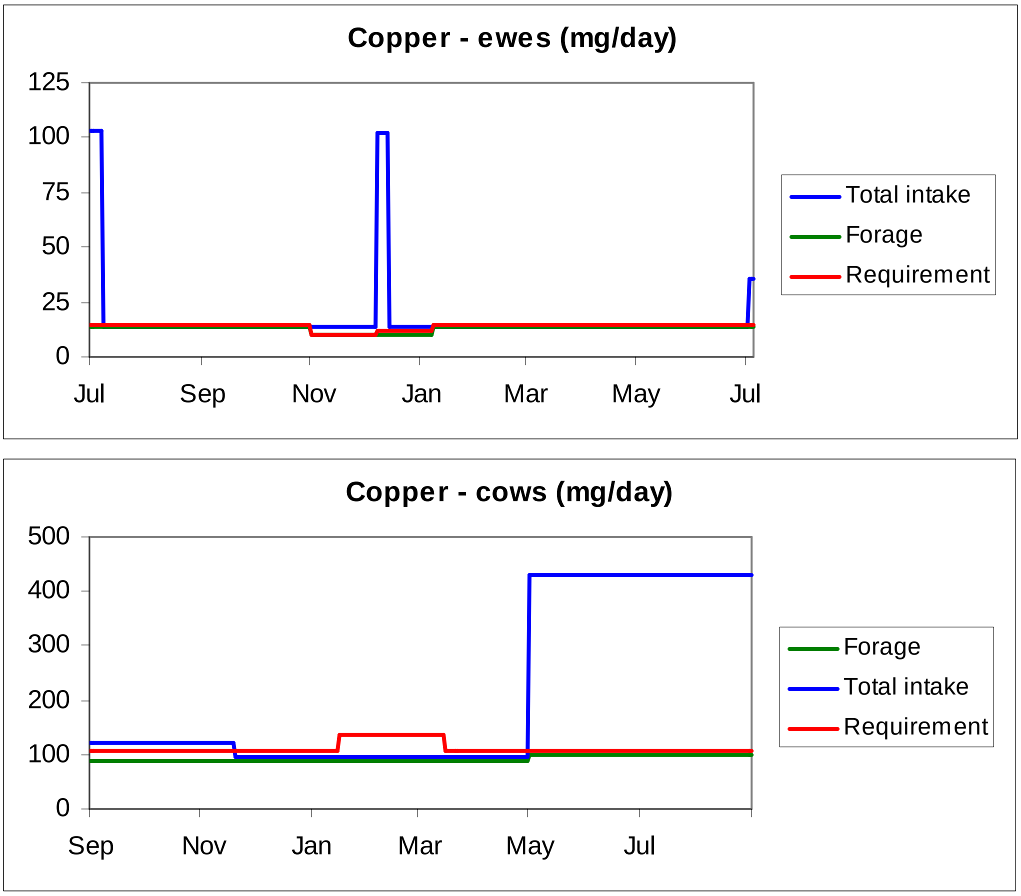


Figure A3. Annual copper profiles for breeding ewes and cattle

Case Study 2

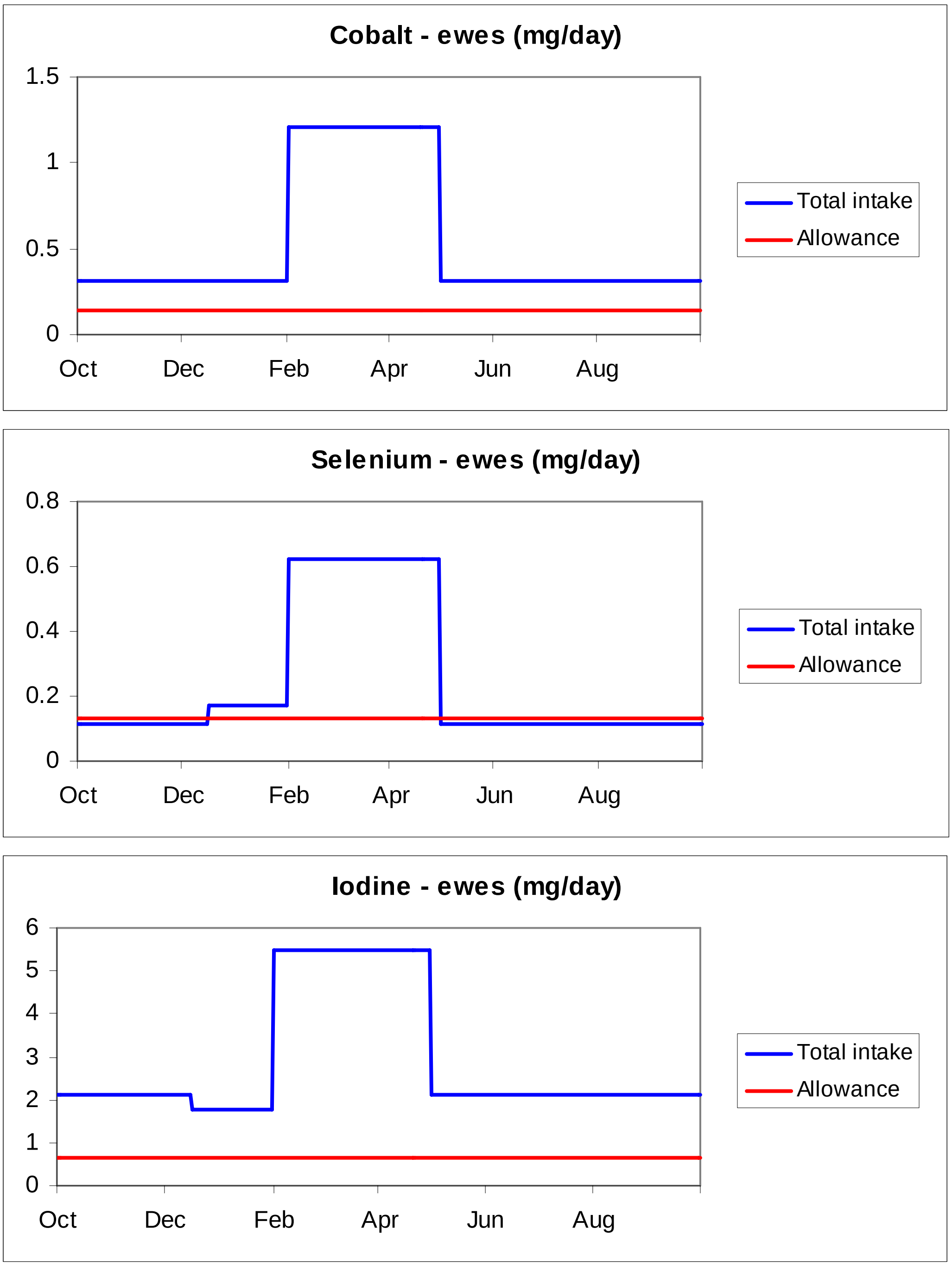


Figure A4. Annual Co, Se and I profiles for breeding ewes

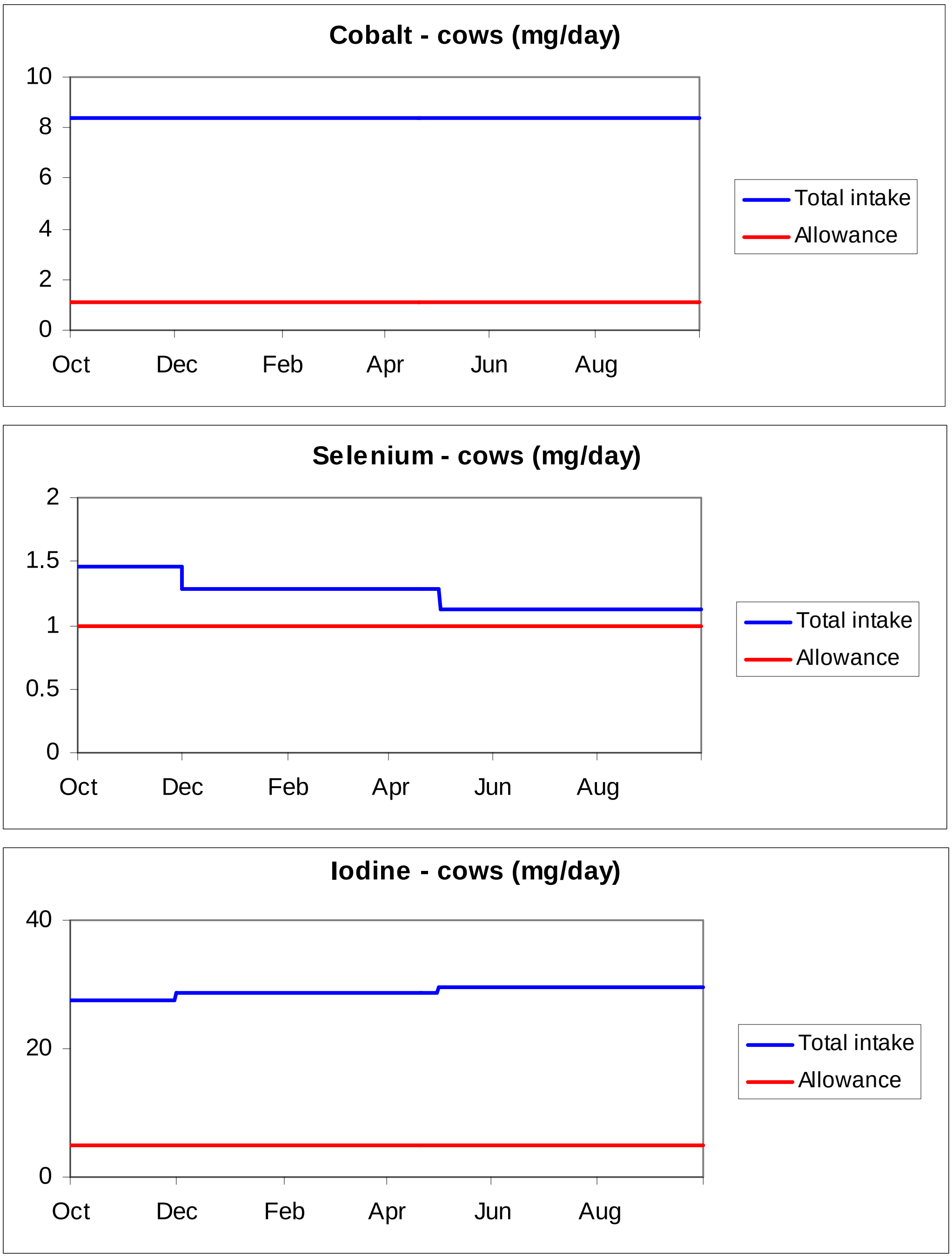


Figure A5. Annual Co, Se and I profiles for breeding suckler cows

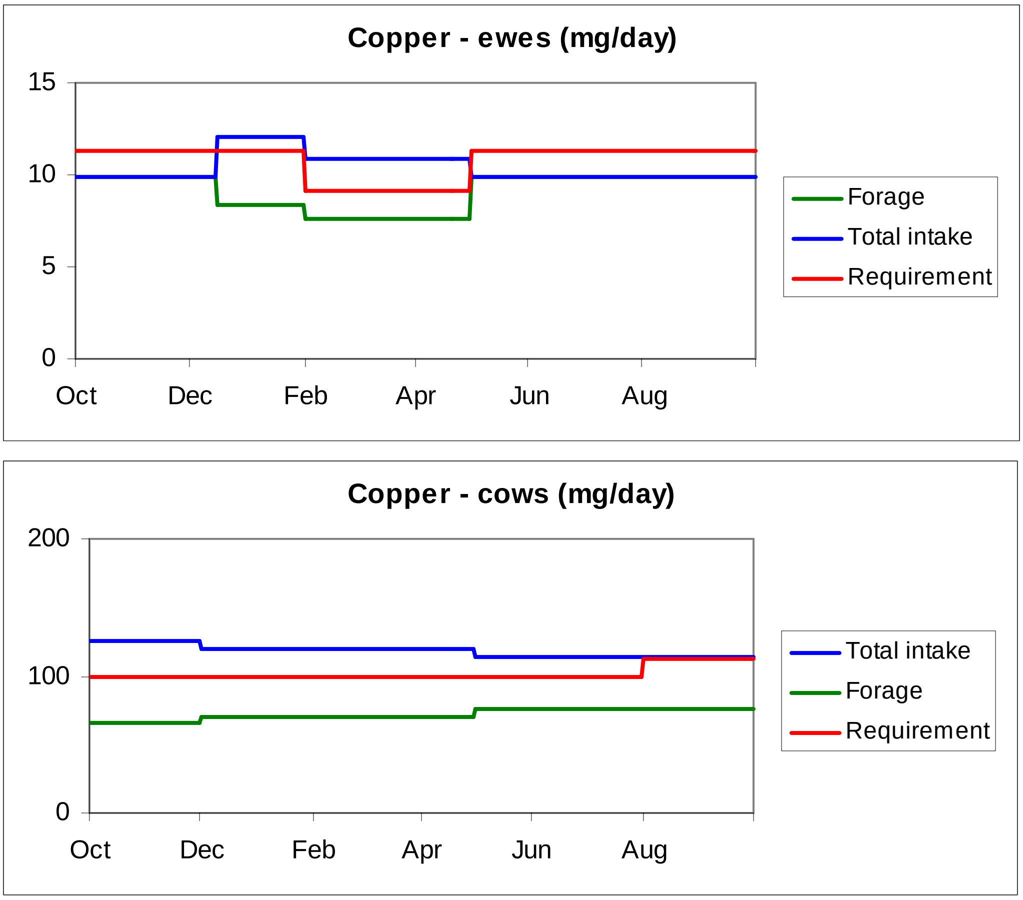
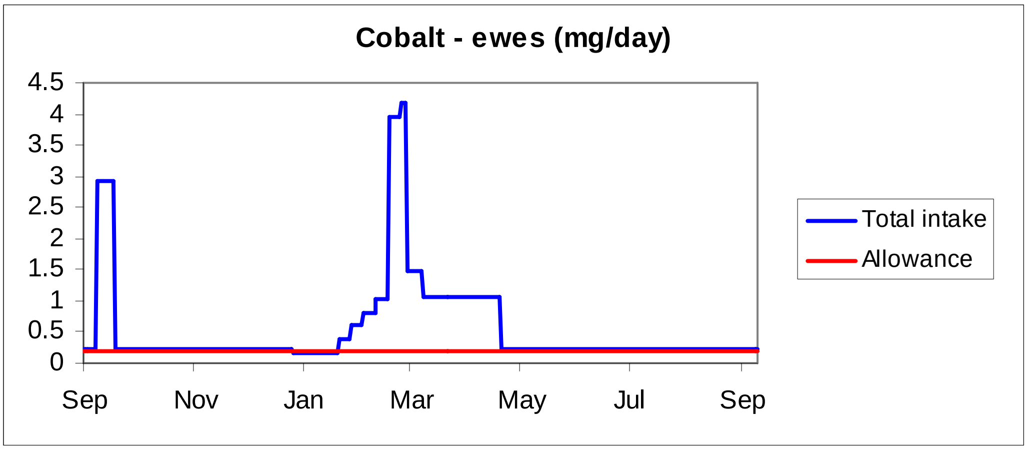
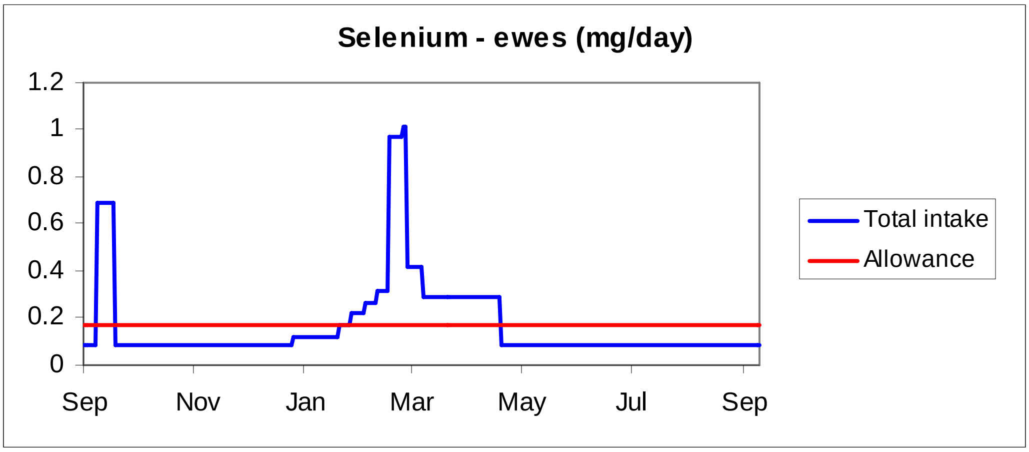


Figure A6. Annual copper profiles for breeding ewes and cattle

Case Study 3





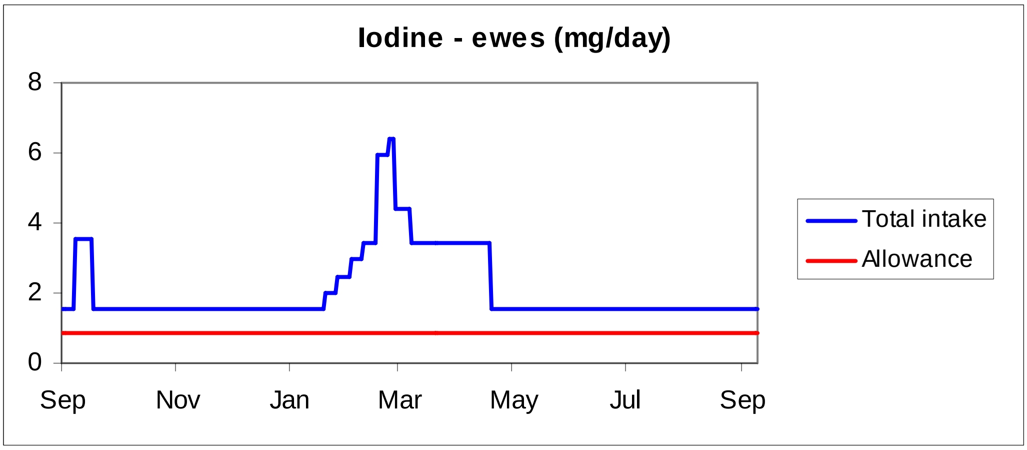


Figure A7. Annual Co, Se and I profiles for breeding ewes

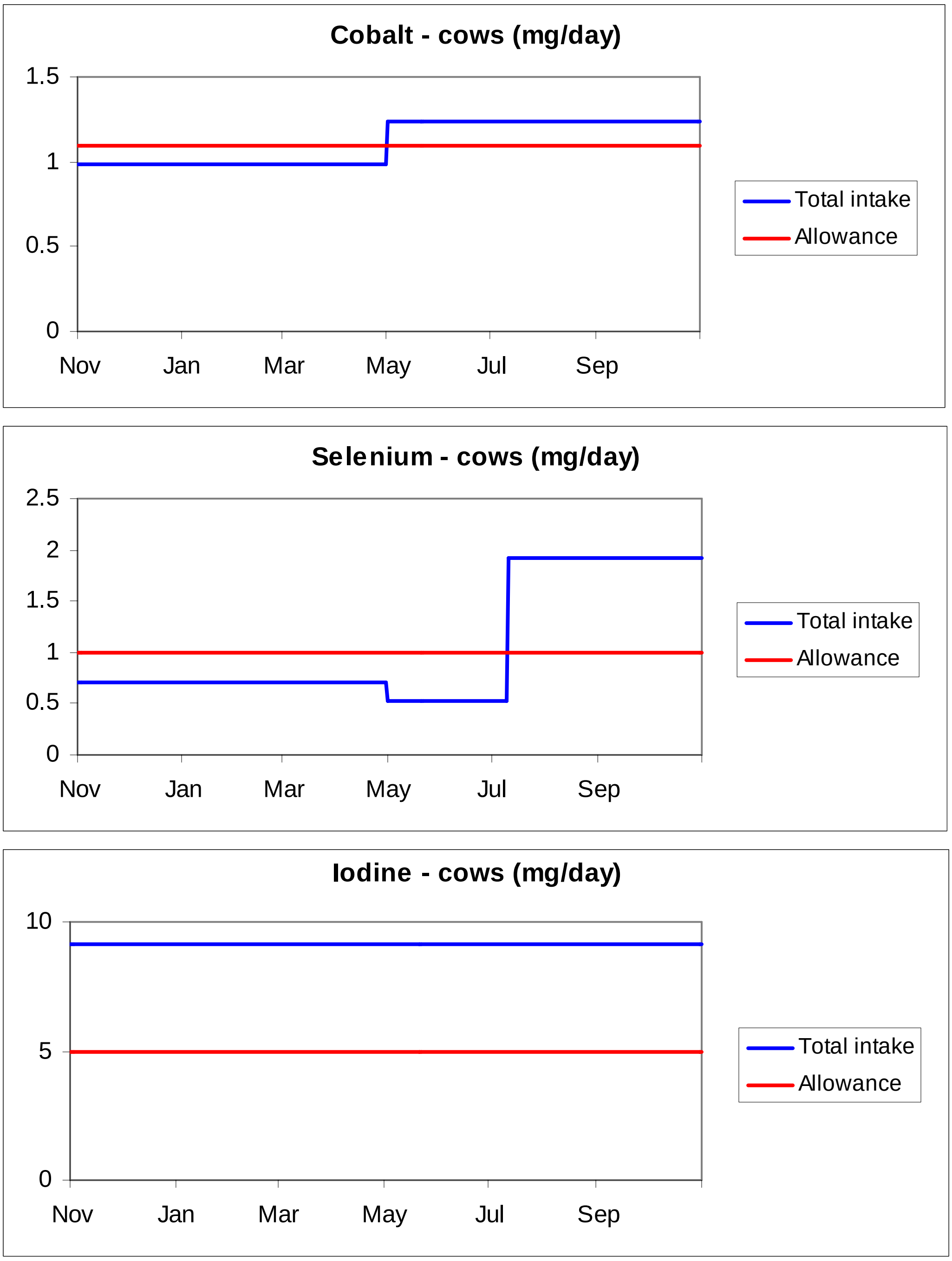


Figure A8. Annual Co, Se and I profiles for breeding suckler cows

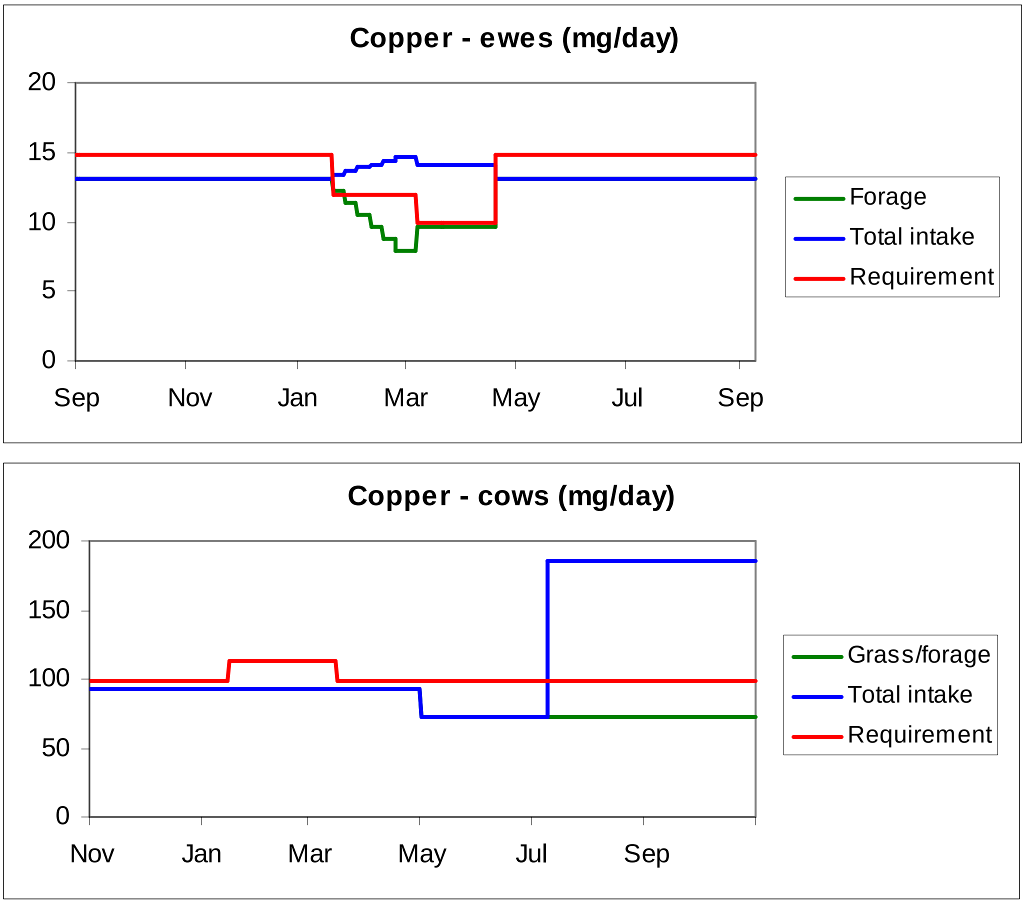


Figure A9. Annual copper profiles for breeding ewes and cattle

Case Study 4

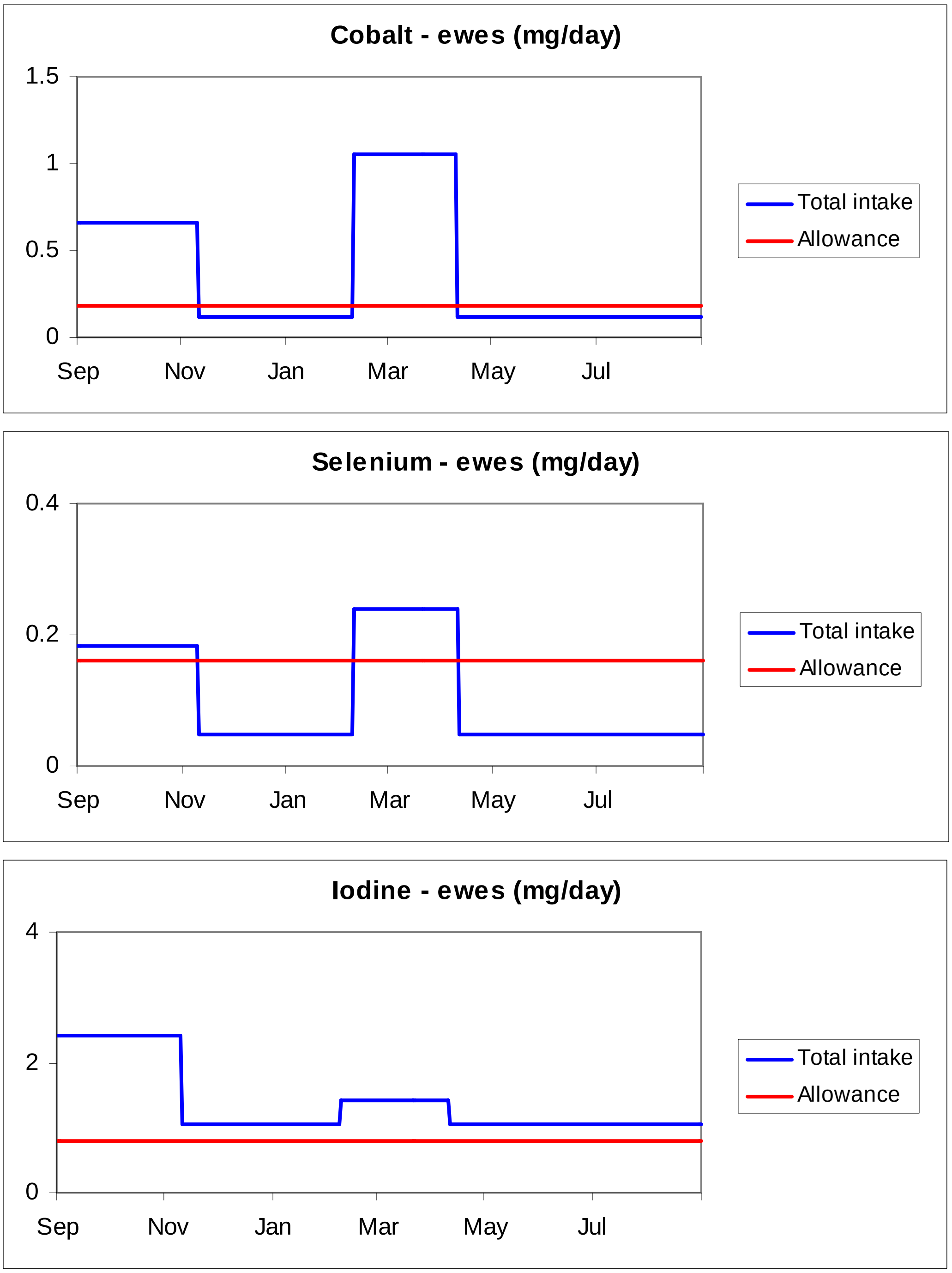


Figure A10. Annual Co, Se and I profiles for breeding ewes

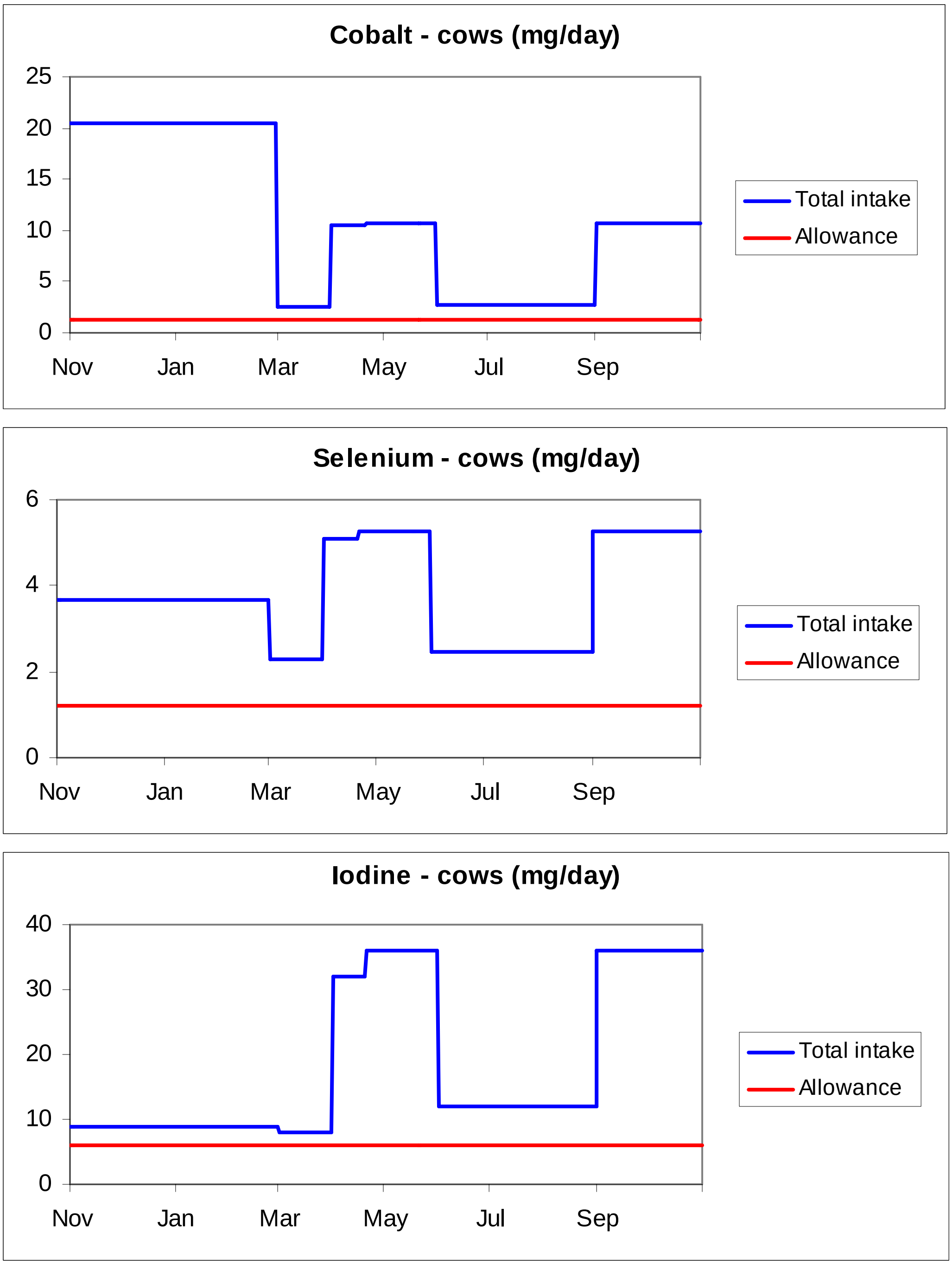


Figure A11. Annual Co, Se and I profiles for breeding suckler cows

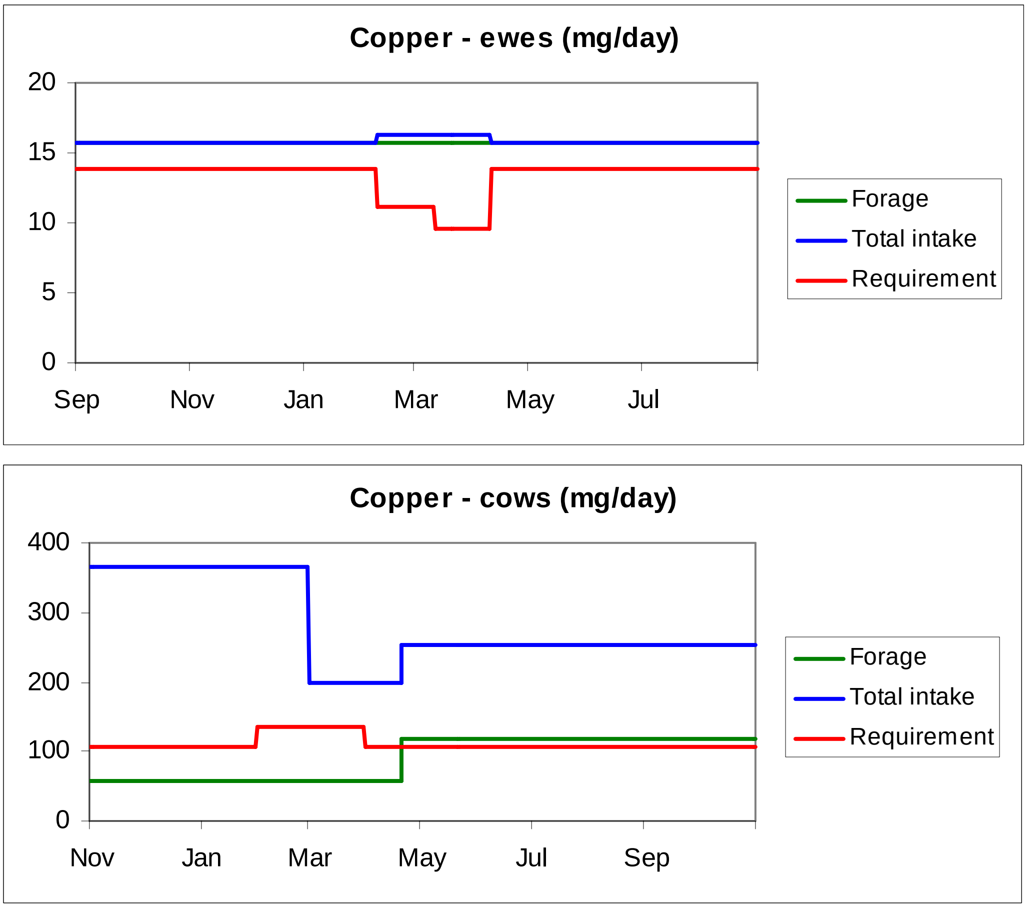


Figure A12. Annual copper profiles for breeding ewes and cattle

Case Study 5

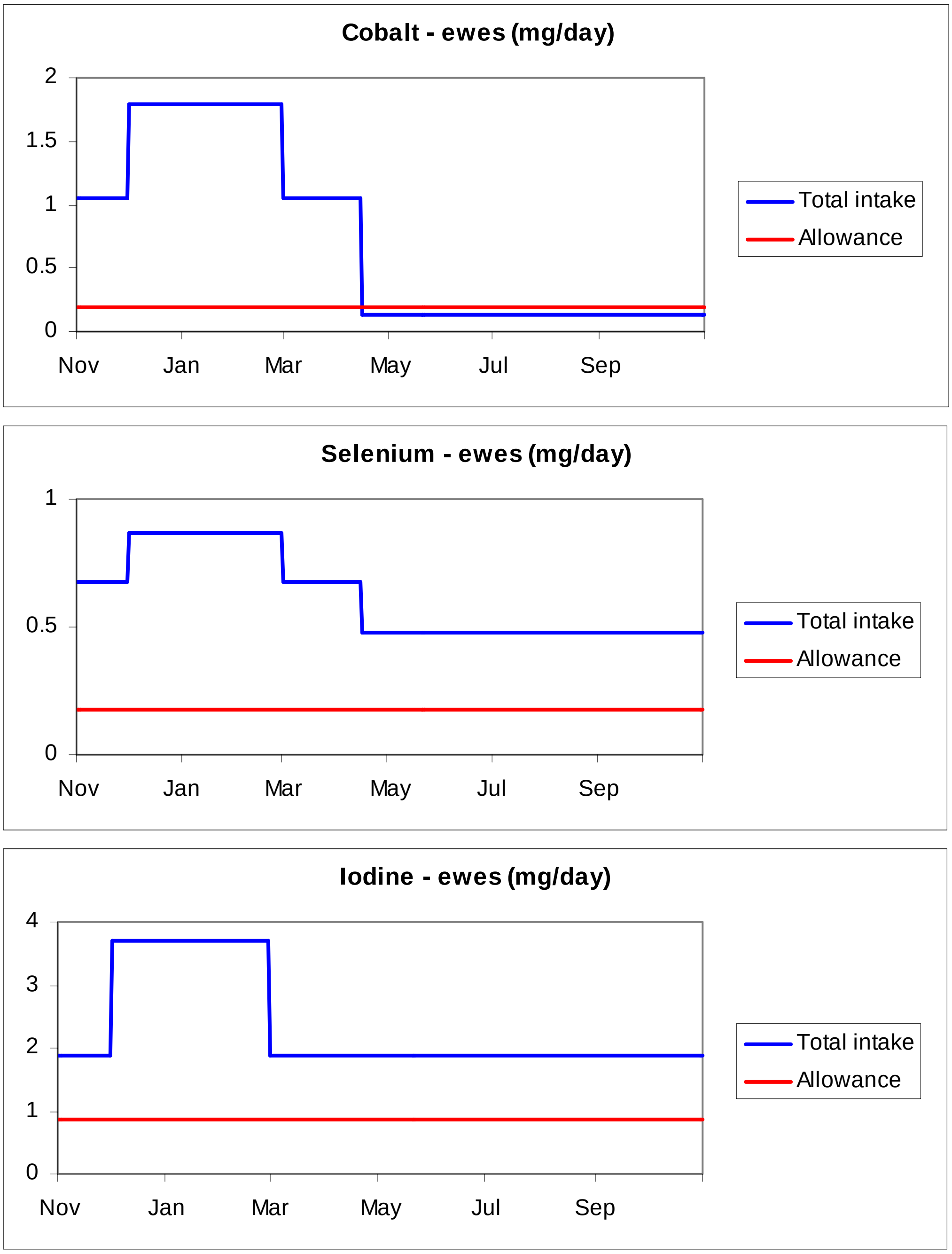
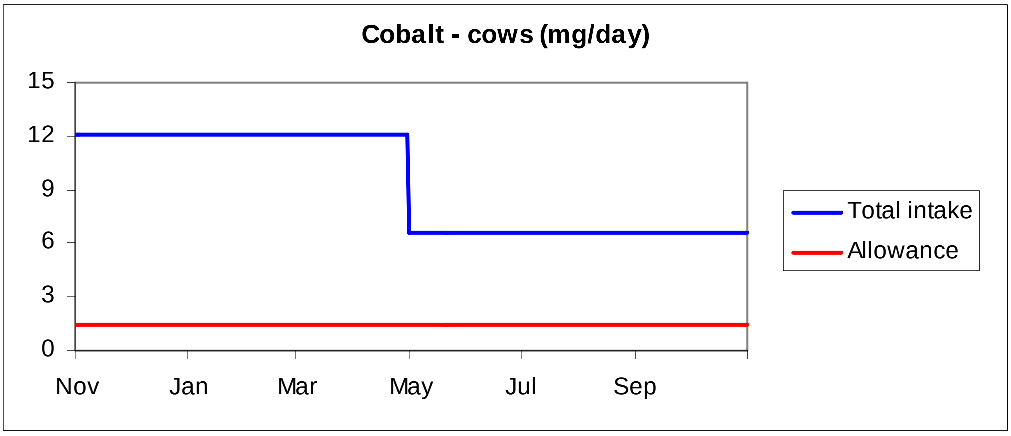
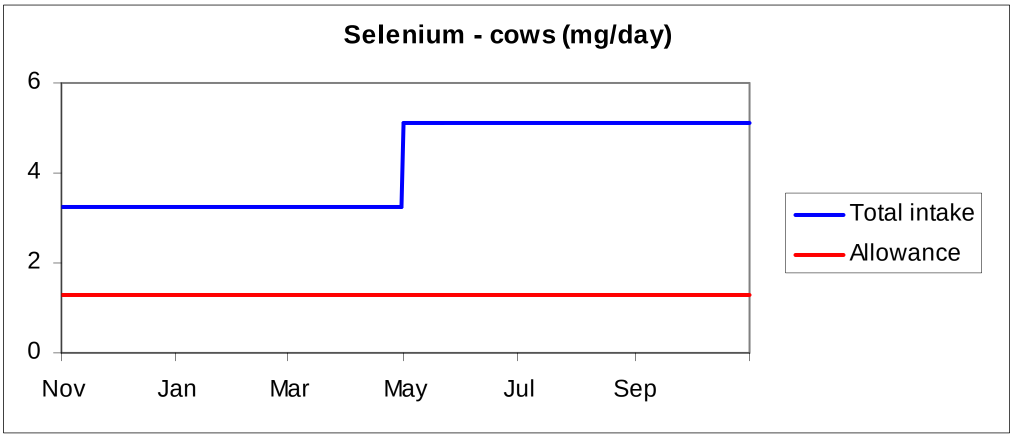


Figure A13. Annual Co, Se and I profiles for breeding ewes





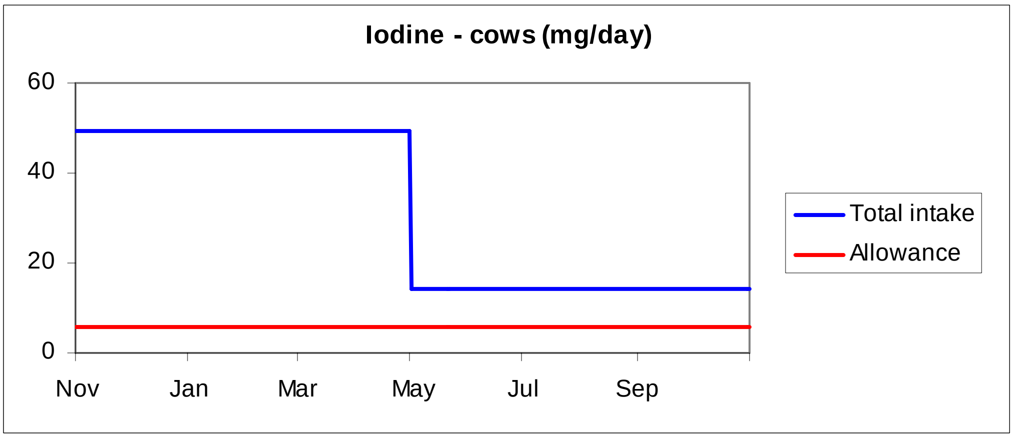
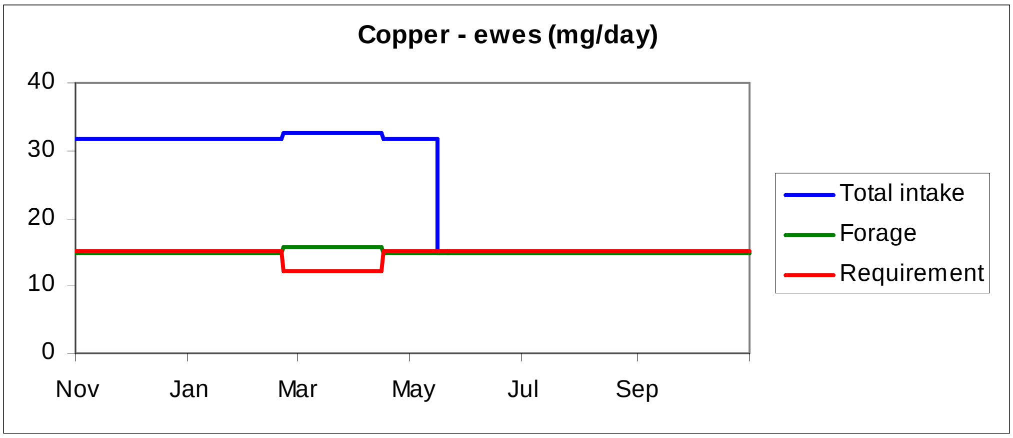


Figure A14. Annual Co, Se and I profiles for breeding suckler cows



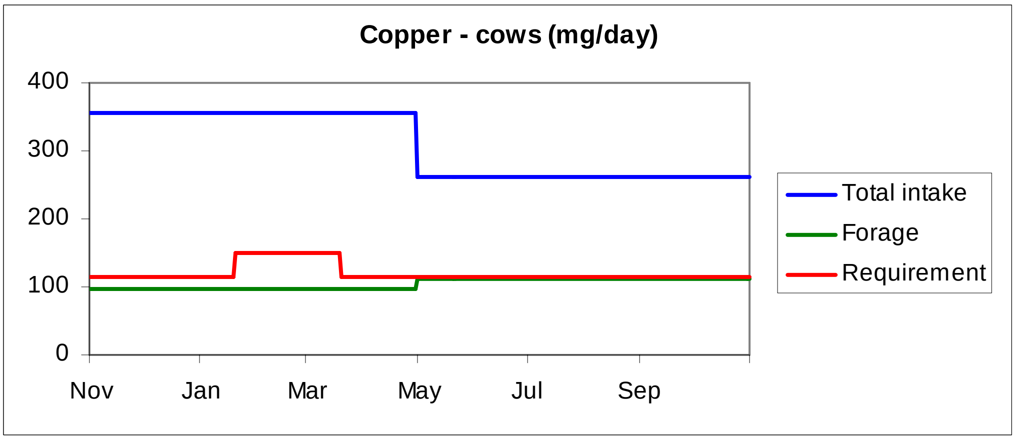


Figure A15. Annual copper profiles for breeding ewes and cattle

Case Study 6

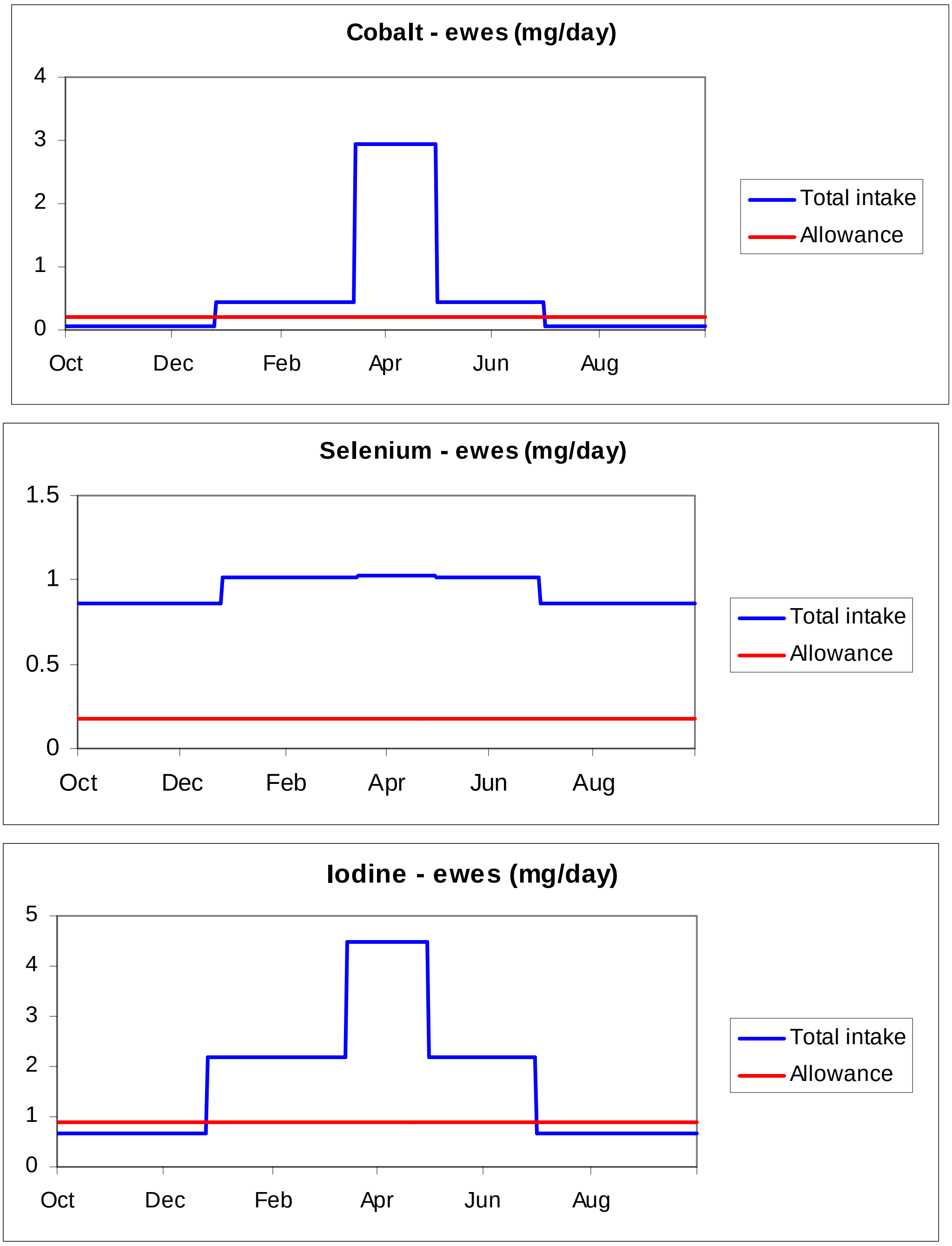


Figure A16. Annual Co, Se and I profiles for breeding ewes

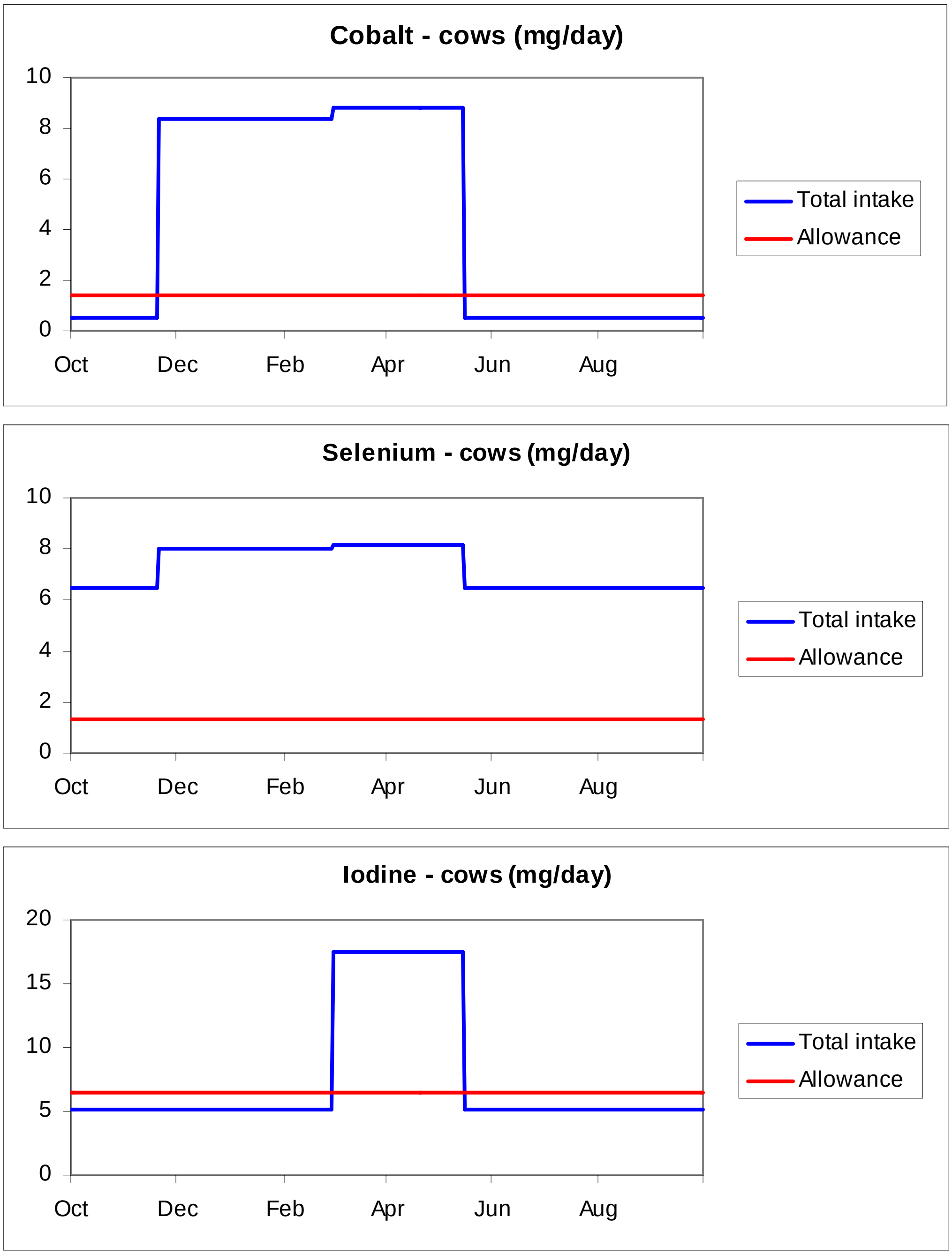
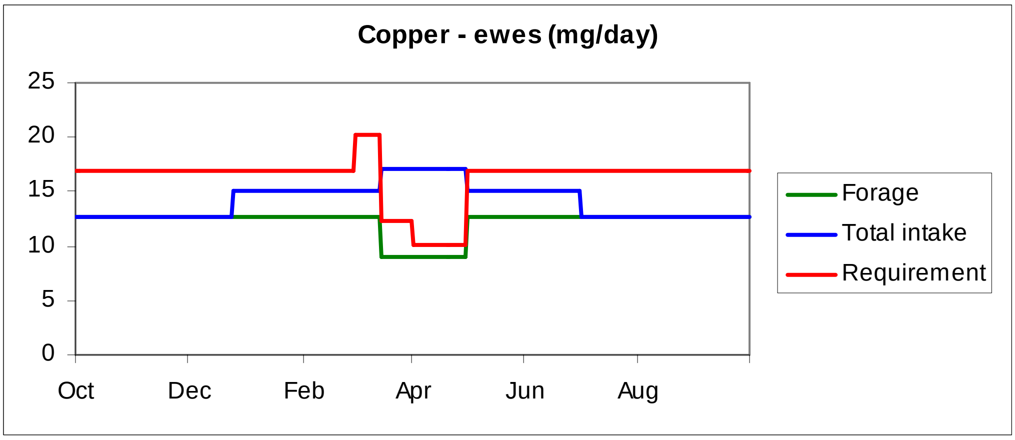


Figure A17. Annual Co, Se and I profiles for breeding suckler cows



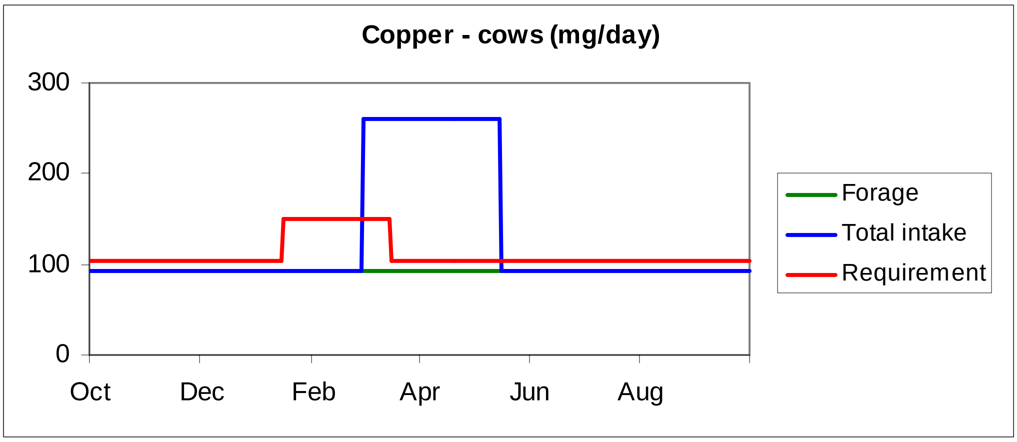
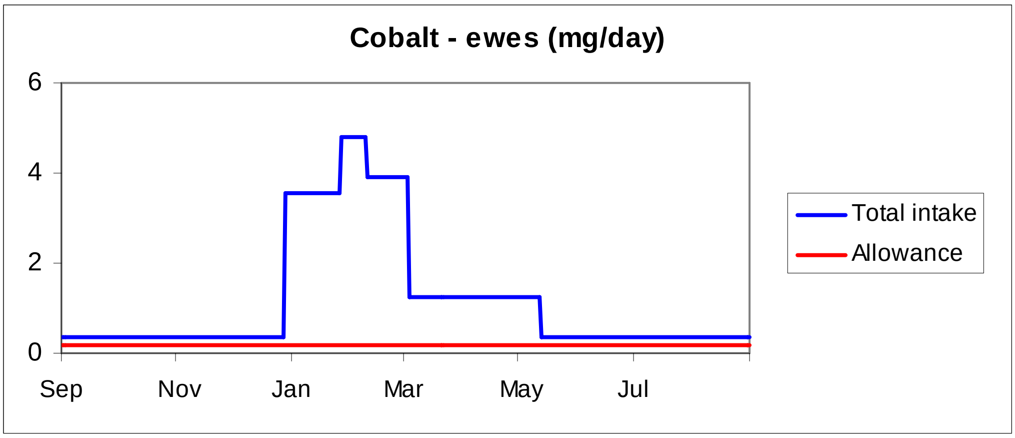
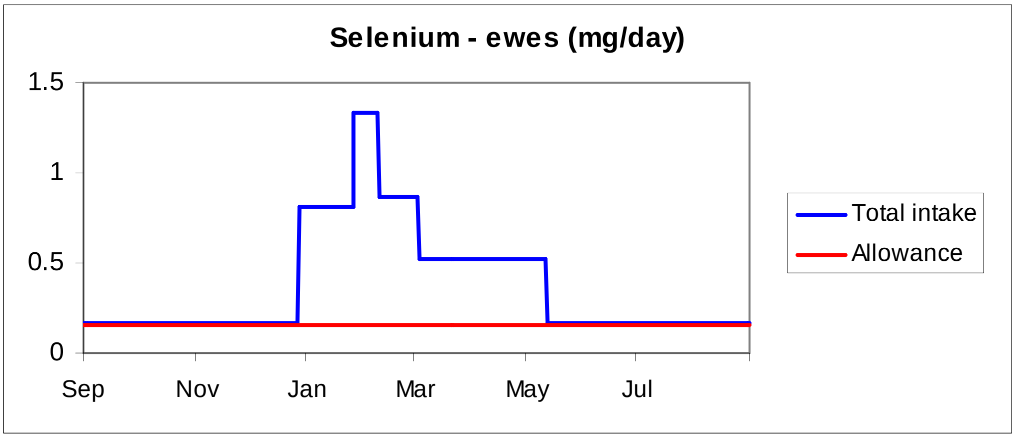


Figure A18. Annual copper profiles for breeding ewes and cattle

Case Study 7





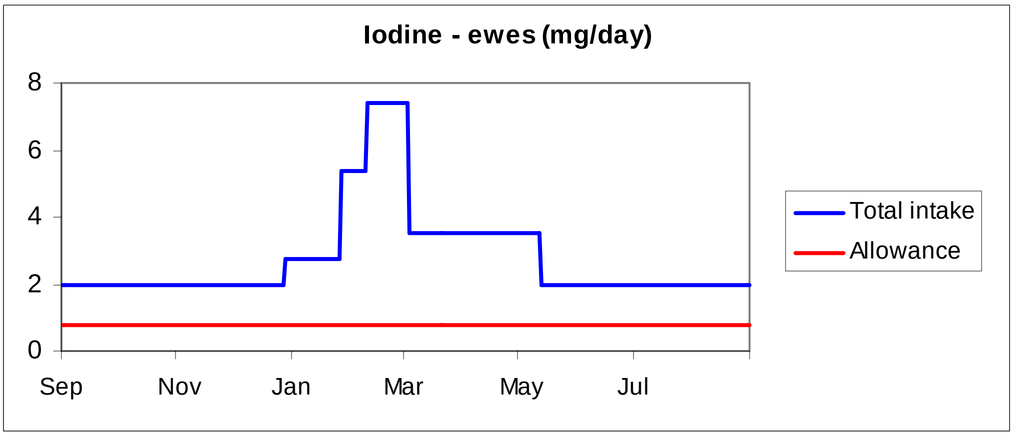


Figure A19. Annual Co, Se and I profiles for breeding ewes

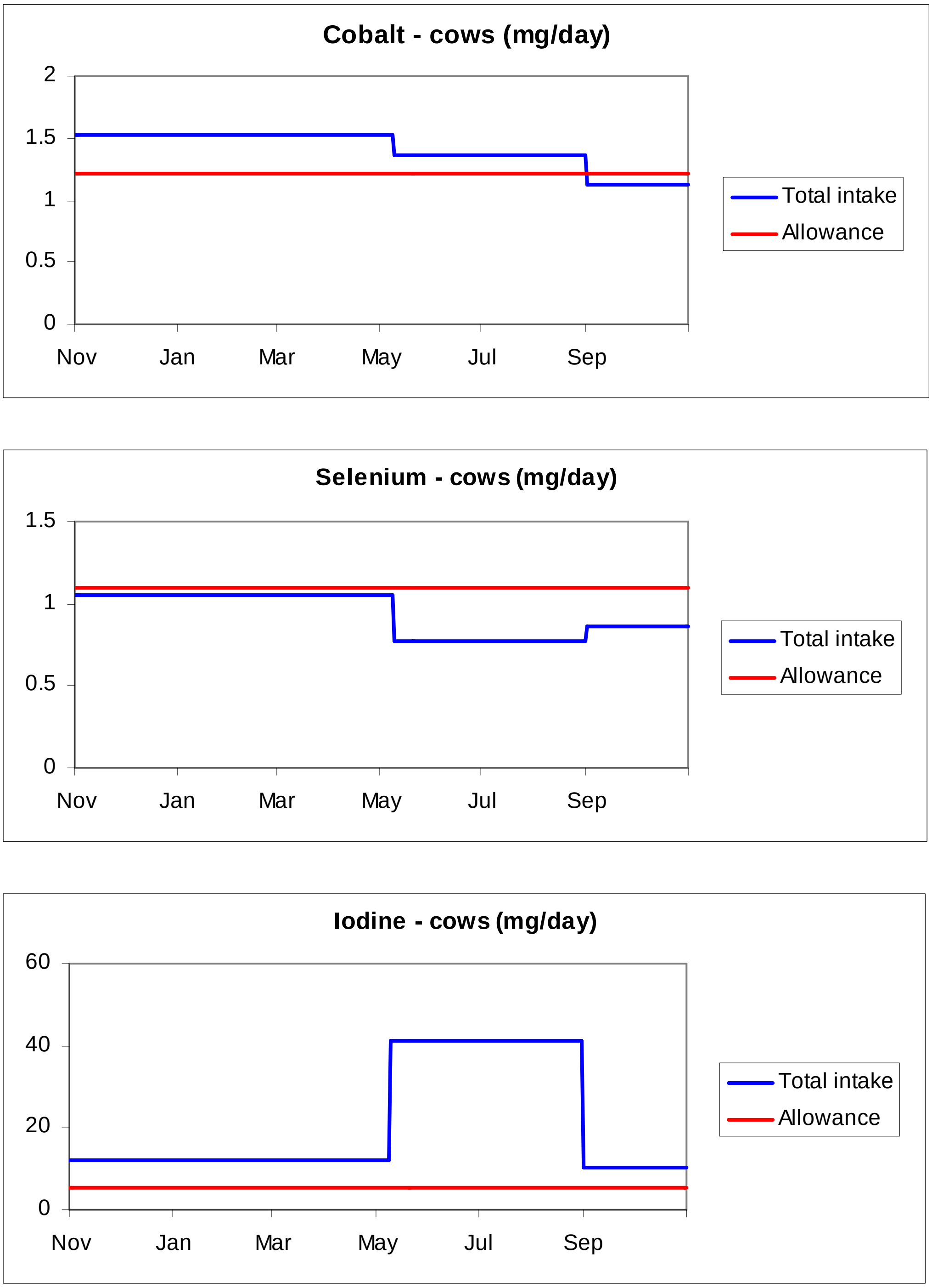
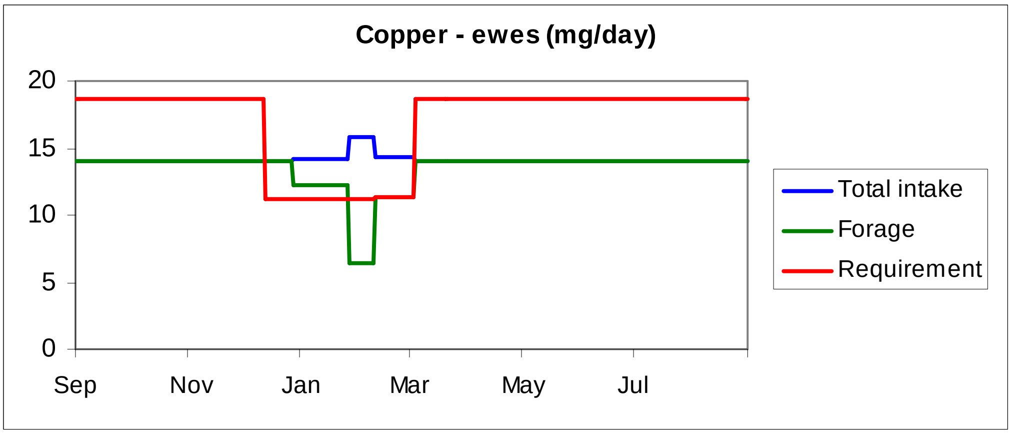


Figure A20. Annual Co, Se and I profiles for breeding suckler cows



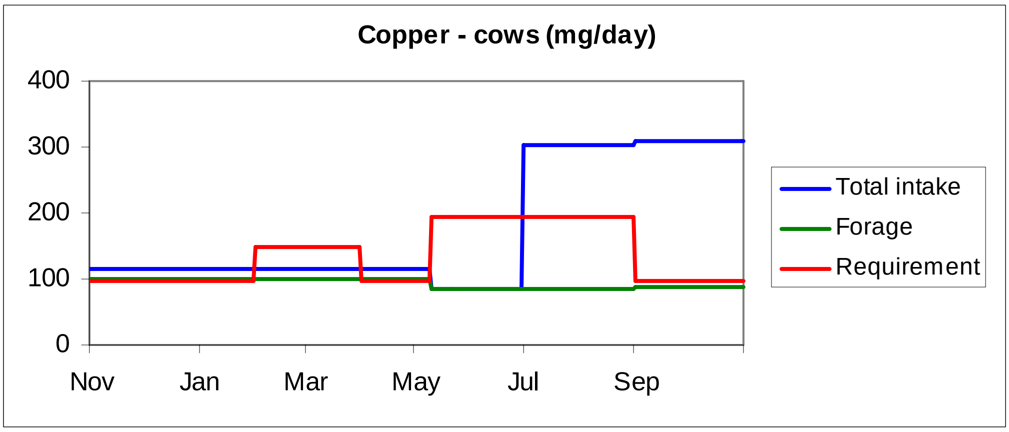


Figure A21. Annual copper profiles for breeding ewes and cattle