NUFG 2006/07 GRAZING TRIAL AT KAMAROOKA

FINAL REPORT

prepared by Mal Brown, NUFG Kamarooka Project Manager

TABLE OF CONTENTS

EXECUTIVE SUMMARY 3

INTRODUCTION 4

- THE HAY FARM 4
- LEGISLATION 4
- ANIMAL HEALTH AND WELFARE 5
- COLLECTING BLOOD FROM THE LAMBS 5
- FACILITIES AND EQUIPMENT 5
- LABORATORY DIAGNOSTICS 5

SUMMARY OF RESULTS 6

BLOOD COMPOSITION ANALYSES 8

BIOMETRICIAN'S REPORT 18

SHEEP NUTRITION 22

LUCERNE 23

SALTBUSH 25

REFERENCES 27

EXECUTIVE SUMMARY

In 2004 Northern United Forestry Group (NUFG), in cooperation with the Hay family (landowners), established a revegetation project on 40 ha of saline land at Kamarooka, 35 km north of Bendigo. The revegetated project site now comprises a mix of planted saltbush, native grasses, farm forestry trees, and biodiversity trees and shrubs. Naturally occurring native grasses and saltbush also grow between the rows of farm forestry trees. Small patches of remnant vegetation (Grey Box trees) are found at the northern and southern ends of the project site.

NUFG, again in cooperation with the Hay family, conducted a 100-day grazing trial at Kamarooka from 9 November 2006 to 15 February 2007. The project involved two trial plots - a lucerne paddock and the revegetated saline land. Weight and blood composition was monitored before and after the trial.

The use of animals for scientific purposes in Victoria is regulated by Part III of *the Prevention of Cruelty to Animals Act 1986* (the Act). Blood collection from a live animal in a research setting, for use in scientific techniques, is regarded as a scientific purpose under the Act. On 12 October 2006 the NUFG grazing trial received approval from the Wildlife and Small Institutions Animal Ethics Committee. A Scientific Procedures Fieldwork licence was also issued to NUFG before the trial commenced.

As expected, there were significant weight gains during both trials (see Table 3, Figure 19). Weight gains on Lucerne were greater than on the revegetated land, however we can make no inference about the significance of this difference (see Biometrics analysis, Pages 18-21).

Blood composition analyses for 20 lambs on each plot revealed differences in the serum levels of a range of indicators before and after the trial. None of the animals suffered any ill-health from the trial. The diagnostic laboratory provided normal ranges considered healthy for sheep for 22 of the 24 blood serum components measured. The lambs grazing the revegetated saline land exhibited a mean value within the normal healthy range for 16 blood components at the start of the trial and 18 at the end of the trial. The 20 lambs grazing the lucerne exhibited a mean value within the normal healthy range for 16 of these components at the start of the trial and 16 at the end of the trial. Most blood variables changed significantly during the trials (see Table 2, Figure 2 a & b). The changes for ALP, ALT, Amyl, CK, Creatine & Cu were different for Lucerne than they were for Revegetation.

Dr David Masters, Senior Principal Research Scientist, CSIRO Livestock Industries, WA, provided the following comments on the results:

- First of all I congratulate you and the group on conducting this study. As far as I am aware no one before has made a serious effort to investigate the animal health consequences of saltbush grazing by using diagnostic indicators as you have done.
- It appears to me that both groups of animals are healthy. There are a few instances of groups or individuals being outside the normal range, but being outside the normal range does not consistently appear to be associated with type of diet.
- With reference to the urea results - a few factors can influence plasma urea, these include high levels of protein or degradeable protein, but also high urea may occur during weight loss and muscle catabolism. Your levels probably reflect the high protein in lucerne. We have recorded similar levels in sheep fed large quantities of lupins. Where sheep have shown signs of acute ammonia toxicosis, plasma urea as high as 17-37 mmol/L have been reported.
- I have a little more expertise in mineral metabolism and most of the mineral levels are well within the expected range. Calcium is over, but not by much.

On Monday 26 February 2007, 16 lambs from the lucerne trial plot were sold into the market at 50-52 kg liveweight (22-23kg dressed @ $3.50/kg), bringing $88 per head, including $10 per skin. On the same day, ten of the lambs that had grazed the revegetated saline land were sold at 47.5 - 49.6 kg liveweight, bringing $85 per head.

INTRODUCTION

In 2004 Northern United Forestry Group (NUFG), in cooperation with the Hay family (landowners), established a revegetation project on 40 ha of saline land at Kamarooka, 35 km north of Bendigo. The project site now comprises approximately one-third saltbush, one-third native grasses, and one-third farm forestry and biodiversity species. Naturally occurring native grasses and saltbush also grow between the rows of farm forestry trees.

In 2006/07 NUFG and the Hay family conducted a grazing trial on 30 ha within the project site and 10 ha of lucerne adjacent to the project site. NUFG was interested in the impact of the two different grazing regimes on lamb weights and general animal health.

In November 2006 Andy Hay identified two mobs of 100 lambs for the trial. All lambs involved in the trial were first cross, May 2006 drop, wethers. The trial lasted 100 days, commencing on 9 November 2006 and concluding on 15 February 2007.

To collect information on animal health blood samples were taken from 20 lambs in each mob before and after the trial. The 20 lambs were selected from each mob by using a set of random numbers supplied by a biometrician.

All 100 lambs grazing the revegetated saline land were weighed before and after the trial. Due to the drought and slower than normal plant growth only the 20 lambs from which blood samples were taken were put into the lucerne adjacent to the project site.

THE HAY FARM

Andy Hay's family has farmed at Kamarooka since 1886. The farm comprises 3 000 acres and carries 2 400 sheep. Each year the ewes on the Hay farm lamb in April and May. The Hays sell between 900 and 1 000 lambs into the market each year. A selection of 45 kg lambs is sold in October. The remaining lambs are shorn and continue to graze until May the following year when they are sold into the market at an average of 55 kg. This level of production has been sustained for the last thirty years. The sheep are well cared for with good quality feed (including lucerne pasture) and have access to water at all times.

Trial site A

100 lambs grazed the 28 ha revegetation project site at a stocking rate of 0.28 DSE/ha. They fed principally on native grasses and saltbush. Although they had access to the trees they were observed to browse them very lightly. The revegetated saline land has had no fertiliser added in 50 years. The lambs had access to fresh clean water at all times.

Trial site B

20 lambs grazed a 10 ha lucerne paddock at a stocking rate of 0.52 DSE/ha. They fed exclusively on lucerne with no supplementary feed. Trial site B is a 10 ha lucerne paddock. It has been sown to lucerne for six years. The site has been top dressed with super and sown to oats which have been cut each year, but no hay was cut in 2006. The lambs had access to fresh clean water at all times.

LEGISLATION

The use of animals for scientific purposes in Victoria is regulated by Part III of *the Prevention of Cruelty to Animals Act 1986* (the Act). Blood collection from a live animal, whether in a commercial or research setting, for use in scientific techniques, is regarded as a scientific purpose under the Act. Thus the collection must be carried out under a scientific licence and the protocol approved by an Animal Ethics Committee (AEC).

On 12 October 2006 the NUFG grazing trial received approval from the Wildlife and Small Institutions Animal Ethics Committee. A Scientific Procedures Fieldwork licence was also issued to NUFG before the trial commenced.

In the application to undertake the grazing trial NUFG demonstrated:

- Concern for animal welfare
- A risk management strategy for the project
- How stock would have access to water at all times
- How the community would benefit from the project
- That the stock would be under the supervision of an experienced stockperson and a veterinarian
- In a stock management plan, the criteria by which animals might be withdrawn from the program based on measures of bodyweight.

ANIMAL HEALTH AND WELFARE

Immediately before a small volume of blood was taken, every lamb was subject to close visual appraisal by Andy Hay, an experienced stockperson. None of the lambs from which a blood sample was taken appeared light in condition or showed malaise or any other sign of ill-health. The lambs were monitored after release for evidence of ill-effects. During the grazing trial no lambs showed signs of ill-health, therefore it was not necessary to withdraw any lambs from the trial.

COLLECTING BLOOD FROM THE LAMBS

According to the Draft Guidelines for the Welfare of Livestock from which Blood is Harvested for Commercial and Research Purposes not more than 15% of the estimated circulating blood volume of an adult sheep should be removed in any 4-week period, ie 0.9% sheep live weight. For sheep 6 months old, not more than 10% circulating blood volume should be removed, with incremental increases to the maximums above when fully grown (more than 12 months old for sheep).

Circulating blood volume (litres) can be estimated from body weight (kg) using a conversion factor of 0.06 for sheep. The mean weight of lambs from which blood was taken in the two trials at the start of the project was 35.6 kg. For 35.6 kg lambs; 35.6 x 0.06 = 2.1 litres. NUFG's research requires blood samples of 14 ml. This is approximately 0.65% of the estimated circulating blood volume.

The volume of blood required per animal is one 10ml plain blood tube, plus one 4 ml Fluoride Oxalate Tube (for Glucose). Total of 14 ml per sheep. Dr Alan R Campey, Veterinarian, from Eaglehawk Vet Clinic collected blood from the lambs using a vacutainer and needle.

FACILITIES AND EQUIPMENT

The sheep yard facilities adjacent to the Hay's woolshed ensured that there was minimal risk of the lambs being injured by projections, wire or sharp corners. The lambs were adequately restrained to allow efficient blood collection. The sheep yards also allowed for clinical examination of the lambs. A Pratley weigh crate with electronic loadbars was used to accurately weigh the lambs.

LABORATORY DIAGNOSTICS

The laboratory diagnostic work was carried out by ACE Laboratory Services, White Hills. ACE Laboratories has developed normal reference ranges for animals that are considered to be healthy for the majority of the tests on offer. Where known, these reference ranges for sheep are included in this report. Each of the blood component reports is presented graphically on pages 6 to 15.

The pre-trial results for GLDH (74 U/L) and AST (154 U/L), along with GLDH (33 U/L) and AST (222 U/L) together with the post-trial CK reading of 1008 U/L were validated by ACE Laboratories.

ACE Laboratory Services advises that these samples were retested to ensure the accuracy of the result at the time of testing as it was noticed they were out of normal range. GLDH and AST are indicators of liver damage. ACE Laboratories has observed elevated results in sheep grazing on heliotrope or with liver fluke infestations.

SUMMARY OF RESULTS

Table 1: Lamb weights before and after the trial involving two different grazing treatments

Randomly sampled Lamb No.	Trial site A (Revegetated saline land)		Trial site B (Lucerne)	
	Weight kg Day 1	Weight kg Day 100	Weight kg Day 1	Weight kg Day 100
1	27	32	31	54
2	28	35	32	42
3	28	34	33	44
4	32	37	33	48
5	32	38	34	48
6	33	39	34	53
7	33	39	34	49
8	35	40	34	50
9	36	38	35	36
10	36	41	35	45
11	36	37	35	42
12	36	40	36	45
13	38	44	36	54
14	39	42	36	39
15	40	48	37	50
16	40	49	38	48
17	40	48	38	42
18	41	46	38	50
19	41	49	39	49
20	44	47	39	54
Mean	36 kg	41 kg	35 kg	47 kg

Table 2: Lamb blood profiles before and after the trial involving two different treatments

Lamb blood component	Normal range (Source: ACE Laboratories)	Trial site A (Revegetated saline land)		Trial site B (Lucerne)	
		Mean value Day 1	Mean value Day 100	Mean value Day 1	Mean value Day 100
Total protein (TP)	57-85 g/L	**71.2**	**72.8**	68.0	73.2
Albumin	24-36 g/L	**38.7**	**31.7**	39.1	33.5
Globulins	32-43 g/L	**32.5**	**41.1**	28.9	39.7
Calcium (Ca)	2.10-2.90 mmol/L	**2.5**	**2.8**	2.7	3.1
Phosphorus (P)	1.15-2.40 mmol/L	**2.0**	**1.8**	2.0	1.8
Glucose	2.8-4.4 mmol/L	**3.5**	**4.0**	3.1	4.2
Blood urea	2.9-7.1 mmol/L	**8.0**	**5.6**	7.4	10.6
Cholesterol (Chol)	1.20-2.60 mmol/L	**1.5**	**1.3**	2.2	1.4
Triglycerides (TG)	0.34-0.80 mol/L	**0.33**	**0.23**	0.20	0.33
Alkaline phosphatase (ALP)	10-200 U/L	**224.4**	**126.0**	153.9	198.7
Creatinine	0.11-0.17 mmol/L	**0.06**	**0.08**	0.10	0.10
Creatine Phosphokinase	0-312 U/L	**364.5**	**221.4**	164.7	219.6
Aspartate aminotransferase (AST)	0-123 U/L	**66.6**	**104.0**	101.4	120.1
Alanine Aminotransferase (ALT)	U/L (not available)	**17.0**	**15.4**	12.0	16.7
Gamma-Glutamyltransferase, (GGT)	0-59 U/L	**53.2**	**44.4**	55.0	45.8
Amylase	U/L (not available)	**24.1**	**16.6**	10.5	15.3
Sodium (Na)	138-160 mmol/L	**149.8**	**155.5**	152.8	160.0
Potassium (K)	3.7-5.8 mmol/L	**5.0**	**4.93**	5.2	4.98
Chloride (Cl)	94-110 mmol/L	**103.9**	**112.1**	109.6	111.8
Iron (Fe)	18-54 mmol/L	**29.0**	**33.5**	32.1	39.0
Magnesium (Mg)	0.7-1.0 mmol/L	**0.72**	**0.9**	0.84	1.3
Copper (Cu)	8.0-24.0 uol/L	**16.6**	**16.4**	13.3	16.8
Zinc (Zn)	12.0-19.0 umol/L	**13.9**	**12.8**	13.4	13.1
Glutamate Dehydrogenase (GLDH)	0-9 U/L	**9.4**	**15.4**	11.6	7.6

Of the 24 blood serum components measured, ACE laboratories was able to provide 22 normal ranges considered healthy for sheep. The 20 lambs grazing the revegetated saline land exhibited a mean value within the normal healthy range for **16** of these components at the start of the trial and **18** at the end of the trial. The 20 lambs grazing the lucerne exhibited a mean value within the normal healthy range for **16** of these components at the start of the trial and **16** at the end of the trial.

BLOOD COMPOSITION ANALYSES

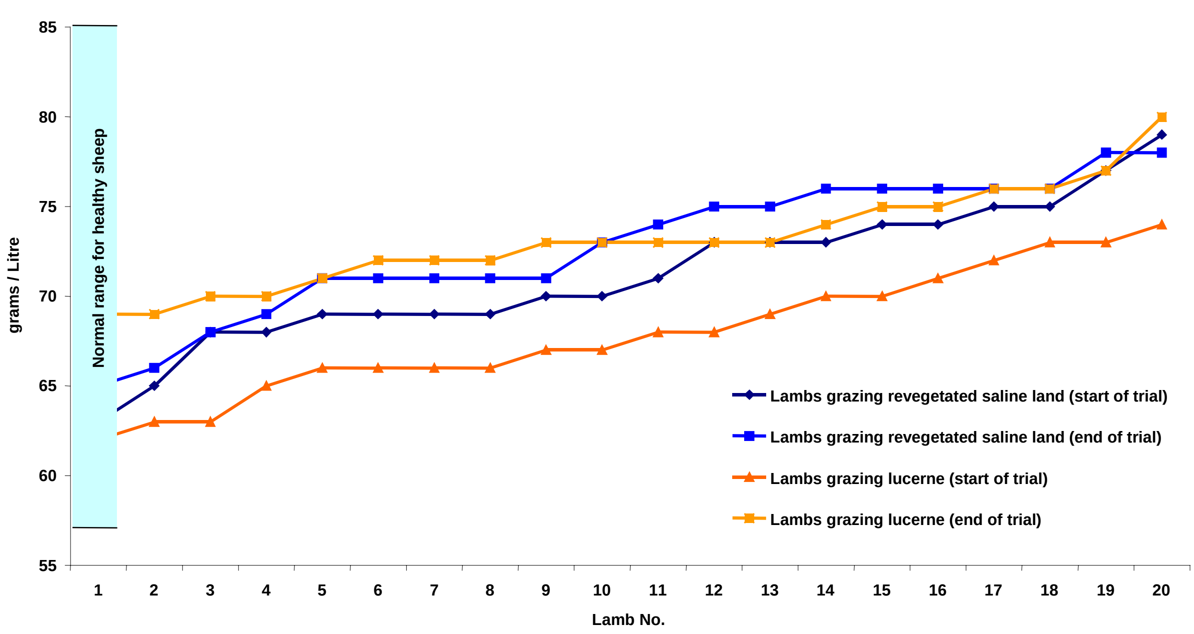
TOTAL PROTEIN (TP)

Total protein is a rough measure of serum protein. Protein measurements can reflect nutritional state, kidney disease, liver disease, and many other conditions. Proteins are important constituents of all cells and tissues. Proteins are made from amino acids. There are many different kinds of proteins in the body with many different functions. Enzymes, some hormones, haemoglobin (oxygen transport), LDL (cholesterol transport), fibrinogen, (blood clotting), collagen (structure of bone and cartilage), immunoglobulins (antibodies) are some examples of proteins.

Serum proteins are separated into two groups: **albumin** and **globulins**. Total protein equals albumin plus globulin. Albumin is the protein of highest concentration in the serum (plasma is serum plus fibrinogen). Albumin is a carrier of many small molecules, but is also of prime importance in maintaining the osmotic pressure of the blood (that is, keeping the fluid from leaking out into the tissues).

Abnormal levels of these proteins are termed dysproteinaemias. Total protein and albumin concentrations are determined and the globulin concentration arrived at by subtraction. Total protein levels are affected by physiological as well as pathological factors. Serum total protein levels are approximately 5% less than those of plasma due to the loss of fibrinogen in the clotting process.

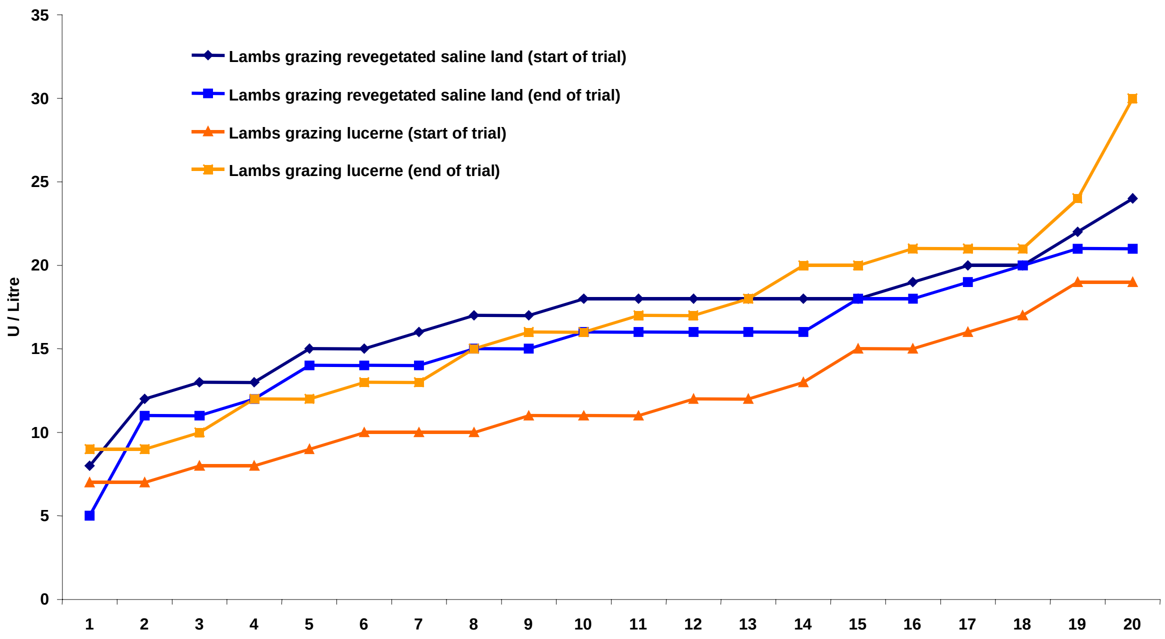
Figure 1: Kamarooka 2006/07 Grazing Trial - Total Protein (TP) blood



ALT (Alanine aminotransferase)

ALT is found in the cytoplasm of hepatocytes and is released into the blood from the liver during changes in cell membrane permeability or necrosis. Its superficial location means that a relatively mild insult, e.g. hypoxia, may lead to increased serum levels. In chronic hepatic disease with loss of functional mass levels may be deceptively low. In acute disease a rapid decline in levels may be a favourable sign. Recent work has demonstrated that ALT levels may also increase due to increased synthesis and release by healthy hepatocytes. No normal range for ALT in healthy sheep is available.

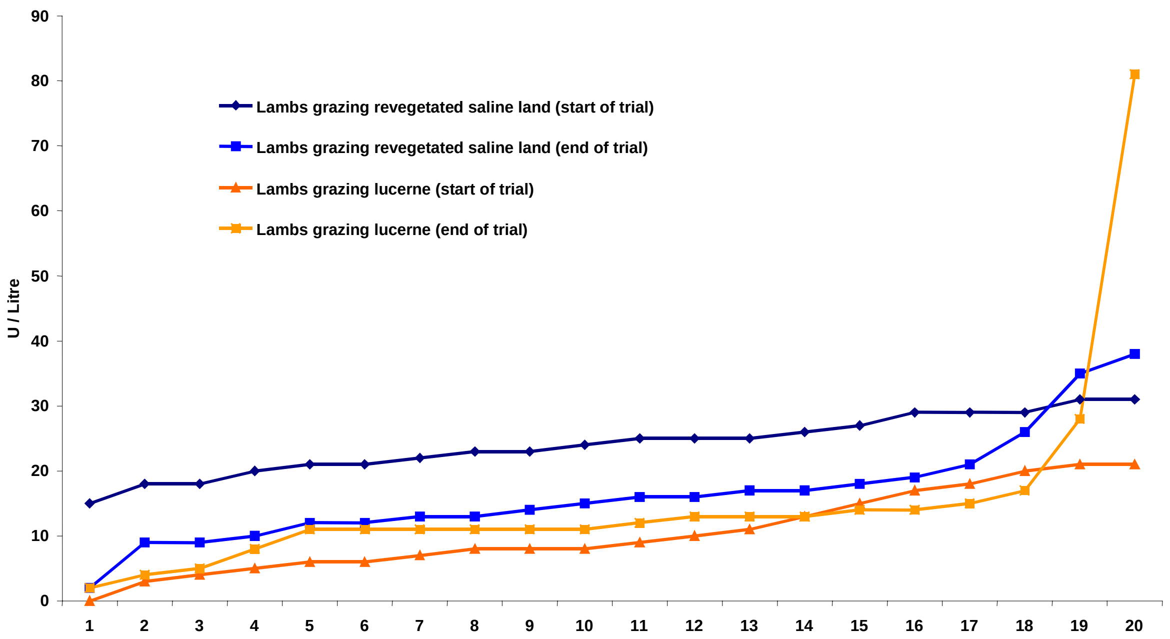
Figure 2: Kamarooka 2006/07 Grazing Trial - ALT blood serum levels



AMYLASE

Only alpha amylase is found in animals. Pancreas, liver and small intestine are the main sources of serum amylase. No normal range for amylase in healthy sheep is available.

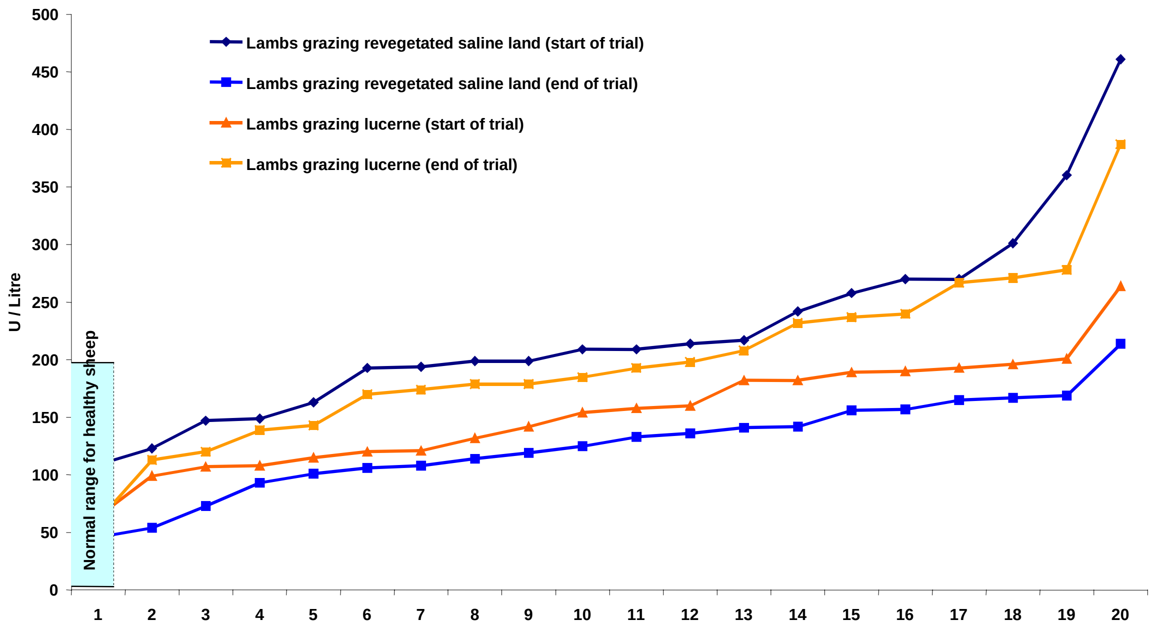
Figure 3: Kamarooka 2006/07 Grazing Trial - Amylase blood serum levels



ALP (Alkaline Phosphatase)

ALP isoenzymes are found in a variety of tissues including intestine, liver, bone, placenta, kidney and leukocytes. Unlike ALT, AST and GLDH, increased serum levels of AP are due to increased synthesis of the enzyme. ALP levels will remain elevated during hepatic repair and this is not a poor prognostic indicator as ALP is released by healthy hepatocytes.

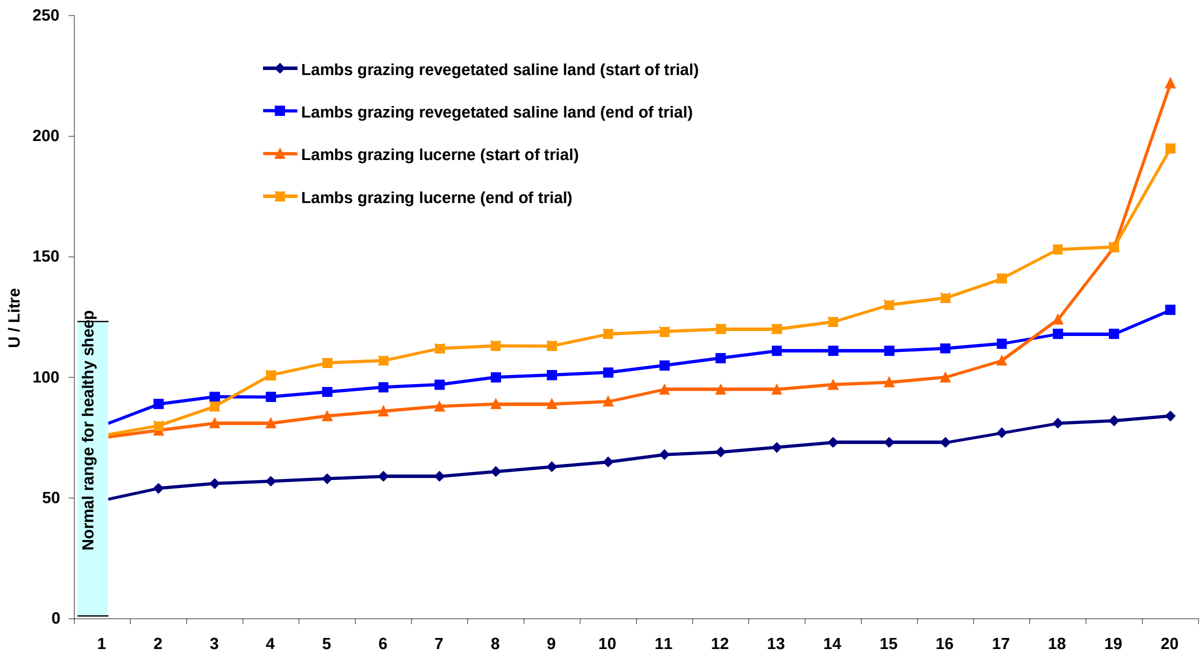
Figure 4: Kamarooka 2006/07 Grazing Trial - ALP blood serum levels



AST (Aspartate aminotransferase)

AST occurs in the liver, erythrocytes and all types of muscle. It is found in the both the cytoplasm and mitochondria of cells hepatocytes and is released into the blood due to hepatucellular damage and during changes in cell membrane permeability or necrosis.

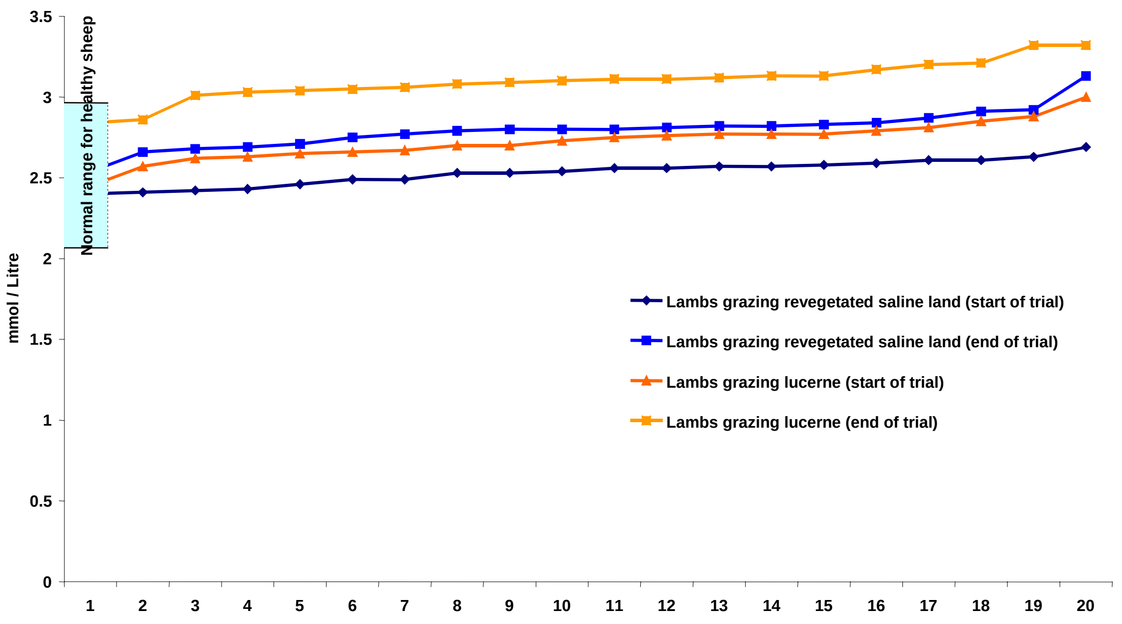
Figure 5: Kamarooka 2006/07 Grazing Trial - AST blood serum levels



CALCIUM

Calcium is an essential mineral involved in many body systems. These include the skeleton, enzyme activation, muscle metabolism, blood coagulation and osmoregulation. In the blood calcium exists as 50% ionized, 40% protein bound and 10% complexed with anions such as citrate and phosphate. Only ionized calcium is biologically active in bone formation, neuromuscular activity, cellular biochemical processes and blood coagulation. Factors governing the total plasma concentration are complex and include interaction with other chemical moieties, proteins and hormones. Calcium, phosphorous and albumin metabolism are interdependent.

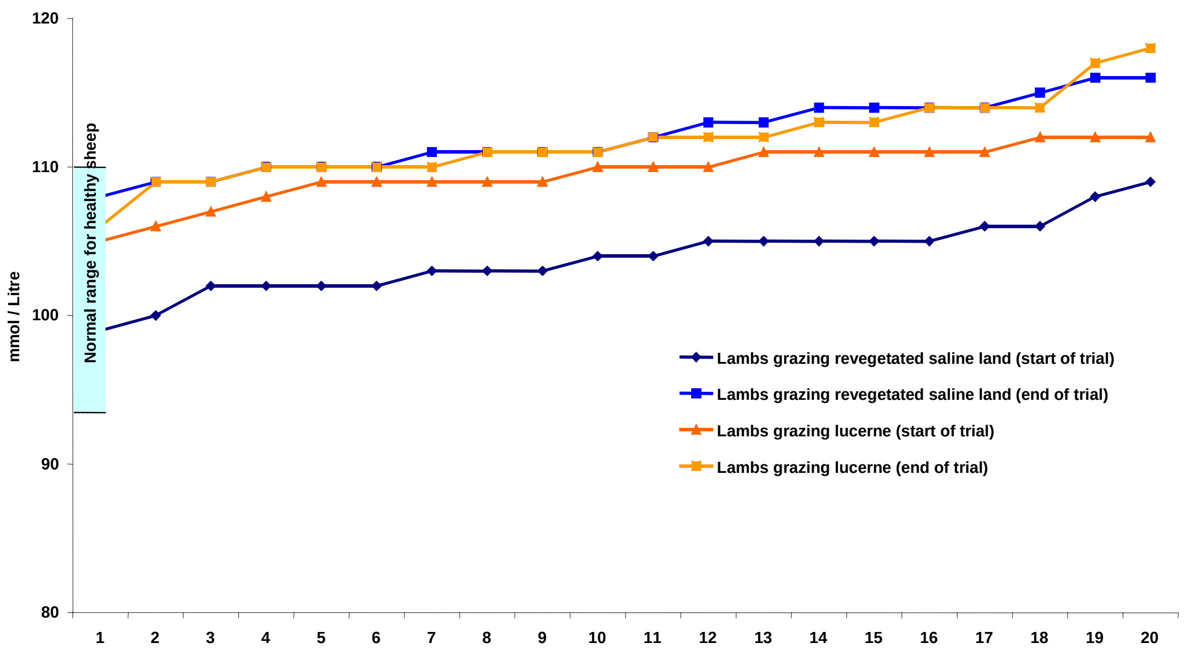
Figure 6: Kamarooka 2006/07 Grazing Trial - Calcium (Ca) blood serum levels



CHLORIDE

Chloride is present in highest concentrations in the extra cellular fluid and tends to accompany sodium movement by passive diffusion.

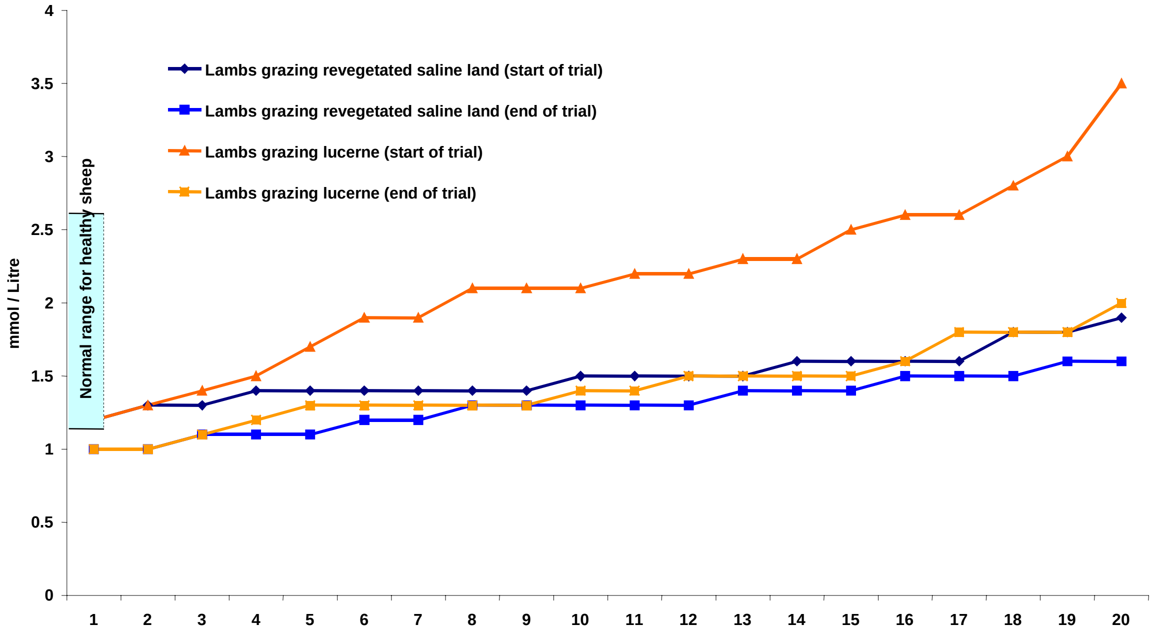
Figure 7: Kamarooka 2006/07 Grazing Trial - Chloride (Cl) blood serum levels



CHOLESTEROL

Cholesterol is produced in the liver and acquired by diet. Plasma cholesterol occurs at high concentration in the esterified form and at much lower concentration in the free form, and these are measured together as total cholesterol. Cholesterol is esterified in the liver. Cholesterol is also broken down in the liver to synthesise bile acids. Triglycerides and cholesterol combine in lipoproteins. Triglyceride levels determine visible lipaemia (abnormally high concentration of lipids).

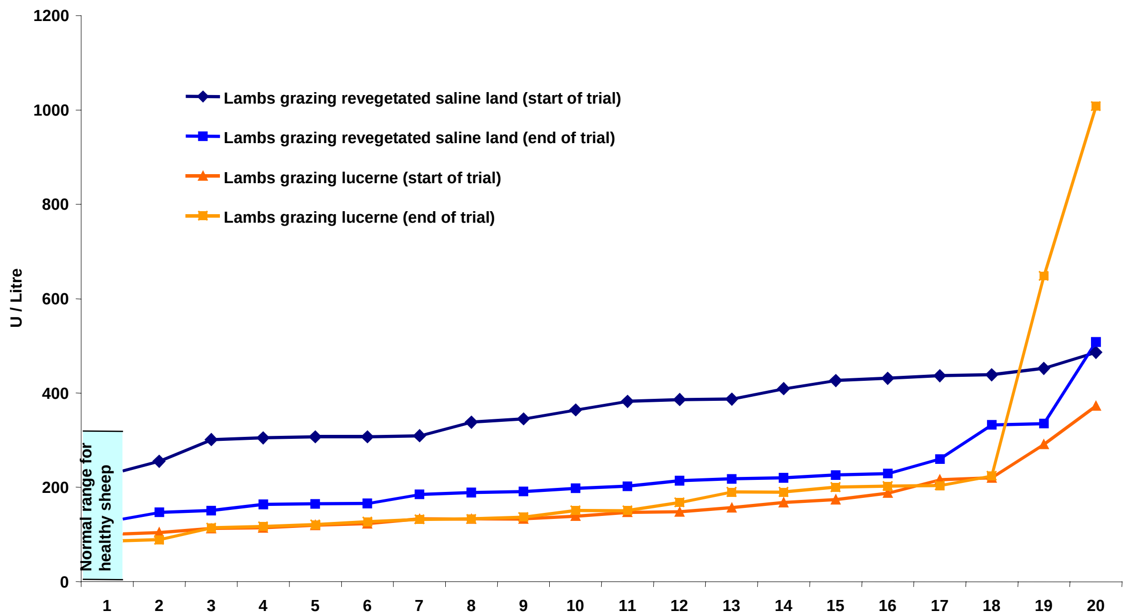
Figure 8: Kamarooka 2006/07 Grazing Trial - Cholesterol blood serum levels



CK (Creatine kinase)

CK occurs in high levels in skeletal muscle, cardiac muscle and brain tissue though only skeletal and cardiac muscle are of major significance. The enzyme is essential for the rapid conversion of ADP to ATP to release energy for muscle contraction. Thus if muscle tissue is disrupted the enzyme is released into the blood stream and is readily detected.

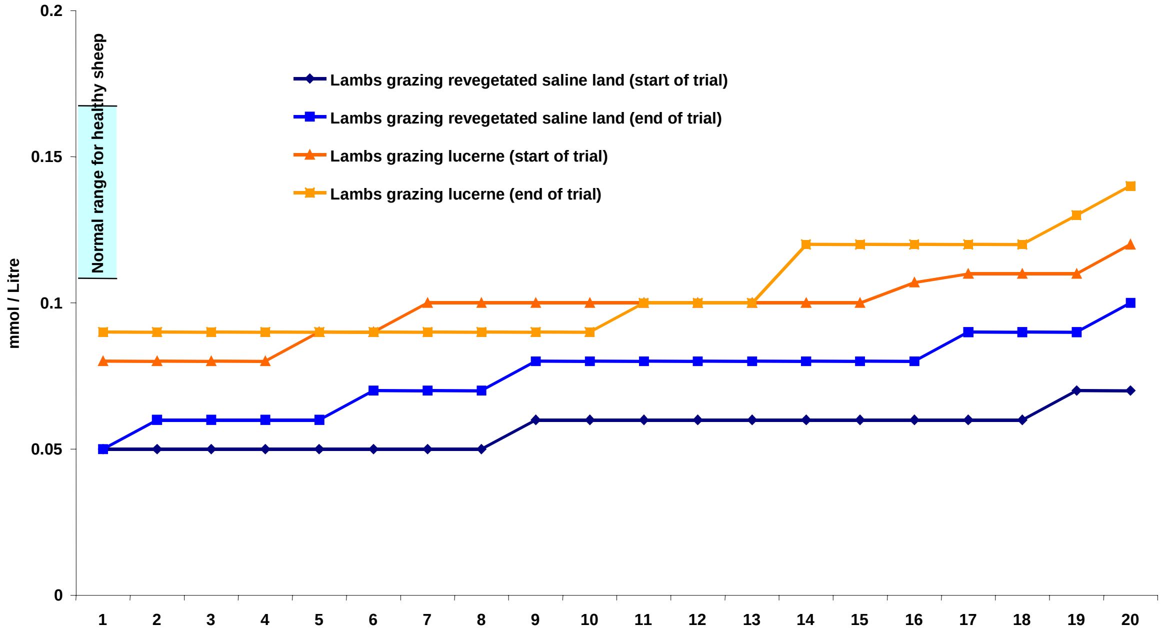
Figure 9: Kamarooka 2006/07 Grazing Trial - Creatine kinase (CK) blood serum levels



CREATININE

Creatinine is produced at a steady rate due to muscle catabolism and is not reabsorbed by the kidney tubules after filtration. Its measurement provides an indirect assessment of the glomerular filtration rate and an indicator for renal dysfunction.

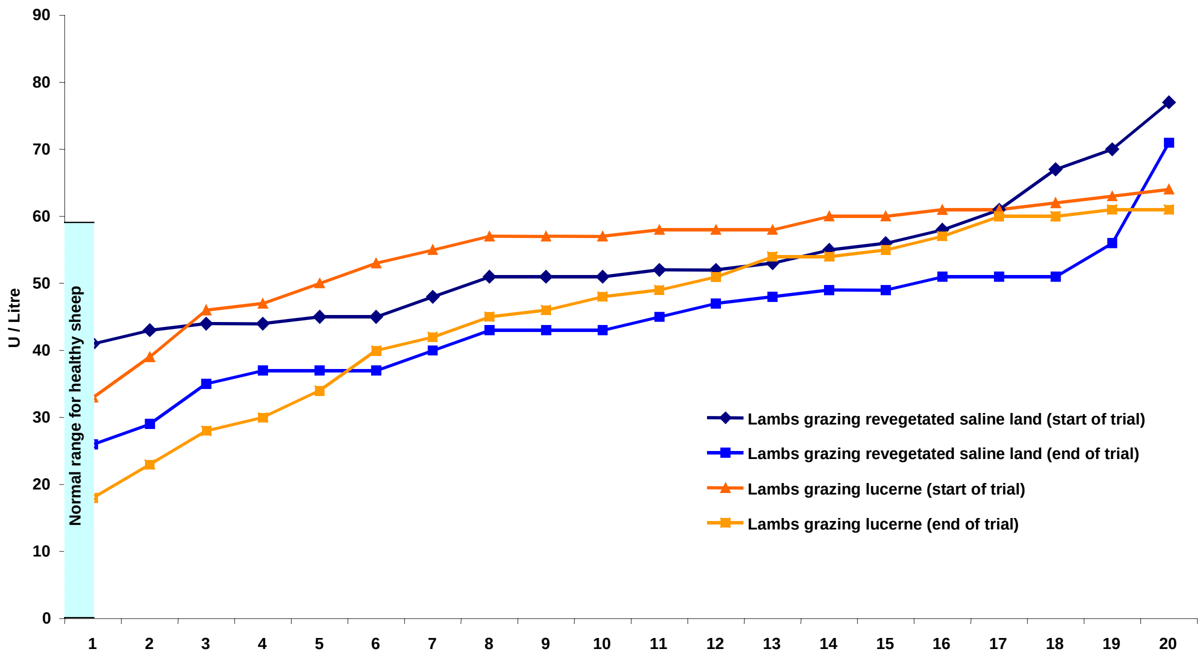
Figure 10: Kamarooka 2006/07 Grazing Trial - Creatinine blood serum levels



GGTL (Gamma-glutamyltransferase)

Serum gamma-glutamyl transferase (GGTL) is a marker of hepatic injury. Circulating enzyme is considered to originate from biliary endothelial cells and hepatocytes from the Liver.

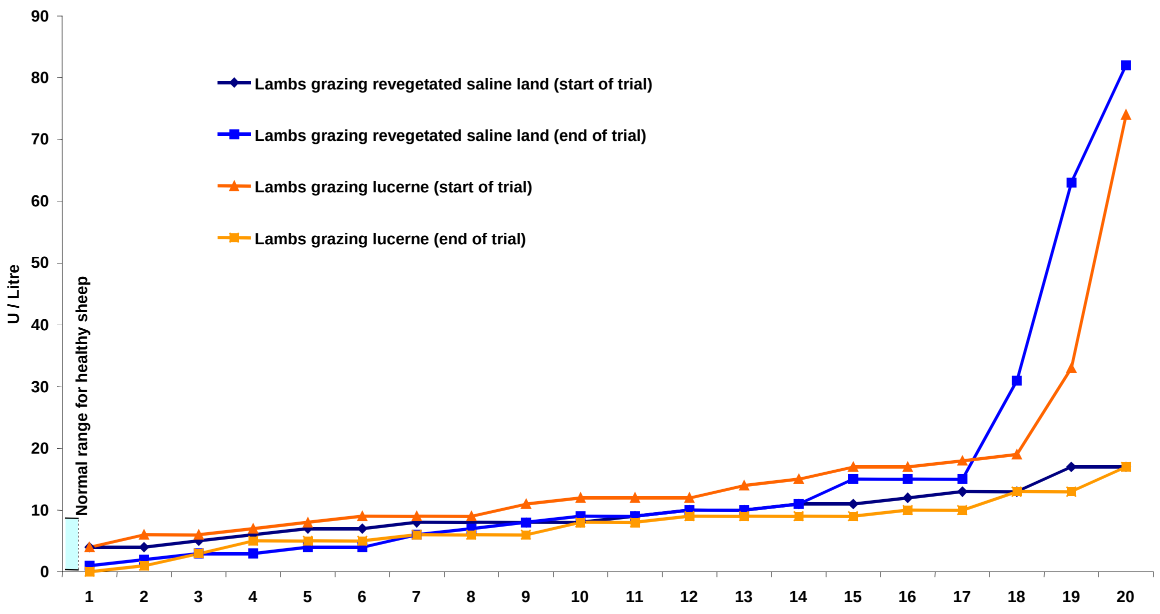
Figure 11: Kamarooka 2006/07 Grazing Trial - GGTL blood serum levels



GLDH (Glutamate Dehydrogenase)

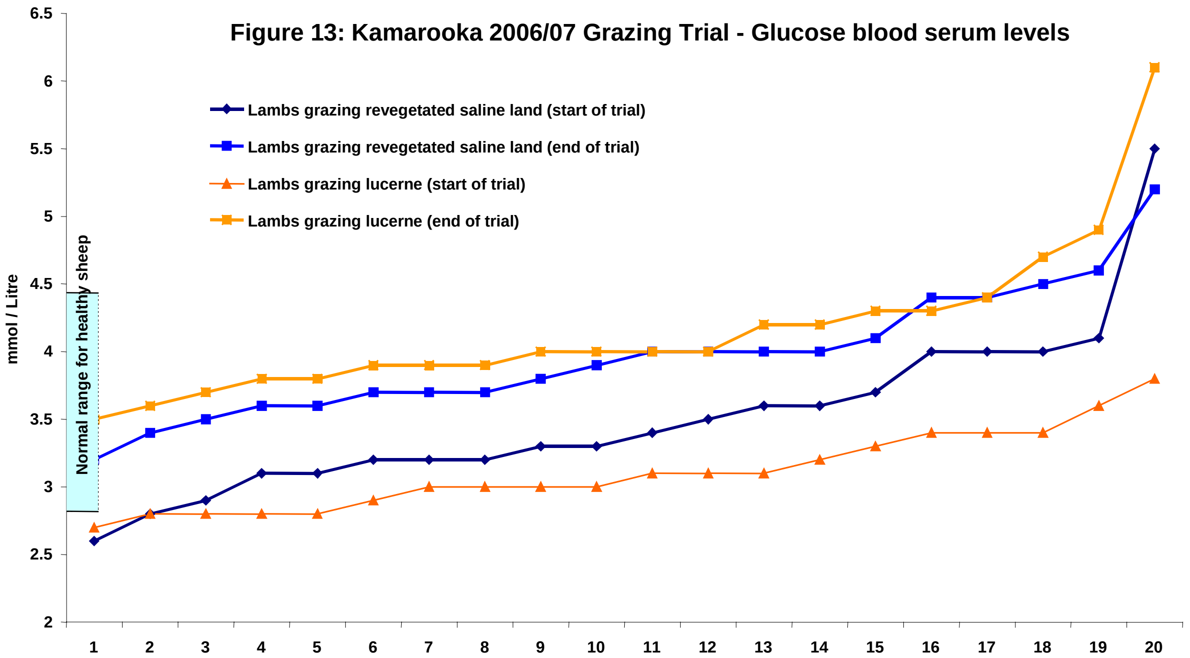
This liver specific enzyme is localised almost exclusively in the mitochondria of hepatocytes. It is generally considered that a severe insult is required to bring about its release and it is therefore not a sensitive general marker for hepatic disease. GLDH has a relatively short half-life so elevated levels therefore indicate active hepatocellular damage.

Figure 12: Kamarooka 2006/07 Grazing Trial - GLDH blood serum levels



GLUCOSE

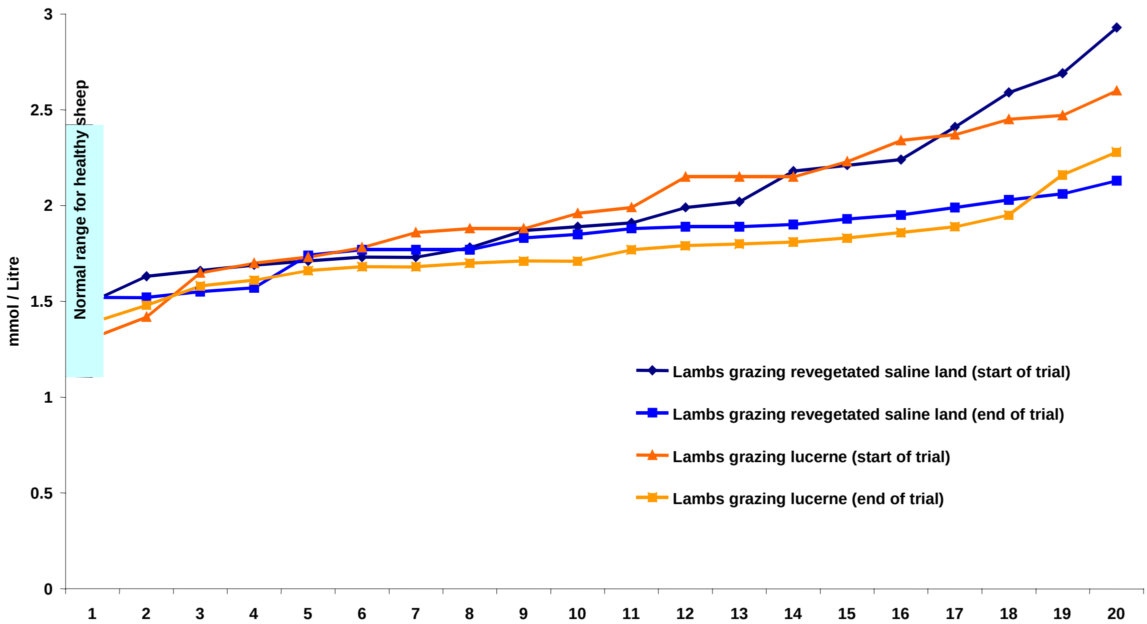
Glucose is the source of energy in the body and is regulated by insulin and glucagon. Glucose passes freely through the renal glomeruli and is totally reabsorbed in the renal tubules. As plasma glucose levels rise this mechanism is saturated and the "renal threshold" exceeded, glucose then appears in the urine.



PHOSPHORUS (Inorganic phosphate)

Serum phosphorus is primarily regulated by the kidney through the action of parathyroid hormone. Abnormal levels are caused by variations in dietary intake, decreased renal excretion and the hormonal imbalances that affect serum calcium.

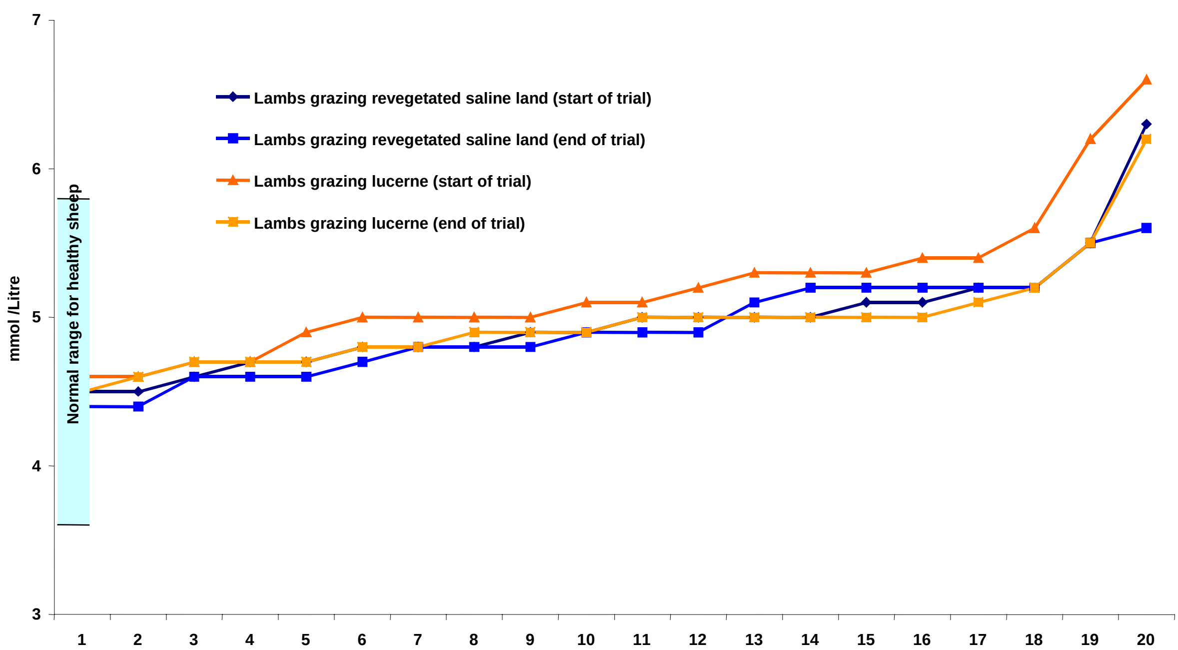
Figure 14: Kamarooka 2006/07 Grazing Trial - Phosphorus (P) blood serum levels



POTASSIUM

Plasma potassium levels are not always a good indicator of intracellular levels; in acidosis the exchange of H+ and K+ ions leads to the depletion of intracellular potassium and elevated plasma potassium. The converse occurs in alkalosis. Hypokalaemia may lead to neurological, muscular and cardiac signs. In most cases, hyperkalaemia arises due to a diminished ability to excrete potassium. Marked hyperkaelaemia is potentially life threatening causing bradycardia and cardiac arrest.

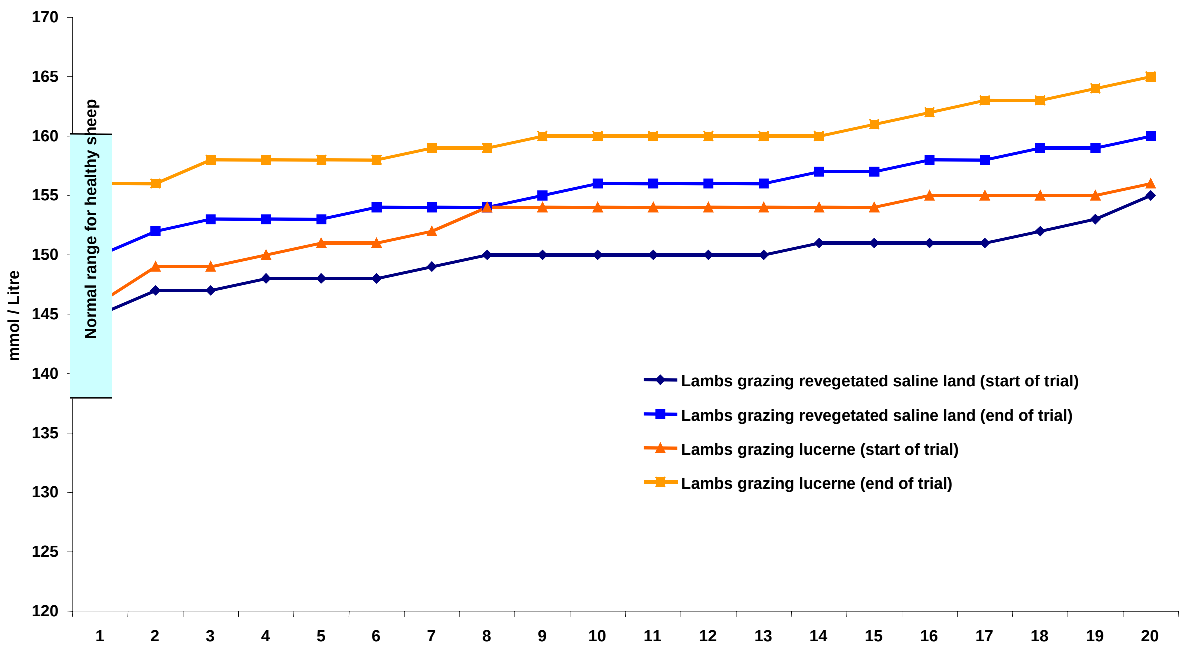
Figure 15: Kamarooka 2006/07 Grazing Trial - Potassium (K) blood serum levels



SODIUM

The distribution of sodium in the body differs from that of potassium. Sodium is predominantly extracellular due to the sodium pump mechanism. In contrast, only 2% of potassium is extracellular, the rest being intracellular. Renal function is the single most important homeostatic mechanism in relation to plasma concentrations of sodium and potassium.

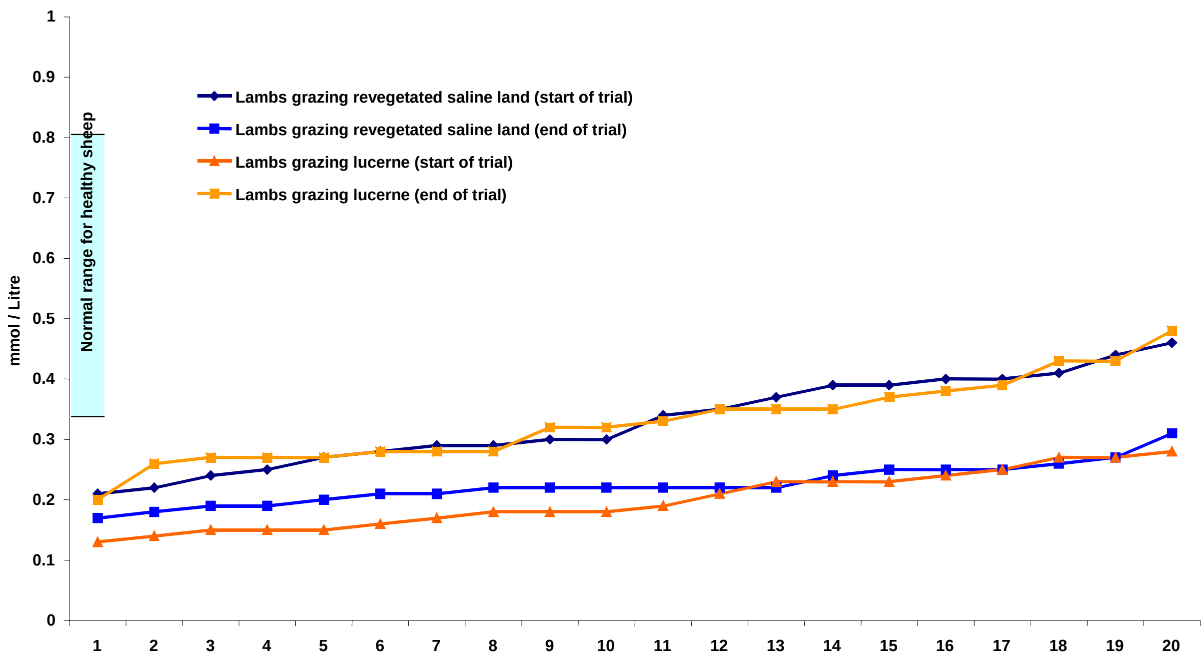
Figure 16: Kamarooka 2006/07 Grazing Trial - Sodium (Na) blood serum levels



TRIGLYCERIDES

Triglycerides may be ingested or synthesised in the liver. They are complexed with cholesterol, phospholipids and plasma proteins to form lipoproteins.

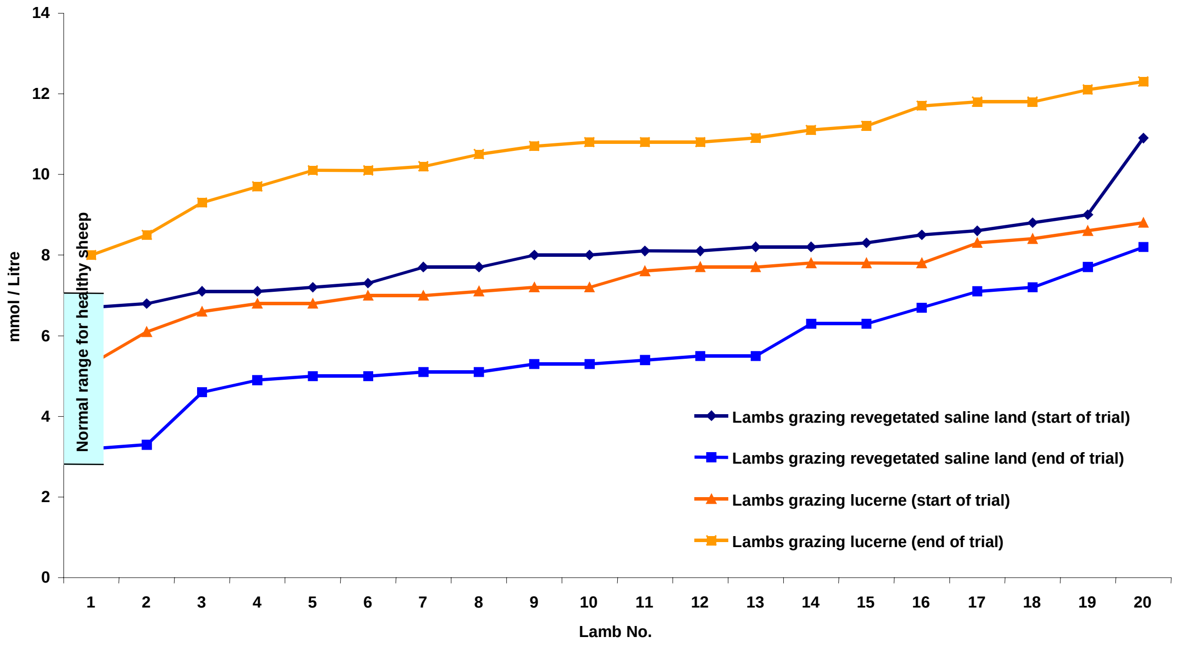
Figure 17: Kamarooka 2006/07 Grazing Trial - Triglycerides blood serum levels



UREA

Urea is principally a product of amino acid deamination in the liver. Urea is primarily excreted by the kidneys and is the most commonly used test of renal function.

Figure 18: Kamarooka 2006/07 Grazing Trial - Urea blood serum levels



BIOMETRICS ANALYSIS

Prepared by Leigh Callinan, PhD, AStat, Bendigo Scientific Data Analysts, Bendigo, VIC

Two trials looking at the growth and changes in blood variables in lambs grazing revegetated or lucerne at Kamarooka.

Background: In November 2006, two mobs of 100 (May 2006 drop) lambs were selected. From each mob, 20 lambs were randomly selected and tagged.

Trial site 1
100 lambs went into a revegetation project site on 9 November, at a stocking rate of 0.28 DSE/ha. They fed on native grasses and saltbush. They did have access to the trees but only browsed them very lightly. They came out on 15 February

Trial site 2
20 lambs went into the lucerne plot adjoining the revegetation project site on 9 November at a stocking rate of 0.52 DSE/ha. They fed exclusively on lucerne with no supplementary feed. They came out on 15 February. They were weighed and blood was taken.

All 100 lambs for trial plot 1 were weighed when they went into the trial and when they came out. Only the 20 lambs that went into the lucerne plot were weighed (not the rest of that mob, because they were on another part of the farm).

Blood was taken from both lots of 20 lambs before and after the trial. Because there were only 20 lambs on the lucerne, blood was taken from the same 20 lambs before and after the trial for both trial plots, NOT a different randomly selected 20 lambs. However there was no record of tag #'s for these sheep, so no analysis could be done on paired data. Instead, the start and end blood samples were considered to be independent, even though they were the same sheep.

Methods: The 95% confidence limits and significances of changes in liveweights (kg) and blood variables were determined by paired and unpaired t-tests.

Comment: For each trial we can test whether there has been a significant change in blood concentrations during the experiment. For each trial we can present the confidence limits for the changes in blood variables measured at the start and end of the trials and the weight changes during the trial.

We can make no inference about the size and significance of the differences between trials, since for this comparison the trial is the experimental unit, ie there is no replication.

Results: As expected, there were significant weight gains during both trials (Table 3, Figure 19). Weight gains on Lucerne were greater than on Revegetation, however we can make no inference about the significance of this difference, as explained above.

Table 3: 95% confidence limits and significances for changes (end – start) in liveweights (kg) for sheep during Trials 1 & 2

Lucerne			Revegetation		
L95CL	U95CL	p value	L95CL	U95CL	p value
8.97	14.01	<0.001	4.22	5.38	<0.001

Most blood variables changed significantly during the trials (Table 4, Figure 20 a & b). The changes for ALP, ALT, Amyl, CK, Creatine & Cu were different for Lucerne than they were for Revegetation.

Table 4: 95% confidence limits and significances for changes (end – start) in blood variables for sheep during Trials 1 & 2

	Lucerne			Revegetation		
Variable	L95CL	U95CL	p value	L95CL	U95CL	p value
Alb	-7.00	-4.10	<0.001	-8.06	-5.94	<0.001
ALP	6.11	83.59	0.024	-140.10	-56.73	<0.001
ALT	1.74	7.66	0.003	-3.93	0.83	0.196
Amyl	-3.18	12.68	0.233	-11.84	-3.16	0.001
AST	-0.81	38.21	0.060	30.35	44.35	<0.001
Ca	0.30	0.45	<0.001	0.20	0.33	<0.001
Chol	-1.02	-0.44	<0.001	-0.32	-0.08	0.001
CK	-49.07	159.00	0.292	-193.60	-92.70	<0.001
Cl	0.66	3.74	0.006	6.60	9.70	<0.001
Creatine	0.00	0.01	0.217	0.01	0.03	<0.001
Cu	1.91	5.15	<0.001	-1.96	1.70	0.887
Fe	2.77	11.08	0.002	1.37	7.74	0.006
GGTL	-16.17	-2.13	0.012	-15.05	-2.55	0.007
GLDH	-15.12	-0.88	0.029	-3.59	15.59	0.213
Glob	8.28	13.22	<0.001	6.15	11.05	<0.001
Glu	0.76	1.34	<0.001	0.10	0.82	0.013
K	-0.50	0.05	0.111	-0.29	0.19	0.671
Mg	0.35	0.59	<0.001	0.15	0.24	<0.001
Na	5.57	8.83	<0.001	4.13	7.27	<0.001
P	-0.42	-0.05	0.013	-0.39	0.00	0.054
Tot Prot	3.17	7.23	<0.001	-0.89	4.09	0.201
Tri	0.09	0.17	<0.001	-0.14	-0.07	<0.001
Urea	2.60	3.88	<0.001	-3.11	-1.65	<0.001
Zn	-1.81	1.23	0.701	-2.18	-0.01	0.048

Figure 19: Means and 95% confidence limits for liveweight changes

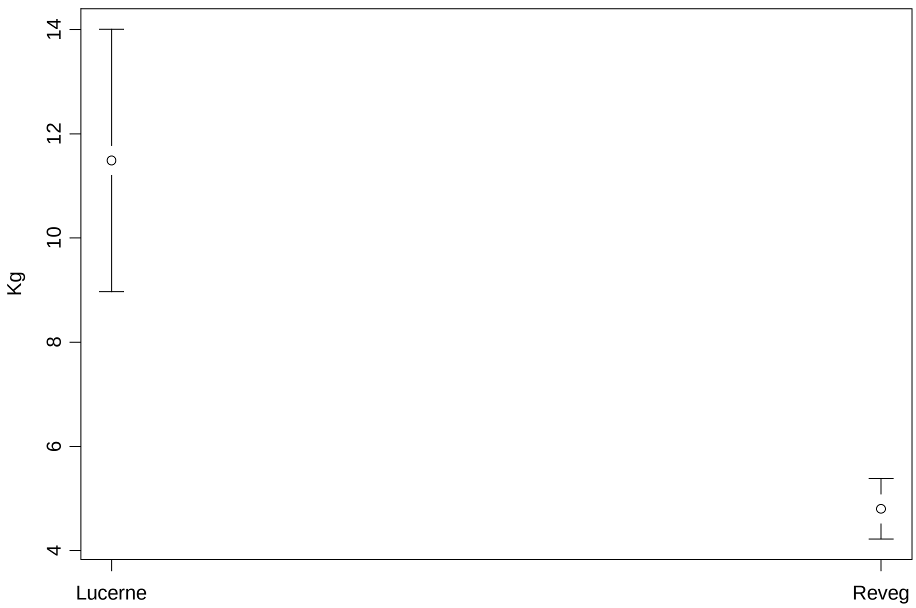


Figure 20a: Means and 95% confidence limits for blood parameters (Alb – Fe)

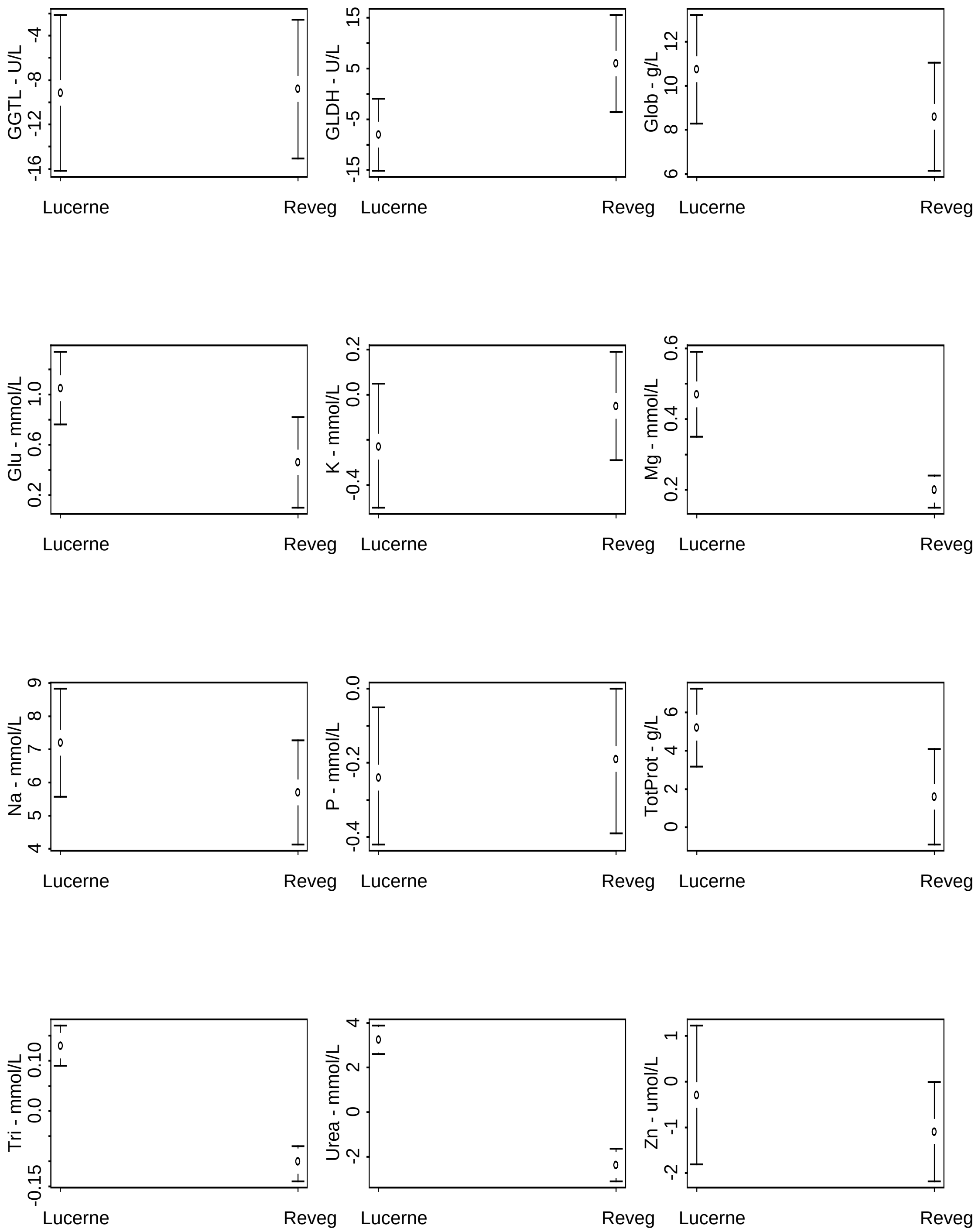
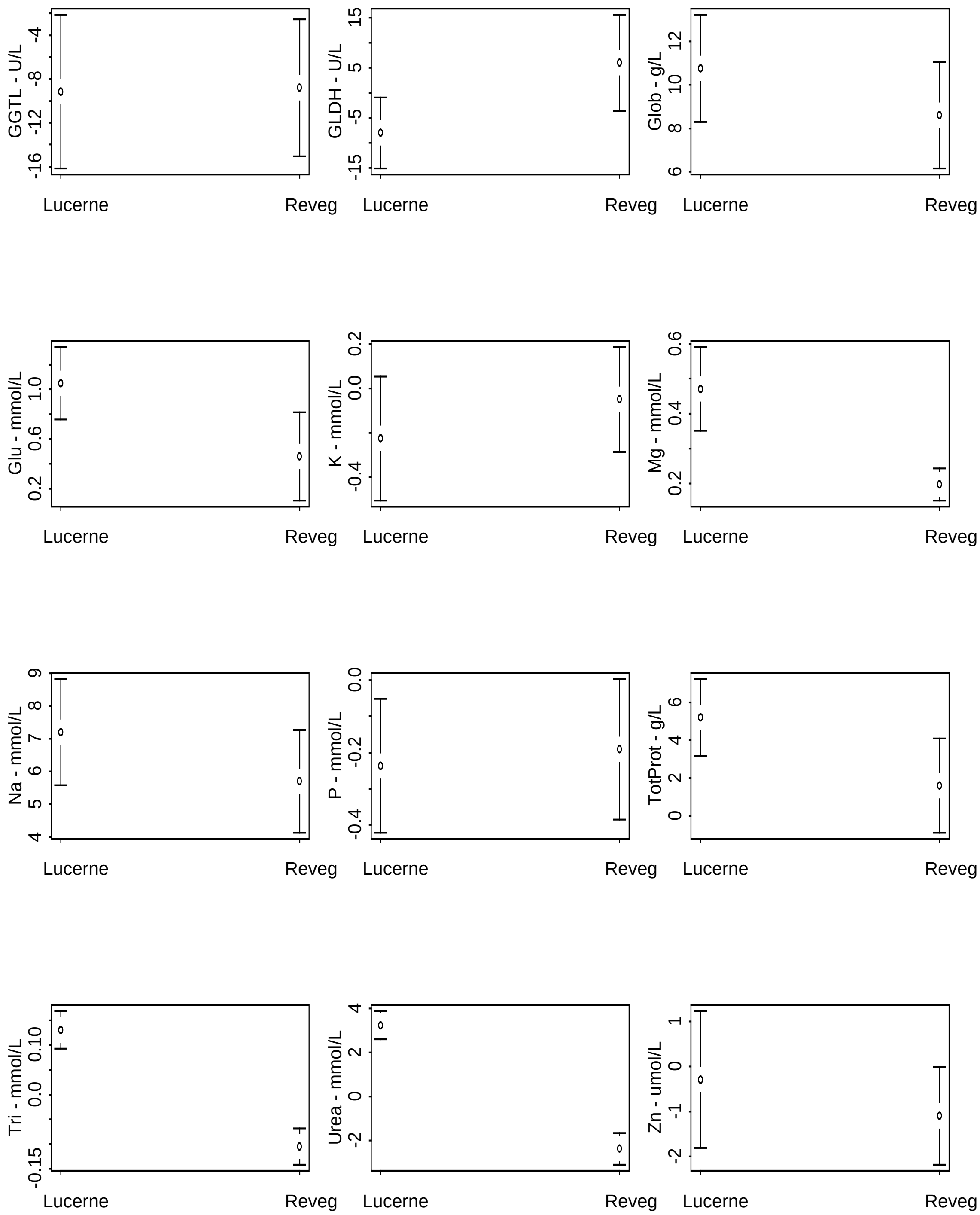


Figure 20b: Means and 95% confidence limits for blood parameters (GGTL – Zn)




Lambs graze among the biodiversity area at Kamarooka

SHEEP NUTRITION

Sheep *(Ovis aries)* have been domesticated for over 10,000 years and figure prominently in the story of civilisation and human survival. During the 20th Century, sheep became the subject of considerable research from the viewpoint of physiological function and animal production, and after humans, dogs and cats have been one of the more studied mammalian species. Being ruminants with specialised four-chambered stomachs, sheep have been studied extensively in their own right, with much knowledge accruing in regard to ruminant nutrition and animal production.

Apart from being adequate in amount and composition to meet requirements for protein and energy, feed for sheep must also satisfy a set of interrelated behavioural and physiological factors. Ruminants have cyclical activities that are geared to demands for water and food and the rest necessary for the processes of rumination and digestion. Sheep apply an impressive array of behavioural adaptations to their herbivorous mode of life.

Sheep possess a complex digestive system to deal with their mixed diet of digestible plant components and relatively indigestible cellulose. Feed takes 25-35 hours to pass through the gut and is exposed to microbial fermentation in the rumen during this time, which provides microorganisms and the products of cellulose breakdown for digestion. Sieving processes are involved, with large particles being regurgitated for re-mastication by the process of rumination and smaller particles of less than one to two mm passing into the stomach. Sheep ruminate for six to seven hours per day and this readily observable activity is a guide to health and well-being. Side benefits of ruminal fermentation include accessory food factors such as water-soluble vitamins and protein elaborated by microbes from simple nitrogen compounds.

MAINTENANCE REQUIREMENT

The maintenance requirement for a 35 kg wether is 5.2 megajoules per day. Water requirements range from 2.4 litres per day for growing sheep of 30 kg body weight to 12 litres per day for 60 kg ewes in early lactation.

O'Dempsey (2002) determined that when lot-feeding Merino lambs during a drought in Queensland a daily ration of 475 g maize and 125 g lucerne hay with 1% limestone should allow a 30 kg lamb to grow at 100 g/day. Over a 4-month feeding period on this ration the lambs should have gained around 12 kg. These growth rates are dependent on feed quality. Target growth rates of 100 g per day or above are ideal.

LUCERNE

Well-managed lucerne pastures can deliver high quality grazing (energy and protein) at all stages of plant growth. Compared with annual pastures, lucerne production and quality is superior during summer and autumn, depending on rainfall, but is likely to be less productive during winter. Superior summer and autumn productivity and quality overcome a major constraint to livestock production from annual pastures and even modest areas of lucerne can allow useful and profitable stocking rate increases.

Lucerne is ideal for finishing prime lambs and for putting weight on ewes during summer, leading to improved lambing percentages. Lucerne can also increase wool quality and tensile strength and reduce the risk of internal parasites in sheep. It follows that livestock production systems that take full advantage of the benefits of lucerne and manage the challenges can significantly improve profitability. (CRC for Plant-based Management of Dryland Salinity, 2006).

Energy value of lucerne

The 'energy value' of lucerne hay (90% dry matter) is often quoted as 8.5 MJ ME/kg dry matter (NSW DPI Agnote DAI-239, Sep 2004 and Victorian DPI, in NECMA newsletter, Nov 2006)

Feed analysis of dryland lucerne provided by James Williams, Jenharwill Bailing, indicates that good quality lucerne hay grown in the Kamarooka area has a mean energy value closer to 9.0 MJ ME/kg dry matter (see Table below).

Test Sample	Jenharwill Bailing Dryland lucerne hay				
	A	B	C	D	E
Moisture	8.5%	9.3%	9.3%	10.0%	13.0%
Dry Matter	91.5%	90.7%	90.7%	90.0%	87.0%
Crude Protein (N x 6.25) [% of Dry Matter]	18.8%	16.0%	14.3%	15.5%	18.4%
Natural Detergent Fibre [% of Dry Matter]	46.0%	53.3%	49.9%	47.4%	42.4%
Digestibility (DMD) [% of Dry Matter]	64.0%	60.8%	61.6%	61.7%	66.0%
Digestibility (DMOD) [% of Dry Matter]					
Metabolisable Energy MJ/kg DM	**9.2**	**8.7**	**8.8**	**8.8**	**9.5**

Comparative liveweight gain studies

It is well known that young stock produce poorly on dry annual pastures. Weaners require a minimum of 14% protein and a highly digestible source of energy to maintain a satisfactory level of liveweight gain and wool growth. A review of the literature reveals the benefits of lucerne as a food source for sheep.

<table>
<tr><th>Study</th><th>Food source</th><th>Liveweight gain</th><th>Days to slaughter</th></tr>
<tr><td rowspan="3">Fraser et al (2004)</td><td>Red clover(Trifolium pratense)</td><td>305 g/day</td><td>38 days</td></tr>
<tr><td>Lucerne(Medicago sativa)</td><td>243 g/day</td><td>50 days</td></tr>
<tr><td>Perennial ryegrass (Lolium perenne)</td><td>184 g/day</td><td>66 days</td></tr>
<tr><td>FitzGerald (1979)
at Wagga</td><td colspan="3">Wethers on pasture containing lucerne were 2.4 -7.0 kg heavier that wethers grazing on pasture containing subclover with phalaris or annual grass for the same length of time.</td></tr>
<tr><td>Morley and Axelsen (1965)</td><td colspan="3">5 month-old crossbred weaners gained 13.2 kg on lucerne and only 1.2 kg or a rye/ subclover pasture from early January to early April.</td></tr>
<tr><td>Brown et al (2003)
at Meckering, WA</td><td colspan="3">After 157 days, 90% of ewe weaners gained 15-22 kg grazing on lucerne compared with 6-15 kg gained by those grazing on a traditional system (stubbles/volunteer annual pastures with supplementation as required).</td></tr>
</table>

SALTBUSH

Saltbushes (*Atriplex* species) are the major salt-tolerant fodder species for productive use of saltland in WA. Good animal production requires fodders that contain high concentrations of metabolisable energy, moderate to high concentrations of crude protein and relatively low concentrations of salt. Saltbush fodder has low metabolisable energy concentrations, high crude protein concentrations and high salt concentrations.

Nutrition and Supplementation

Saltbush leaves have high salt concentration (up to 30%). Because sheep can only consume up to 200 grams of salt per day, they can not eat enough saltbush to achieve weight maintenance (Masters *et al.* 2005). A high energy, low salt supplement is needed to maximise the utilisation of the saltbush.

Water

In addition to providing a low salt, high energy supplement, the high salt content of saltbush means that sheep will need a fresh, plentiful supply of drinking water. The fresher the source of water, the more saltbush the sheep can consume. Sheep grazing saltbush pastures can consume up to 11 litres of water per day, to assist with flushing the salts from their body. (WADA Farmnote 74/2004)

Stocking Rates

Stocking rates of up to 7 DSE have been achieve by saltland pasture farmers, but generally the rate is around 4 DSE. This rate may be increase by rotationally grazing sheep in smaller paddocks.

When saltland pastures are grazed at low stocking rates, sheep initially select the more nutritious components (grasses and clovers) before the saltbush. Research suggests that higher stocking rates and rotational grazing in these systems can reduce selective grazing. This means the sheep will graze the high protein saltbush simultaneously with the low salt understorey.

Weight gains on saltbush

The key to the use of saltbush fodder is to mix it with feeds with complementary characteristics. The potential of this approach is clear from a pen-feeding trial in which sheep were fed diets of 100% low quality hay (dry matter digestibility 57%), 100% wavy leaf saltbush, or a 50:50 mixture of hay and saltbush (13). Sheep fed the saltbush or the hay alone had low feed intakes and lost liveweight. However, when saltbush leaf was mixed with hay, feed intake doubled, and the sheep gained liveweight at about 70 g/day.

Feed value of revegetated saline land

Kamarooka Grazing Trial	Kamarooka					
	Grasslands		Pasture among trees		Salt Bush	
Test Sample	A	B	A	B	A	B
	Jan-06	Nov-06	Jan-06	Nov-06	Jan-06	Nov-06
Moisture	48.1%	50.1%	41.3%	31.2%	66.4%	60.3%
Dry Matter	51.9%	49.9%	58.7%	68.8%	33.6%	39.7%
Crude Protein (N x 6.25) [% of Dry Matter]	9.3%	8.4%	7.6%	7.5%	16.5%	9.3%
Natural Detergent Fibre [% of Dry Matter]	65.7%	66.4%	64.4%	74.7%	37.4%	63.0%
Digestibility (DMD) [% of Dry Matter]	49.9%	56.7%	47.1%	47.8%	69.8%	58.3%
Digestibility (DMOD) [% of Dry Matter]	49.1%	54.9%	46.7%	47.3%	66.0%	56.2%
Metabolisable Energy MJ/kg DM	7.0	8.1	6.5	6.6	10.4	8.4

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