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**EVALUATION OF *LOTUS CORNICULATUS* FOR INCREASING THE  
EFFICIENCY OF GROWTH IN YOUNG DEER**

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**1997**

**EVALUATION OF *LOTUS CORNICULATUS* FOR INCREASING THE  
EFFICIENCY OF GROWTH IN YOUNG DEER**

A Thesis Presented in Partial Fulfilment of the Requirement for the  
Degree of Masters of Applied Science  
Animal Science option  
at Massey University

**EMMANUEL KWADWO ADU**

**1997**

*To Theresa, my wife  
and to Nhyira, my son*

## DECLARATION

The studies presented in this thesis were completed by the author whilst a postgraduate student in the Department of Animal Science, Massey University, Palmerston North, New Zealand. This is all my own work and the views presented are mine alone. Any assistance received is acknowledged in the thesis. All references cited are included in the bibliography.

I certify that the substance of the thesis has not already been submitted for any degree and is not being currently submitted for any other degree. I certify that to the best of my knowledge any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

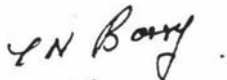
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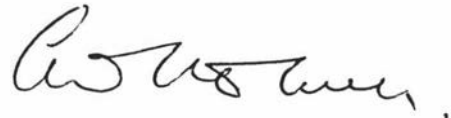
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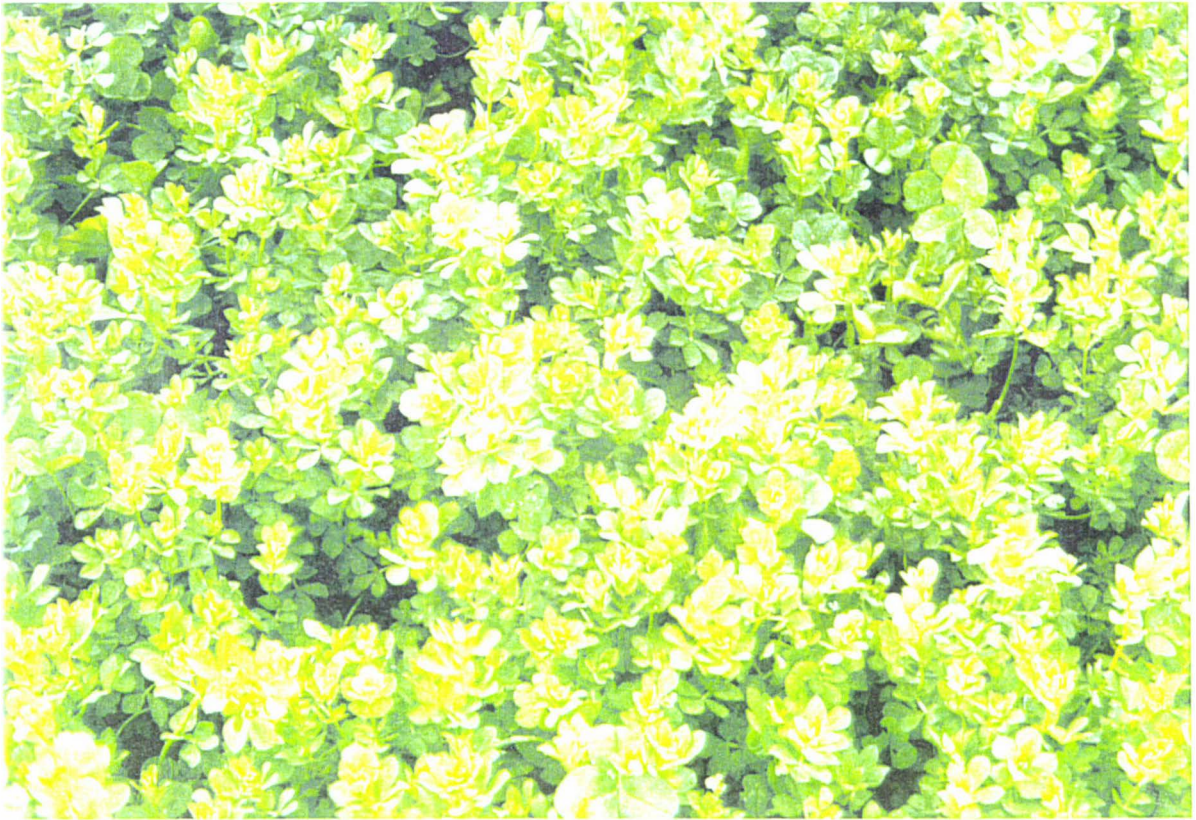
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**ABSTRACT**

EMMANUEL KWADWO ADU, Department of Animal Science, Massey University, Palmerston North, **New Zealand**. EVALUATION OF *LOTUS CORNICULATUS* FOR INCREASING THE EFFICIENCY OF GROWTH IN YOUNG DEER.

A grazing trial with lactating red deer (*Cervus elaphus*) hinds and their calves (EXPERIMENT 1), and an indoor digestion and calorimetric study (EXPERIMENT 2) were conducted at Massey University, New Zealand during 1996, to measure the feeding value of *Lotus corniculatus* compared to perennial ryegrass (*Lolium perenne*)/white clover (*Trifolium repens*) pasture for increasing the efficiency of growth in young deer. Half of the hinds and their calves were grazed on *Lotus corniculatus* and the other half were grazed on perennial ryegrass/white clover pasture during summer (Chapter Three) in a rotational grazing system. Half of the hinds in each group suckled pure red calves with the other half suckling hybrid (0.25 elk : 0.75 red deer) calves. The indoor experiments (Chapter Four) involved feeding one animal of a pair on either freshly cut perennial ryegrass or freshly cut *Lotus corniculatus* during autumn and spring, in metabolism cages and calorimetry chambers at maintenance (1M) and twice maintenance (2M) levels of energy intake.

**1. EXPERIMENT 1 (CHAPTER THREE).** Liveweight gains of hinds and their calves, weaning weight of calves and voluntary feed intake of hinds were measured on *Lotus corniculatus* or perennial ryegrass/white clover pasture during lactation in

summer 1996. The percentage of dead matter in both the forage on offer and diet selected was lower in *Lotus corniculatus* than in perennial ryegrass/white clover pasture. The condensed tannin (CT) levels in *Lotus corniculatus* and perennial ryegrass/white clover pasture were 21 g and 1.6 g total CT/kg DM respectively. Organic matter digestibility (OMD) was higher for *Lotus corniculatus* than for perennial ryegrass/white clover pasture. Hinds grazing *Lotus corniculatus* had higher voluntary feed intake (VFI) and liveweight change than hinds grazing perennial ryegrass/white clover pasture, and liveweight gain and weaning weight of calves were greater on lotus. Liveweight gain and weaning weight of hybrid deer were superior to pure red deer calves, with pre-weaning liveweight gain of hybrid deer calves grazed on *Lotus corniculatus* exceeding 500 g/d for the first time. CT in *Lotus corniculatus* was more tightly bound in red deer oesophageal fistula (OF) extrusa samples than in comparable studies with sheep.

**2. EXPERIMENT 2 (CHAPTER FOUR)** Energy losses as methane, urine and heat were consistently lower when the deer were fed *Lotus corniculatus* (21 g total CT/kg DM) than perennial ryegrass (< 1 g total CT/kg DM), but faeces energy losses were similar for the two forages. The efficiency of utilisation of ME for growth ( $k_g$ ) was lower in autumn-grown than in spring-grown perennial ryegrass, and tended to be greater in autumn-grown *Lotus corniculatus* than autumn-grown perennial ryegrass. No significant differences existed in faecal N and urine N losses in deer fed the two forages, and N retention was similar in deer fed *Lotus corniculatus* and perennial ryegrass. Presence of CT-binding salivary proteins in deer but not in sheep is advanced as a reason for N retention not being greater on lotus.

3. The overall conclusion from this thesis was that as a summer feed during deer lactation, the feeding value of *Lotus corniculatus* is higher than that of perennial ryegrass/white clover pasture but essentially similar to that of other special purpose feeds developed for deer production such as chicory (*Cichorium intybus*) and red clover (*Trifolium repens*). The most cogent explanations for the higher performance in deer fed *Lotus corniculatus* is the higher VFI and the greater efficiency with which ingested energy was utilised. Because of the presence of salivary CT-binding proteins in deer, forages with higher CT concentrations are suggested for the realisation of the beneficial effects of forage CT on the efficiency of protein digestion in farmed deer. Two such forages are sulla (*Hedysarum coronarium*; 35-60 g CT/kg DM) and *Lotus pedunculatus* (50-100 g CT/kg DM). The incorporation of *Lotus corniculatus* into the pastoral agricultural system of NZ may be hindered by the slow establishment of the plant, and by the special management system required. It may be better suited agronomically to warm low to medium fertility hill country conditions, such as found in East Coast areas, where competition from other plant species is less.

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*Now to him who is able to do immeasurably more than all we ask or imagine, according to his power that is at work within us, to him be glory in the church and in Christ Jesus throughout all generations, for ever and ever! Amen (Ephesians 3: 20-21, NIV).*

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## LISTS OF ABBREVIATIONS

ADF	acid detergent fibre
ADIN	acid detergent insoluble nitrogen
AFRC	Agricultural and Food Research Council
ATP	energy (adenosine trinucleotide phosphate)
BEN	basal endogenous nitrogen
BF	butterfat
<i>c.</i>	about
CH <sub>4</sub>	methane
cm	centimetre
Co.	company
CO <sub>2</sub>	carbon dioxide
Cr	chromium
CRD	control release device
Cr <sub>2</sub> O <sub>3</sub>	chromium sesquioxide
Cr-EDTA	chromium ethylenediaminetetra acetic acid
CT	condensed tannin
CWC	cell wall component
<i>cv.</i>	cultivar
d	day
D	organic matter digestibility
DLWG	daily liveweight gain

DM	dry matter
DMD	dry matter digestibility
DMI	dry matter intake
$E_g$	energy retained for growth
EAA	essential amino acid
e.g.	for example
etc.	and so on
EUP	endogenous urinary protein
$EV_1$	energy value of milk
Expt.	experiment
F	faecal output
FME	fermentable metabolizable energy
FMR	fasting metabolic requirement
FOR	fractional outflow rate
FV	feeding value
g	gram
GE	gross energy
GED	apparent gross energy digestibility
GEI	gross energy intake
GH	growth hormone
GI	gastrointestinal
GR	a measure of total soft tissue depth over the 12 <sup>th</sup> rib at a point 11 cm from the carcass line

GT	grazing time
h	hour
H	hybrid deer
ha	hectare
HCl	Hydrochloric acid
H <sub>2</sub> SO <sub>4</sub>	sulphuric acid
I	intake
IB	herbage intake per bite
i.e.	that is
IGF-1	insulin-like growth factor -1
IRL	irreversible loss rate
k	efficiency of utilisation of metabolizable energy
k <sub>c</sub>	efficiency of utilisation of metabolizable energy for foetal growth (the conceptus)
k <sub>f</sub>	efficiency of utilisation of metabolizable energy for fat deposition
k <sub>g</sub> ( or k <sub>pf</sub> )	efficiency of utilisation of metabolizable energy for growth
k <sub>l</sub>	efficiency of utilisation of metabolizable energy for milk production (lactation)
k <sub>m</sub>	efficiency of utilisation of metabolizable energy for maintenance
k <sub>p</sub>	efficiency of utilisation of metabolizable

	energy for protein deposition
$k_w$	efficiency of utilisation of metabolizable energy for work
$k_{wool}$	efficiency of metabolizable energy for wool growth
kg	kilogram
$kgW^{0.75}$	kilogram metabolizable body weight
l	litres
LH	luteinizing hormone
LOT	<i>Lotus corniculatus</i>
Ltd	limited
LWG	liveweight gain
LWT	liveweight
$LWT^{0.75}$	metabolizable liveweight
M/D	energy value of a diet
ME	metabolizable energy
$ME_{lactation}$	metabolizable energy requirement for lactation
$ME_m$	metabolizable energy requirement for maintenance
$ME_{(m+g)}$	metabolizable energy requirement for both maintenance and growth
$ME_p$	metabolizable energy requirement for production
MFP	metabolic faecal protein

mg	milligram
min	minute
MJ	megajoule
ml.	millilitre
mm	millimetre
$\mu\text{mol}$	micromole
MN	microbial nitrogen
MP	Metabolizable protein
MRT	mean retention time
MW	molecular weight
n	sample size
N	nitrogen
NAN	non-ammonia nitrogen
ND	not determined (not detected)
NDF	neutral detergent fibre
NE	Net energy
NEAA	non-essential amino acid
$\text{NH}_3$	ammonia
$\text{NH}_3\text{-N}$	ammonia nitrogen
NV	nutritive value
NZ	New Zealand
NZGIB	New Zealand Game Industry Board
$\text{O}_2$	oxygen
OF	oesophageal fistula (ted)

OM	organic matter
OMD <sub>A</sub>	organic matter apparently digested
OMI	organic matter intake
P	phosphorus
P:E	protein to energy ratio (the proportion of protein to energy in a diet)
PEG	polyethylene glycol
pH	a measure of acidity or alkalinity of a solution
PRG	perennial ryegrass
QDN	quickly degraded nitrogen
R	red deer
RB	bite rate
S	sulphur
<i>S</i>	seasonal coefficient
SDN	slowly degraded nitrogen
SEM	standard error of the mean
SNF	solid nonfat
sp (spp).	species
t	tonne
TAA	total amino acid
TAAN	truly absorbed amino nitrogen
TDN	Total digestible nutrients
UDN	undegraded nitrogen
UDP	undegradable dietary protein

UK	United Kingdom
US (USA)	United States of America
V	volume of milk at peak lactation
VFA	volatile fatty acid
VFI	voluntary feed intake
vs.	versus
v/v	volume by volume
yr	year
1M	maintenance level of food intake
2M	twice maintenance level of food intake