Investigations of pasture and grazing management within farmlet systems on the Northern Tablelands of New South Wales

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A THESIS SUBMITTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
UNIVERSITY OF NEW ENGLAND
May 2006
Images of some Cicerone farmlet paddocks over a range of seasons

Mix sheep and cattle grazing on paddock C4

Patch grazing observed on paddock B5

Field day visit to paddock A6

Herbage accumulated after long rest on paddock C16

The author (RHS) explaining technique to Cicerone members

Paddock C5 (left); paddock A3 (right)
DECLARATION

I declare that the substance of this thesis is the result of my own original work. Where references have been made to the published literature, the authors have been acknowledged accordingly in references. This material has not been presented previously to the University of New England or any other tertiary academic institution for the award of the degree.

Libuseng Matilda Mpiti-Shakhane
This thesis is dedicated to my beloved parents, Maria and John Mpiti, who did not live long enough to see my achievements. In memory of my mom, who valued education so much that she wanted all her seven children to go to university.
Summary

In temperate regions of New South Wales, Australia, there is increasing evidence of pasture decline, especially of deep-rooted, perennial pastures. Due to the high costs of farm inputs and of re-establishing pastures, grazing management has recently been investigated as a useful management tool to maintain production levels over the long-term - for the benefit of both pasture and animal. There is however inadequate knowledge of how to use grazing management to match the nutritional requirements of grazing animals with a variable pasture supply.

This study was conducted at the CSIRO's Chiswick property, Armidale as part of the Cicerone Project - a producer-led research and adoption group which commenced a whole-farmlet study of grazing enterprises in July 2000. The overall aim of the farmlet study was to assess the relative sustainability and profitability of three farmlet systems varying in farm inputs and grazing management. The main purpose of the study reported in this thesis was to examine the balance between both supply of feed (mostly from pastures) and the demand for feed by the range of livestock able to be supported by each farmlet. The data collected allowed the calculation of a ‘partial’ metabolisable energy balance (the estimate of a ‘partial’ balance was based on pasture growth and supplements and animal requirements without taking into account utilisation of the standing herbage mass, due to insufficient measurement of intake) as a means of comparing the relative match between supply and demand over time on each farmlet.

The two primary hypotheses tested in this thesis related to the effects of two different farm management strategies (high inputs or intensive rotational grazing) to provide superior pasture and/or animal outcomes compared to a moderate-input, flexible grazing system which is typical of the region.

The three farmlet systems, each of 50 ha, were farmlet A (high input system), farmlet B (typical district practice) and farmlet C (intensive rotational grazing). The control treatment, Farmlet B, represented the most common grazing system employed by graziers on the Northern Tablelands of New South Wales. The farmlets differed both in the level of inputs applied (pasture and fertiliser) as well as the system of grazing management employed.

On farmlet A, the fertiliser strategy aimed at achieving target levels of 60 and 10 mg kg\(^{-1}\) of soil phosphorus and sulfur respectively. On farmlets B and C, the target levels were 20 and 6.5 mg kg\(^{-1}\) of soil phosphorus and sulfur respectively. In addition, the pastures on farmlet A
were planned to be re-sown where necessary to provide a farmlet where all paddocks were dominated by deep-rooted, fertiliser-responsive perennial grasses, together with persistent legumes.

Two forms of grazing management were investigated: on farmlets A and B, flexible grazing according to PROGRAZE principles, was attempted. This involved moving the livestock, usually as 4 or 5 mobs, over the 8 paddocks of each farmlet according to the livestock condition and the availability of sufficient herbage mass and quality in each paddock. The target carrying capacity of farmlets A and B were 15 and 7.5 DSE ha\(^{-1}\) respectively. In contrast, farmlet C employed intensive rotational grazing; this farmlet was subdivided into 16 and then 33 paddocks, allowing the movement of stock to be rotated between paddocks usually as 3 mobs, with short grazing intervals (commonly of 3-5 days) and long rest periods (80-200 days). The target carrying capacity for this system was 15 DSE ha\(^{-1}\), the same as for farmlet A.

Over the first 5 years of the project, the mean stocking rates achieved on farmlets A, B and C were 13.4, 9.2 and 8.8 DSE ha\(^{-1}\) respectively.

While the high input system (farmlet A) consistently registered a higher percentage of sown fertiliser-responsive perennials than either of the moderate input systems (farmlets B and C), there was clear evidence that the proportion of the pastures represented by this species group declined across the three farmlets from 2000 to 2005. This decline was most strongly marked on farmlet B (from 28% to 5%) compared to farmlet A (from 76% to 41%) and farmlet C (from 44% to 18%). Conversely, while the percentage of native perennial grasses on farmlet A was consistently low (from 12 to 5%), these natives substantially increased from 49% to 62% on farmlet B and from 38% to 50% on farmlet C. The percentage of legumes and weeds remained low across the three farmlets during the study years, although some significant episodes of legume growth were observed on farmlet A during brief periods of favourable seasonal conditions.

The changes in pasture growth, herbage mass, and quality followed a seasonal pattern, generally with higher levels of these variables recorded over spring/summer and low levels in autumn/winter. While significant differences in pasture growth were not able to be detected at the level of measurement intensity employed over the generally drier than average years of the experiment, it was apparent that subtle differences did result in different levels of accumulation of herbage mass and quality leading to significant differences in livestock
production. Calibrated visual estimates of total and dead herbage mass were significantly higher on farmlets B and C compared to farmlet A. The green herbage mass on farmlet A was consistently higher than on the other farmlets, although the differences were not significant. It appears that the pasture growth rate on farmlet A was depressed somewhat due to the generally high level of pasture utilisation brought about the high stocking rate, resulting in relatively low levels of photosynthetically active leaves at many times.

Measurements of green herbage both before and after grazing demonstrated the rapid disappearance of green herbage, especially on farmlet C paddocks due to the high stock density. The rate of disappearance of green herbage on farmlet A was intermediate, due to its higher carrying capacity and higher pasture quality whilst the lowest rates of green herbage disappearance were on farmlet B paddocks.

Throughout most of the study period, pastures under a high input system (A) had significantly higher dry matter digestibility of dead herbage than pastures under either of the moderate input systems (B and C). In spite of this difference, over a two year period from autumn 2003 to autumn 2005, the digestibility of the dead herbage across all farmlets was lower than the level required to maintain animal condition. The digestibility of the green herbage was also significantly higher on farmlet A than on farmlets B and C. Crude protein levels in green herbage were also significantly higher on farmlet A compared to farmlets B and C.

Using the alkane technique within one paddock of each farmlet, sheep under both flexible grazing management systems (farmlets A and B) were found to be able to selectively graze particular pasture species more than under the intensive rotational grazing system (farmlet C). The estimated daily dry matter intake of weaners on farmlet A was found to be significantly higher than that of weaners grazing on farmlets B or C.

In 2003, the ewe liveweights and fat scores at joining, pre-lambing, and weaning were significantly higher on farmlets A and B than on C. Although in 2004 and 2005 the differences between the farmlets were not significant, there was a tendency for these values to be higher on farmlets A and B than on C. Ewes on farmlet A had significantly higher pregnancy rates, detected through scanning, and hence higher twinning rates than ewes on farmlets B and C in the years 2003 and 2005; however, there was no significant difference in 2004. Both the initial and final liveweights for wethers on farmlets A and B were significantly higher than those on farmlet C.

There was a significantly higher daily liveweight gain for steers and heifers both per head and
per hectare on farmlet A than on farmlets B and C. Also, sheep on the high input system produced significantly higher fleece cut per head and per hectare compared to those on moderate input systems. However, there was less difference between the farmlets in terms of fleece quality.

Measurements of animal production, both on a per head and per hectare basis, showed that the high input system (farmlet A) was more productive than the other farmlets. Animal production on the intensive rotational grazing farmlet (C) was found to be lower than that measured on the typical district grazing farmlet (B), thus demonstrating that some of the claims made for this system of grazing were not supported by the evidence.

The nutritional needs of all livestock were assessed using equations based on the Australian feeding standards for ruminant livestock. The significant increase in stocking rate, liveweight, growth rate, and reproductive rate of sheep on the high input system meant higher levels of metabolisable energy were required to satisfy the nutritional demand of these animals. The metabolisable energy supplied in pasture growth and through supplementation was generally inadequate to meet the demand calculated for the livestock, resulting in a generally negative partial balance between supply and demand across all farmlets. The fact that this balance was similar between farmlets supports the contention that the grazing ‘pressure’ applied to each farmlet was similar, in spite of the farmlets diverging in the number of livestock carried on each farmlet. At times, the extent of the negative partial balance on farmlet A was greater than on the other farmlets confirming that, at least at times, the stocking rate carried on this farmlet was probably too high, perhaps resulting in an accelerated rate of loss of valuable species and limiting the potential growth due to lower than desirable levels of green leaf capable of photosynthesising.

Matching the conflicting needs of pastures and animals was particularly challenging in this whole-farmlet experiment where complete capture of all necessary information across all paddocks and all animals was not feasible. Nevertheless, this situation is common in grazing enterprises where much less quantitative information is available. The needs of the broader Cicerone Project, determined by the Cicerone management team, influenced many of the decisions on stocking rate and stock movement thus posing some substantial challenges to the conduct of this research.

It is concluded that, with further development of more timely assessments of the balances between metabolisable energy supply and demand, paddock and grazing management could
be markedly improved, leading ultimately to more sustainable and profitable outcomes from grazing enterprises.
Acknowledgements

While pursuing my PhD was seemingly an endless job, the contributions, curiosities, and talents of many people, all of which worked towards its successful outcome, deserve to be acknowledged.

First and foremost, my special tribute goes to my principal supervisor Professor Jim Scott and my co-supervisor Dr. Geoff Hinch. Their foresight, enthusiasm, professional criticisms and never-ending open-door policy, provided excellent supervision right from conception to completion of this thesis. I have no words to express my deep gratitude to Professor Jim Scott. His initiative and assistance through continuous involvement in the research set up, field data collection and processing, laboratory analysis, statistical analysis, daily visits to my office and enabling the support from several database experts was invaluable.

The opportunity to undertake this research was provided by the Cicerone Project, which allowed access to the study site and the experimental animals. Funding for this research was provided by the University of New England with additional funds granted by Australian Wool Innovation and the National University of Lesotho in southern Africa. All this financial support is gratefully acknowledged.

I am indebted to Dr. Hugh Dove at CSIRO Plant Industry in Canberra, who developed the alkane technique, for his invaluable advice and clear explanations of how to use the technique for measuring intake and diet selection. I thank him also for providing free-of-charge the ‘Eatwhat’ software package used to compute many of the alkane results. I would like to express my special appreciation to Mr. Dan Alter and Ms Leanne Lisle for kindly purchasing all the required laboratory equipment and chemicals for the alkane analysis. I further thank Mr. Dan Alter for his skilled assistance in conducting the alkane extraction and chromatography. Additional information on how to use the alkane technique was provided by Dr. Chen Wen and Dr. Roger Hegarty – to whom I am very grateful.

My sincere thanks go to Mr Duncan Mackay, Dr. Paul Kristiansen, and Dr. Robert Murison for the high quality statistical advice and guidance they provided right from the commencement of this research to the final draft of my thesis. Particular recognition is due to Mr. Greg Chamberlain and Mr. Michael Raue for their invaluable field-technical assistance for two years. My candid appreciation goes to all technical staff in the Department of Agronomy and Soil Science for setting up the cages in the field to measure pasture growth, as well as for their assistance in sorting the pasture material into green and dead.
The complex database queries which needed to be constructed to assess the various pasture and animal data would not have materialised without the support of all the staff in the Relational Database Unit (Mr. Colin Lord, Mr. Dion Gallagher, Mr. Jim Cook and Mr. Ed Campbell). Some of the data used in this study were provided by the Farm Manager (Mr. Justin Hoad), the Executive Officer (Ms. Caroline Gaden), and the technical pasture consultant to the Cicerone Project (Mr. Colin Mulcahy). Not only did I enjoy doing field work with Mr. Colin Mulcahy, but I also gained a great deal of knowledge and skills from him regarding the identification of most of the pasture species in the Tablelands of NSW.

Professor Alfred Ebenebe, Dr. Keith Hutchinson, Dr. Kathy King, Dr. Graeme Blair, and Mr. Perminus Migwi, have generously given time, comments, and suggestions, which have led to me completing this thesis. My sincere gratitude goes to the Academic Skills Office (Ms. Julie Godwin) for professional guidance regarding scientific writing for a thesis. I also thank Mr. Craig Birchall for formatting assistance and Ms. Nicola Windeyer and Richard Willis for proof-reading my thesis chapters. The Office Administrator of the Department of Agronomy and Soil Science (Ms. Elizabeth Davies) provided immense assistance in all the administrative issues.

My thanks also go to the three anonymous external examiners for their critical and constructive comments which have guided me as I have worked to refine the thesis.

It is certain that I would never have ventured this far all alone without the unfailing love, support and encouragement of my dear husband, Elia, and our daughter, Mary-Stella Shakhane. I must say, Elia, that you have been my inspiration throughout my education career (from Diploma to PhD). Above all, I thank the merciful hand of the Almighty Lord that has seen me through this entire undertaking. "My grace is sufficient for you, for my power is made perfect in weakness" (2 Corinthians 12: 9).
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Table 3.1 Preliminary analysis of n-alkane concentration (mg/kg DM) in Trifolium repens done in four repeats to set appropriate time to digest. 1hr heating, 2 extractions, and 3 washes (1A-1C); 1hr heating, 3 extractions, and 3 washes (2A-2C); 3hrs heating, 2 extractions, and 3 washes (3A-3C); 3hrs heating, 3 extractions, and 3 washes (4A-4C).

Table 3.2 Reported values for the recovery of naturally occurring n-alkanes in sheep faeces used to correct faecal alkane values prior to estimating diet composition. Source: (Lee 2000).

Table 3.3 Concentrations of n-alkanes (mg/kg DM) in grasses, legumes and broadleaf weeds during 2005 summer (February), autumn (April) and spring (October) in one representative paddock of farmlet A (A7).

Table 3.4 Concentrations of n-alkanes (mg/kg DM) in grasses, legumes and broadleaf weeds during 2005 Summer (February), Autumn (April) and Spring (October) in one representative paddock of farmlet B (B1).

Table 3.5 Concentrations of n-alkanes (µg/g DM) in grasses, legumes and broadleaf weeds during 2005 summer (February), autumn (April) and spring (October) in one representative paddock of farmlet C (C1).

Table 3.6 The variance in the pattern of odd-numbered alkanes explained by the first three principal components.

Table 3.7 Mean values of the first three principal components in pasture species at first sampling (Summer 2005. In brackets are the species codes used in Figure 3.1)

Table 3.8 Mean values for the first three principal components in pasture species at second sampling (Autumn 2005. In brackets are the species codes used in Figure 3.1)
Table 3.9 Mean values for the first three principal components in pasture species at third sampling (Spring 2005). In brackets are the species codes used in Figure 3.1.

Table 4.1 Summary of $R^2$ values for linear and quadratic fitting of equations to calibration data for monthly assessments of herbage mass and digestibility (green and dead).

Table 5.1 Analysis of variance showing the F-value tests and probability differences for the factors with their interaction effects on pasture growth rate.

Table 5.2 The average means of total, green and dead herbage (kg DM ha$^{-1}$ on farmlets A, B and C over two years (visually estimated data from all the paddocks).

Table 6.1 The mean liveweight (kg head$^{-1}$) and fat score for the ewes on three farmlets from 2003-2005.

Table 6.2 Pregnancy scan (%) for empty, single and twin bearing ewes during their pregnancy in years 2003-2005 on farmlets A, B and C.