Potential of intensive rotational grazing for control of ovine gastrointestinal nematodosis in a cool temperate environment with summer dominant rainfall

by

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A thesis submitted for the degree of Doctor of Philosophy of the University of New England

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SEPTEMBER 2006

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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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Alison Frances Colvin

Acknowledgements

Firstly I would like to thank my principal supervisor Steve Walkden-Brown for his unmeasurable guidance and support through my candidature, he has an energy and mental capacity which is astounding. Malcolm Knox as my secondary supervisor has provided a wealth of support for my work and I thank him also for his guidance. I would like to thank Jim Scott for his boundless enthusiasm for the Cicerone Project and for his contribution to supervision during my work.

The person who has been most integral to the practical completion of this study is Justin Hoad, to whom I owe a thousand thanks for moving sheep to and fro, fitting into my timetable and for always being a pleasure to work with.

I would like to acknowledge the funding provided by the Australian Sheep Industry Cooperative Research Centre, Australian Wool Innovation and the University of New England. This research and thesis could not have been completed without their financial contributions.

I also thank the Cicerone Board who have provided such an unique environment in which to carry out my studies. In particular I would like to thank Caroline Gaden for providing me with data, Betty Hall for her positive contribution to my work and Colin Lord and Dion Gallagher for their patience in setting up a section of the Cicerone Database in which to store my results.

I have also to thank Michael Raue, John Gorham and Neil Baillie for their invaluable help during experimental work and sample collection without whom, along with the following list of helpers, I would never have complied such a large amount of data:
Anne Beasley, Emma Doyle, Grahame Chaffey, Lauren O'Connor, Fiona Macarthur, Libuseng Shakane, Steve Walkden-Brown, Sebastian Herry, Jasper Scholten, Mandy Choice, Tanya Norman, Justin Bailey, Carmel Healey, Michael Colvin, Dominic Neimeyer, Troy Kalinowski, Peter Bradley, David Paul, Patrick Sakwa and Greg Stuart.

My colleagues Anne Beasley and Emma Doyle have been a fountain of strength and have been invaluable in their advice and friendship over the last 3 years, I would like to thank them for sharing their journey with me.

I would like to thank my mother Carmel who gave me every opportunity in life to do my best despite hardship, something which can only be repaid through giving my best.

Finally, I would like to thank my husband Michael for his unending love and support which kept me sane and focused during my PhD candidature.

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BZ: Benzimidazole/ albendazole anthelmintic compound

CM: Sheep conventionally managed for worms on each management system

cMFD: Mean fibre diameter estimated from a cored mid-side sample (commercial laboratory)

dMFD: Derived mean fibre diameter along the staple

ELISA:

FECRT: Faecal egg count reduction test

GIN: Gastrointestinal nematodosis

HCT: haematocrit

***Hc*WEC**: *Haemonchus contortus* faecal worm egg count

HI: Farmlet A, High input management system

IgG: Anti-trichostrongylid Immunoglobulin G

IRG: Farmlet C, intensive rotational grazing system

LEV: Levamisole anthelmintic compound

MOX: moxidectin anthelmintic compound

NAP: Napthalophos anthelmintic compound

***Ost*WEC:** *Teladorsagia circumcincta* faecal worm egg count

PBST: Phosphate buffered saline plus Tween detergent

QC: Quality control

***Tc*WEC**: *Trichostrongylus colubriformis* faecal worm egg count

***T*WEC**: *Trichostrongylus* spp. faecal worm egg count

TYP: Farmlet B, conventional/typical management system

WEC: Faecal worm egg count

WF: 'Worm free' sheep

List of Publications

Colvin AF, Walkden-Brown SW (2006) Assessing the cost of parasitic nematodes on 3 management systems. In 'ASP & ARC/NHMRC Research Network for Parasitology Annual Conference'. Gold Coast p. 83

Colvin AF, Walkden-Brown SW, Knox MR (2006a) Sheep management system markedly effects worm infections in the New England. In 'Wool meets Meat -Tools for a modern sheep enterprise, Proceedings of the 2006 Australian Sheep Industry CRC Conference'. Orange. (Eds PB Cronje and DK Maxwell) pp. 225-226. (Australian Sheep Industry CRC)

Colvin AF, Walkden-Brown SW, Knox MR, Scott JM (2006b) Intensive rotational grazing assists control of gastrointestinal nematodosis of sheep in a cool temperate environment with summer-dominant rainfall. *Veterinary Parasitology* Submitted.

Healey AF, Hall E, Gaden CA, Scott JM, Walkden-Brown SW (2004a) Intensive rotational grazing reduces nematode faecal egg counts in sheep on the Cicerone Project. In 'Animal Production in Australia'. Melbourne pp. 85-88. (CSIRO Publishing)

Healey AF, Walkden-Brown SW (2004) Intensive rotational grazing: A potential tool for worm control on the Northern Tablelands. In 'Australian Society of Animal Production One-day Research Symposium'. Armidale

Healey AF, Walkden-Brown SW (2005) Dissecting the effects of intensive rotational grazing on gastrointestinal nematodiasis. In '20th International Conference of the World Association for the Advancement of Veterinary Parasitology'. Christchurch p. 214

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Healey AF, Walkden-Brown SW, Knox MR (2005a) Superior performance of worm-free sheep over conventionally managed sheep in the New England region is dependant upon the production system. In 'Proceedings of the 2005 Annual Postgraduate Conference of the Australian Sheep Industry CRC'. Noosa

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Abstract

To date there have been no reports of practical rotational grazing systems for the control of ovine gastrointestinal nematodosis in cool temperate climates, despite their success in the humid tropics. However there is anecdotal evidence that the intensive rotational grazing systems (such as "cell grazing") that are gaining in popularity in these regions, offer significant control. Intensive rotational grazing involves the use of large groups of animals at high stock densities moving through a series of 20 to 40 paddocks at a rate dependant on the amount of feed on offer and pasture growth rate (not based on rigid time periods). The grazing period generally ranges from 2-3 days with rest periods of 40-90 days, resulting in paddocks being rested for 90-95% of the year. The work contained in this thesis was conducted to investigate the merits of these claims. The unifying hypothesis was that intensive rotational grazing reduces faecal worm egg counts in sheep by interrupting the nematode lifecycle in its free-living stages and that the greatest effect will be on the blood-sucking parasite *Haemonchus contortus*. The work was conducted on the Cicerone Project, a producer-led project comparing three different sheep management systems in the New England Region of Northern NSW. The three management systems were typical (TYP – moderate input, limited rotational grazing, graze periods average 53±0.1 days and rest periods average 78±10 days), high input (HI, high input, limited rotational grazing, graze periods average 40±0.1 days, rest periods average 65±8 days) and intensive rotational grazing (IRG, moderate input, short graze periods average 3±0.1 days, long rest periods average 108±4 days).

Experiment 1 comprised a 2-year longitudinal study of faecal worm egg count (WEC) and performance in lambs, hoggets and ewes of the three management groups. It revealed lower *Haemonchus contortus* WEC and a markedly reduced number of anthelmintic treatments in sheep on the IRG treatment (Chapter 3). The subsequent experiments were designed to tease out the mechanisms behind this phenomenon. A fixed larval challenge study (Experiment 2, Chapter 4) showed that IRG sheep exhibited resistance to infection that was no better, and in two seasons much worse, than sheep on the HI and CON treatments ruling out improved host resistance as the factor mediating the effects of IRG. In contrast a tracer experiment investigating levels of pasture contamination with infective larvae (Experiment 3, Chapter 5) and a study into the free-living ecology of *Haemonchus contortus* on the Cicerone project (Experiment 4, Chapter 6) demonstrated reduced pasture infectivity for all classes of stock on the IRG treatment for the 3 seasons of the year (winter, spring and summer) when the short graze periods and long rest periods were maintained. The tracer studies and fixed larval challenge both show that the dynamics of GIN epidemiology can change rapidly with changes in the rotations on the IRG

system (longer graze periods of up to 30 days in April 2005) which reinforces the hypothesis that GIN is reduced on IRG through interruption of the free-living stages of the parasitic lifecycle. The ideal graze and rest periods for worm control fluctuate with weather conditions, during warm, wet, summer months graze periods need to be around 3 days and rest periods around 60-80 days. In winter, graze periods can be lengthened to 7 days and rest periods lengthened to 100 days or more. The lower proportions of *H. contortus* contributing to WEC on the IRG treatment in Experiment 1 (Chapter 3) were also observed in the tracer experiment (Chapter 5) confirming a differential effect of IRG on *H. contortus* relative to *Trichostrongylus* spp. and *Teladorsagia circumcincta*. Experiment 4 (Chapter 6) demonstrated that the half-life of *H. contortus* infective larvae on pasture was 19 days in summer meaning that rest periods on IRG in that season were sufficient for most of the deposited larvae to have died off between grazings. There was also very limited development of eggs to L_3 for *Haemonchus* in spring and autumn but there were recoveries of *Trichostrongylus* spp. and *Teladorsagia circumcincta* infective larvae from faecal culture in all seasons on IRG. Experiment 5 (Chapter 7) investigated the production and economic impacts of worm infection on the different management systems and further confirmed the high level of control of GIN achieved on the IRG system, with no production losses attributable to nematodes on IRG whilst bodyweights, fat scores and fleece weights were higher in 'worm-free' sheep on the HI and TYP management systems. Levels of GIN were very similar on the TYP and HI treatments with no consistent differences between them across the different experiments.

The main conclusions were that intensive rotational grazing markedly reduces faecal worm egg counts in sheep and the level of anthelmintic intervention required. It does so by breaking the nematode lifecycle in two ways: i) short graze periods (2 to 4.5 days) prevent autoinfection from the current graze period, and ii) long rest periods (80 to 140 days) ensure most of larvae that developed from the last grazing incident have died before sheep return to graze. The improved control of GIN on IRG was not associated with improved performance when compared to HI and TYP managed sheep. The implementation of IRG on the Cicerone Project requires fine-tuning to obtain the full benefits of better nematode control with improved productivity. Intensive rotational grazing was most effective against *Haemonchus contortus* due to its susceptibility to desiccation and cold in its egg and larval stages. The effect of IRG on *Trichostrongylus* spp. and *Teladorsagia circumcincta* was less pronounced as these worm species have the ability to survive as eggs in drier and colder conditions than *H. contortus*. Therefore, the unifying hypothesis was accepted.

General Introduction

Gastrointestinal nematodosis (GIN) is the principal disease of sheep in Australia and world wide. In the most recent published estimate of its cost to the Australian sheep industry GIN was estimated at $222 million dollars per year and it caused the greatest economic loss of all sheep diseases (McLeod 1995). Chemical anthelmintic treatments have been the principal method of worm control over the last 40 years, however, resistance has developed to all major classes of anthelmintic compounds, with the possible exception of Napthalophos, an organophosphate, and is rapidly worsening. The development of new anthelmintic compounds is constrained by the relatively small size of the worldwide market for sheep anthelmintics and the lack of significant anthelmintic resistance problems in the much bigger cattle market. Hence, alternative control methods are required to form part of an integrated approach to gastrointestinal nematode control. Grazing management is an obvious alternative to anthelmintic treatment and has been used with mixed results to date. Successful grazing management strategies include dilution strategies such as mixed grazing of susceptible sheep classes with non-susceptible animals (eg: cattle or older dry sheep) and preventative strategies such as grazing cattle alternately with sheep to 'clean' the pasture of infective larval nematodes. Our understanding of the ecology of the free-living stages of parasitic nematodes also suggests that rotational grazing systems could assist in the control of GIN in sheep by interrupting the nematode lifecycle (Donald 1967). However, up to the late 1980s, there was little success in developing and implementing practical rotational grazing systems that reduced GIN. Early studies on rotational grazing in cool temperate environments involved grazing periods of 7 days and rest periods between grazing events ranging from 3 to 7 weeks (Morgan 1933; Morgan and Oldham 1934; Roe *et al.* 1959; Gibson and Everett 1968). These rotations, however, were ideal for the proliferation of parasitic nematodes allowing both autoinfection from the current grazing period in summer months, and re-grazing at the peak of L_3 availability. *Haemonchus contortus* will develop from egg to L_3 in 3-5 days at 25-26°C but will take 15-30 days at 10-11°C (Rose 1963). Season therefore determines the length of safe grazing periods that prevent autoinfection. The time of peak L_3 on pasture in the Sydney Basin, NSW is generally around 35 days after deposition with smaller peaks at days 14 and 28 (Donald 1967). This author concluded that the spelling period for a paddock should be no less than 8 weeks to enable a significant reduction in pasture infectivity. This may also vary with season as L_3 on pasture survive longer in cooler conditions than warm or hot conditions (Dinaburg 1944a; Thomas and Boag 1972; Southcott *et al.* 1976; Besier and Dunsmore 1993a).

Donald (1967) thought that such long rest periods were inefficient in terms of optimal pasture utilisation. This is supported to some extent by Robertson and Fraser (1933) using much longer rest periods than those suggested by Donald. Their study in north Scotland achieved control of GIN through what they termed 'progressional grazing' and was especially effective in reducing the incidence of *H. contortus*. The rotation employed for 'progressional grazing' was 10 days of grazing followed by 100 days of rest. The authors concluded that 10 days was a sufficiently safe period of time for grazing before eggs reached the infective stage. However, over-mature grass undermined the success of 'progressional grazing' with sheep failing to maintain body weight despite lower parasite burdens.

Some 60 years after Robertson and Fraser (1933) an effective rapid rotational grazing system was devised by Barger *et al.* (1994) for small ruminants in the humid tropics based on the findings of Banks *et al.*(1990) in Fiji on the rates of larval survival and mortality in hot, humid environments. The system comprised a grazing period of 3.5 days and a rest period of 31.5 days and has been used with success throughout the tropics in both sheep and goats (Barger *et al.* 1994; Chandrawathani *et al.* 1995; Sani *et al.* 1996; Gray *et al.* 2000). However, Banks *et al.* (1990) and Barger *et al.* (1994) suggest that rapid rotational grazing would not be economically viable in cooler climates, presumably because the rigid application of timing of graze and rest periods would be unsuitable given the seasonal variability of temperature and rainfall which are the major drivers of development and survival of the free-living stages of parasitic nematodes in these environments.

In the early 1990s in the temperate regions of Australia, intensive rotational grazing systems such as 'cell grazing' and 'holistic grazing' were introduced on the basis of improved pasture and animal performance. These systems claimed to increase pasture biodiversity, ground cover, and the ratio of palatable to non-palatable plant species, and improve soil structure (Earl and Jones 1996; McCosker 2000; Sparke 2000). They involve the use of large groups of animals at high stock densities moving through a series of 20 to 40 paddocks at a rate dependant on the amount of feed on offer and pasture growth rate (not based on rigid time periods). The grazing period generally ranges from 1-3 days with rest periods of 40-90 days, resulting in paddocks being rested for 90-95% of the year (Earl and Jones 1996). This type of grazing management has become increasingly used throughout Australia with its highest prevalence being in the New England region on the Northern Tablelands of NSW (Reeve and Thompson 2005). The consequences of such intensive grazing systems on GIN in sheep in cool temperate climates have not been documented despite considerable anecdotal evidence of marked reductions in faecal worm egg counts (WEC) and the number of anthelmintic treatments required.

The Cicerone project is a farmer-led project comparing three sheep management systems in the New England region of Northern NSW. The 3 management systems are Typical (TYP), High Input (HI), and Intensive Rotational Grazing (IRG) and are detailed later in the thesis. There was evidence that sheep on the IRG management system, had lower faecal worm egg counts than those run with slower rotational grazing management on the TYP and HI systems. A retrospective analysis of the routine faecal worm egg counts under the three management systems strongly supported the proposition that intensive rotational grazing reduced GIN (Healey *et al.* 2004). This doctoral study was designed to confirm this finding in a controlled, balanced study and to:

- determine on which classes of stock it was operative
- determine which times of the year it is operative
- determine which parasite species are affected by it
- uncover the underlying mechanisms by which its was working

The study also aimed to investigate what differences, if any there were in GIN between the TYP and HI management systems on the Cicerone project.

This thesis details the epidemiology of GIN on the Cicerone Project farmlets dissecting the host, environment and pathogen effects on the disease under the 3 different management systems. A two-year longitudinal study (Experiment 1) aims to confirm the effect of the three management systems on GIN and animal production and provide insight into possible mechanisms. A fixed larval challenge study (Experiment 2) investigates host effects on GIN while the pasture larval contamination is investigated in a tracer sheep experiment (Experiment 3). The development and survival of free-living stages of *Haemonchus contortus* on the Cicerone project is investigated in a plot study (Experiment 4). Finally, the cost of GIN on animal performance is investigated by comparison of ‘worm-free’ sheep with those managed for worm control within each management system in Experiment 5. Grazing systems in general are not designed for worm control, so an holistic approach has been adopted with animal performance measured in this doctoral study whilst a fellow doctoral student, Libuseng Shakhane, has investigated the pasture aspects.

The general hypothesis under test in this thesis is that intensive rotational grazing reduces faecal worm egg count in sheep through interruption of the nematode lifecycle in its free-living stages.

Subsidiary hypotheses are that the reductions in WEC associated with IRG will be greatest for *Haemonchus contortus* due to the greater susceptibility of its free-living stages to desiccation and cold, and that WEC will be higher in the high input grazing system than the typical grazing system.