A dynamic simulation model for planning and controlling grazing systems

Luis G Barioni
1997

A thesis presented in partial fulfilment of the requirements for the degree of Master of Applied Science in Agricultural Systems and Management at Massey University

ABSTRACT

This study reports on the development of a stochastic dynamic model to simulate a pastoral sheep enterprise. The event driven model was constructed using the iconic simulation package, Extend™. Events corresponded to the shifting of animals from one paddock to another. Each paddock was represented as a single entity with inherent attributes such as grazing area, sward characteristics and pasture production potential. The rotation sequence for grazing was determined by always allocating the flock of ewes, flock replacements or lambs to the paddock with the greatest pasture mass. Herbage mass was divided into three fractions: leaf, stem and dead. Pasture growth and senescence rates for individual paddocks were calculated from pasture leaf mass. A Micherlich-type function was used to relate leaf mass to total pasture growth. Senescence was assumed to increase linearly with herbage mass. Deterministic or stochastic pasture growth rate data can be generated by the model. Pasture responses to nitrogen were estimated dynamically and moderated for the farm by entering a user-defined response for a standard 50 kg/ha nitrogen application.

Animal performance was calculated using average attributes for ewes, ewe hoggets and rams, but lambs were simulated individually. Lamb performance is affected by its date of birth and sex, and this information was generated by a sub-model for mixed-age ewe and ewe hogget reproduction. The potential herbage intake of the sheep was defined by their rumen fill and physiological energy demand, and herbage availability which was defined by pre-grazing green herbage mass and green herbage allowance for rotational grazing and leaf mass for continuous grazing. The grazing time spent in each paddock was derived from a linear interpolation of user-defined herbage allowances for each month of the year. The proportion of leaf, stem and dead material in the diet was calculated according to the proportion of these fractions in the sward and herbage availability. If animals were supplemented they consumed all of the material offered. This caused pasture substitution by decreasing the physiological energy demand and utilising rumen space otherwise taken up by grazed pasture. The partitioning of nutrients by animals was estimated from the ratio between energy intake and energy demand in an animal growth sub-model. This was driven by the DNA, protein and fat content of individual lambs and the average for animals in other sheep classes. Lambs were drafted for sale and graded according to user-defined threshold drafting weights. Carcass weight and fatness (GR) were generated from the live weight and sex of individuals lambs. A genetic optimisation algorithm was developed to optimise the systems control variables incorporated in the model. These were pasture allowance, supplement fed, nitrogen applied and lamb drafting weight.

The model was evaluated against three New Zealand "farmlet" grazing experiments. This validation suggested re-parameterisation of the physiological intake limit is needed and that the British equation used to relate intake to leaf mass availability is overly sensible to the pasture conditions found in New Zealand. The model was also used to test the effects of pasture measurement errors on the profitability of a grazing system. Significant differences in profitability occurred when a CV of 40% in measurement of pasture mass was assumed (Gross margin = $NZ 495 /ha vs. $NZ 542 /ha and $NZ 570 /ha for 20 and 0% CV in measurement estimations and normal variability in pasture accumulation rates and Gross margin = $NZ 587 /ha, $NZ 576/ha and $NZ 519/ha, respectively for 40, 20 and 0% CV in measurement estimates and no pasture accumulation rate variability). It was concluded that low gains in system performance can be expected by improving the accuracy of measuring pre-grazing herbage mass beyond the level (13-16% CV) provided by the correct use of current measurement techniques.

Keywords: Model, grazing management, Extend™, optimisation, variability
Title: A dynamic simulation model for planning and controlling grazing systems
Author: Luis Gustavo Barioni
Degree: Master of Applied Science

ACKNOWLEDGEMENTS

My deepest gratitude is due to God for His great love and paternal care throughout my course.

I cannot find words to express my immense gratefulness to my wife, Renata, for her constant understanding, help and love.

To my parents Isidro and Meudes Barioni who always supported and encouraged me during my studies with their earnest love; my most sincere thanks. The constant support of my parents-in-law, Jose and Neuza Dellamatrice, is also greatly acknowledged.

Special thanks are due to my supervisors Dr. Chris Dake and Professor Warren J. Parker for their encouragement and major contribution to this work. Prof. Warren J. Parker input on management of grazing systems is greatly acknowledged. Also his accuracy and promptness in correcting the thesis and solving problems pertinent to the project were very much appreciated. I also thank Dr. Chris Dake for his bright ideas, suggestions, encouragement and endless patience.

Thanks to Dr. Moacir Corsi, lecturer at the University of São Paulo, Brazil, for his great incentive to my studies in grazing systems. Thanks also to my friend Luis Orlindo Tedeschi for initially stimulating my interest in agricultural modelling and for his friendship through my time at Massey University despite the physical distance that separated us.

I also thank Arturo Luqué, Carolina Realini, Cassandro Amarante, Cesar and Beatriz Poli, Daniel and Betina Laborde, Daniel and Margarita Real, Danilo and Mary Cabrera, David and Evelin Soong, David Pacheco-Rios, Greg Bishop-Hurley, Henrique Coutinho , Jenny Groat, João Gomes da Silva, José Roberto and Cristiele Marques, Karl and Luciana Gradon, Kevin and Ros Tongs, Mauricio Cunha, Mauricio Padilla, Shirley Cunningham, Silvia Assuero, Terry McGrath, Tracey Hunt, Tim and Yun-a Hong and Wagner and Angela Beskow for their friendship, help and company during my stay in New Zealand.

The New Zealand Ministry of Affairs and Trade is acknowledged for the financial support they provided me to understand post-graduate study in New Zealand.

Any errors that may remain in this thesis are my responsibility and not due to those mentioned above.

TABLE OF CONTENTS