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*Systems, component, and modelling studies of
pasture-based dairy systems in which the cows calve at
different times of the year*

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of the requirements for the degree of

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ABSTRACT

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The New Zealand's dairy system is characterised by a concentrated calving period in late winter-early spring, which aims to synchronise cows' feed requirements with the seasonal pattern of pasture growth, but which also results in an uneven distribution of milk supply to the factories. Changing the calving season of some herds from spring into autumn could improve the overall efficiency of the dairy industry. However, pasture-based autumn-calving systems are usually perceived to be less "efficient", because of the lack of synchrony between feed supply (grazed pasture) and feed requirements. One conclusion of the literature review (Chapter 1) was to hypothesise that autumn- and spring-calving systems would perform at similar levels provided that sufficient supplementary feed was available during wintertime. This thesis integrated three experimental approaches (system, component, and modelling) in order to test the above hypothesis, and to investigate the physical performance of pasture-based dairy systems that differed in their calving dates. A 3-year system study conducted at No 1 Dairy Farm, Massey University, in which autumn, spring, and autumn/spring calving systems were compared, showed that all systems achieved similar performances and overall efficiencies (Chapter 2). A key factor for this was the greater total yields by the autumn-calved cows, due mainly to their greater yields in mid and late lactation and their longer lactations (Chapter 3). A new technique that combines the n-alkanes and ^{13}C methods in order to quantify herbage and maize silage DM intakes by individual grazing cows which are given access to the silage as a group, was developed and validated (Chapter 4), and re-evaluated in a separate study (Chapter 5). Overall, individual cows differed considerably in their intakes of maize silage DM, but this variation was not always related to variation in milk yields. An innovative, dynamic, interactive simulator of seasonal pasture-based dairy farms (IDFS) was developed as part of this thesis (Chapter 6). The model allows computer experiments to be run, with pastures and cows managed on the basis of logical decision rules; therefore, it resembles real farm management. The user makes decisions (which paddocks are to be grazed, pre- and post-grazing herbage mass, supplement feeding, etc) continuously, and can see the impact of his/her management decisions on the graphical interface provided. Based on comparisons with actual data, it was concluded that IDFS simulates the main components of seasonal dairy farms with reasonable realism (Chapter 7), although the model is at an early stage of development and has not been completely validated. In conclusion, this thesis has 1) demonstrated that pasture-based systems with contrasting calving dates can achieve similar physical performances provided that supplementary feeds are available, and 2) developed two new tools (quantification of herbage and maize silage intakes by individual cows, and the IDFS model) that can be applied in future systems research.

Dedicated to Valeria

PREFACE

This thesis is the result of a project that originated from debate about the very basis of the New Zealand dairy industry: the need to synchronise feed supply (rate of herbage growth) with feed demand (cows' requirements) by means of concentrating the calving season in early spring. Is this the best alternative for all farmers? Will farmers reduce the overall physical efficiency of their systems if they decide to change the calving season? Will they need to use increased quantities of supplementary feed? These and many other related questions, all of them with important implications for farmers in particular and for the whole industry in general, played a key role in the initiation of this project.

However, research is concerned not only with *what* questions are to be asked, but also with *how* the problem is to be addressed and the questions are to be answered. I started this project with the idea of just comparing different pasture-based systems that would differ in their milk supply pattern. However, it soon became obvious that the complexity involved in these 'real-world' systems, would make it very difficult to fully understand the systems and to reach meaningful conclusions. I needed to apply other tools to the systems comparison in order to gain more insight into the main factors and interactions that govern those systems. It was then disappointing to discover that research methodologies for systems studies were not straightforward or readily available, and that different research approaches, such as systems studies, component or analytical research, and modelling studies, did not appear to have been integrated in the past. That is why I integrated these three approaches with the aim of addressing the questions at the systems level, as well as contributing to the research methodology in the field.

This thesis is the result of these three approaches to the study of the systems. It comprises results that range from comparisons of the whole-farm systems, through the evaluations of different methods designed to improve the analysis of some key components of the systems, to finish with the development and evaluation of an innovative dairy farm simulator model. Each of these studies is presented as a self-explained unit that has already been, with one exception, either published in, or submitted to a refereed-scientific journal. Each single paper is presented in a form which is as close as possible to the original publication. However, in order to ensure a better and more logical flow in the text, some minor changes were necessary to make the ~~thesis~~ papers into chapters of the thesis.

The 3-year systems study, which provided the framework for this thesis, was jointly funded by the Technology for Business Growth (TBG) program of The Foundation of

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Alastair MacDonald is the Project Manager of Agricultural Services at Massey University. Alastair has not been a formal supervisor of my thesis but he should have been. Alastair gave me so many opportunities and helped me so much during these years with both the research project and my personal life matters that I am unable to recall them all. Alastair has been always concerned about my wellbeing as well as that of my family and he always has had time to listen and help. Tell Alastair that you have a problem and he would stop anything he was doing to listen to you, no matter how busy he was....Better still, he will sort out your problem! He is, as he calls himself sometimes, a "facilitator" and in fact, I have never seen any other person with such enthusiasm and expertise to work out problems. Thank you Alastair, thank you very much indeed for all your help and support during these years. I'll see you back in Mar del Plata!

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Yani

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