Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.
PRODUCTION CHARACTERISTICS AND RESPONSES
TO FEEDING BY FRIESIAN COWS
FAT AND THIN AT CALVING OF HIGH AND LOW GENETIC MERIT

A thesis presented in partial fulfilment
of the requirements for the degree of
Master of Agricultural Science
in Animal Science
at Massey University

SUPACHAI NGARMSAK

1984
ABSTRACT

A review of literature is given on herbage intake achieved by grazing lactating dairy cows. The lactating cows have higher herbage intake than non-lactating cows. Condition at calving may have an effect on herbage intake by dairy cows. The theory of response, the response to feeding both before and after calving are also reviewed. The literature is reviewed which discusses responses to feeding in Europe (where diet of the cows are mainly concentrates) and in Australia and New Zealand where dairy cows graze mainly on pasture. The evidences of improving cows quality by selection are given with special emphasis on New Zealand dairy cows. Genetic merit of a New Zealand cow for milkfat production is measured by her breeding index (BI).

The main objective of the work was to study production characteristics and response to feeding in early lactation by Friesian cows, fat and thin at calving, of high and low genetic merit. Over lactation High BI cows produced more than Low BI cows. The differences between BI groups in milkfat production was in close agreement with the expected differences based on BI’s. High BI cows had slightly higher herbage intake than Low BI cows but no significant differences were found. Low BI cows were fatter than High BI cows. No significant difference in fatty acid composition of milk between the BI groups was found. Over lactation Fat cows produced more milkfat than Thin cows. Improving 1 condition score at calving was associated with an increase of 10.5 kg milkfat.

No significant differences in response to feeding in early lactation between High BI and Low BI cows nor between Fat and Thin cows were found. The response to moderate underfeeding during early lactation was mainly immediate response. The residual effects of underfeeding were small and confined to 2 weeks after returning to full feeding. Underfeeding significantly increased mole % of long chain fatty acids of milk and significantly decreased mole % of short chain fatty acids.
ACKNOWLEDGEMENTS

I am grateful to my supervisor, Dr. C.W. Holmes for his valuable guidance.

I am grateful to the New Zealand Government and people for the assistance through the Bilateral Aid Programme enabled me to undertake this study.

I am grateful to the staff of the Animal Science Department (Dairy Husbandry section) for their contributions to the work.
TABLE OF CONTENTS

ABSTRACT.............................................................................................................I

ACKNOWLEDGEMENTS.......................................................................................II

TABLE OF CONTENTS.........................................................................................III

LIST OF TABLES..................................................................................................VIII

LIST OF FIGURES ................................................................................................X

LIST OF APPENDICES........................................................................................XII

CHAPTER 1

1 LITERATURE REVIEW.....................................................................................1

1.1 INTRODUCTION.........................................................................................1

1.2 HERBAGE INTAKE BY GRAZING DAIRY COWS............................................2
  1.2.1 HERBAGE ALLOWANCE........................................................................2
  1.2.2 RESIDUAL HERBAGE MASS.................................................................4
  1.2.3 HERBAGE INTAKE...............................................................................5
     1.2.3.1 Herbage Intake By Lactating Cows.................................................5
     1.2.3.2 The Changes of Herbage Intake and Stage of.............................6
     1.2.3.3 Herbage Intake & Mobilisation of Body.....................................6
     1.2.3.4 Herbage Intake & Animal Condition.........................................7
     1.2.3.5 Herbage Intake Achieved By Grazing Dairy.............................8

1.3 RESPONSE TO FEEDING BY DAIRY COWS..............................................9

  1.3.1 THEORY OF RESPONSE TO FEEDING BY DAIRY COWS....................9
     1.3.1.1 Short-term effects........................................................................9
     1.3.1.2 Long-term effects......................................................................11

  1.3.2 PRE-CALVING FEEDING.....................................................................12
     1.3.2.1 The Early Works With Emphasis On Liveweight...................13
1.3.2.2 Recent Works With Emphasis On Body Condition......14
1.3.2.3 A Note on Condition Score.....................................17
1.3.3 POST-CALVING FEEDING (During Lactation).................18
1.3.3.1 Response To Underfeeding Early Lactation..............18
1.3.3.2 Response To Underfeeding Late lactation..............24
1.3.3.3 Priorities For Feed..............................................25
1.3.3.4 Other Aspects of Underfeeding..........................27
1.3.3.5 Conclusion For Response To Feeding By Dairy...27
1.4 DAIRY COW QUALITY.......................................................28
1.4.1 HIGH AND LOW YIELDING COWS........................................28
1.4.1.1 Production Characteristics of High and Low.....29
1.4.1.2 Partition of Nutrients towards Lactation.............29
1.4.2 EVIDENCE OF IMPROVED COW QUALITY BY SELECTION........30
1.4.3 GENETIC VARIATION IN NUTRITION OF DAIRY COWS........31
1.4.3.1 Breed Differences.................................................31
1.4.3.2 Heritabilities of Feed Efficiency.........................31
1.4.3.3 Genetic Differences in Feed Intake......................31
1.4.3.4 Genetic Variation Maintenance Requirement.........32
1.4.3.5 Heritability of Yield Traits.................................32
1.4.4 EVIDENCE OF GENETIC IMPROVEMENT OF DAIRY COWS IN NEW...32
1.4.5 NEW ZEALAND FRIESIAN VS. EUROPEAN- AND...............33
1.4.6 PRODUCTION CHARACTERISTICS OF HIGH BI AND LOW BI........35
1.4.7 Production Performances...........................................35
1.4.7.1 Energy Metabolism...............................................36
1.4.7.2 Grazing and Milking Behaviour..........................36
1.4.7.3 Marginal & Gross Efficiency Of Milk Fat.............37

CHAPTER 2

2 MATERIALS AND METHODS........................................38
2.1 OVERVIEW OF EXPERIMENT DESIGN.................................38
2.1.1 Pre-experimental Period.........................................38
2.1.2 Experimental Period..............................................38
2.1.3 Post-experimental Period.......................................40
2.2 ENVIRONMENTS OF THE EXPERIMENTS ................................. 40
   2.2.1 Pasture .......................................................... 40
   2.2.2 Animals .......................................................... 40

2.3 FEEDING REGIME AND ASSOCIATED PARAMETERS MEASURED .......... 41
   2.3.1 Herbage Mass .................................................... 41
   2.3.2 Herbage Allowance .............................................. 41
   2.3.3 Residual Herbage Mass ......................................... 41

2.4 ESTIMATION OF HERBAGE DM INTAKE .................................. 41
   2.4.1 Estimate Herbage DM Intake Sward-Cutting Technique ........... 41
   2.4.2 Estimate Herbage DM Intake Using Chromic Oxide ............... 42
      2.4.2.1 Faecal Output ............................................. 42
      2.4.2.2 Estimate DM intake ....................................... 42

2.5 ESTIMATE OF DIGESTIBILITY OF PASTURE ................................ 42
   2.5.1 Estimation of the Quality of Herbage Consumed .................. 42
   2.5.2 Estimate In Vivo Digestibility .................................. 43

2.6 MEASUREMENTS OF ANIMAL PRODUCTION .................................. 43
   2.6.1 Milk Production .................................................. 43
   2.6.2 Fat and Protein Concentration in Milk .......................... 44
   2.6.3 Fatty Acid Composition of Milk Fat ............................. 44
   2.6.4 Liveweight ...................................................... 44
   2.6.5 Condition Score ................................................ 44

2.7 STATISTICAL ANALYSES .................................................. 45

CHAPTER 3

3 RESULTS .................................................................. 46

3.1 LACTATION PERFORMANCES .......................................... 46
   3.1.1 MILK YIELD ...................................................... 46
   3.1.2 MILK FAT YIELD ................................................. 48
   3.1.3 MILK PROTEIN YIELD .......................................... 49
   3.1.4 MILK FAT CONCENTRATION ................................... 50
   3.1.5 MILK PROTEIN CONCENTRATION ............................... 51
   3.1.6 FATTY ACID COMPOSITION OF MILK ......................... 52
   3.1.7 LIVESTOCK ........................................................ 52
### Chapter 3: Results from Grazing Trials

#### 3.1.8 Condition Score
- Condition Score

#### 3.2 Results from Grazing Trials
- Milk Yield
  - 3.2.1 Milk Yield During 3 Week Pre-experimental
  - 3.2.1.2 Milk Yield During Experimental Period
- Milk Fat Yield
  - 3.2.2.1 Milk Fat Yield during pre-experimental
  - 3.2.2.2 Milk Fat Yield During Experimental Period
- Milk Protein Yield
  - 3.2.3.1 Pre-experiment milk protein yield
  - 3.2.3.2 Milk Protein Yield During Experimental
- Milk Fat Concentration
  - 3.2.4.1 Milk Fat Concentration During
  - 3.2.4.2 Milk Fat Concentration During Experimental
- Milk Protein Concentration
  - 3.2.5.1 Milk Protein Concentration During
  - 3.2.5.2 Milk Protein Concentration During
- Fatty Acid Composition of Milk due to Differential
- Liveweight
- Condition Score

### Chapter 3: Herbage Intake
- Herbage Intake
  - 3.3.1 Estimate Herbage Intake, By Sward Cutting Technique
  - 3.3.2 Herbage Intake, Estimate by the Marker Technique
    - 3.3.2.1 Intake Estimated Prior To Differential Feed
    - 3.3.2.2 Estimated Herbage Intake due to Differential
- In Vivo Digestibility Values

### Chapter 4: Discussion
- Discussion
  - High and Low Bi Cows and Their Performances
  - Fat and Thin Cows and Their Lactation Performances
  - Herbage Intake
  - The Effects of Underfeeding During Early Lactation
4.4.1 The Effect of Underfeeding on Milk Yield and Milk....88
4.4.2 The Effect of Underfeeding on Fatty Acid Composition...89
4.5 RESPONSE TO FEEDING......................................................91
  4.5.1 Milk Production.........................................................91
  4.5.2 Effect on liveweight and condition score.................95
4.6 GENERAL CONSIDERATION................................................96

5 REFERENCES.................................................................98

6 APPENDICES...............................................................105
**LIST OF TABLES**

Table 1.1: The effects of different levels of feeding in the 7th or 8th months of pregnancy ..........................15

Table 1.2: The effect upon mean daily milk yield of herbage restriction and supplementation during the treatment periods and during 7 weeks in residual period .................................................................20

Table 1.3: Effects of levels of feeding in early lactation on milkfat production during week 0-6 of lactation ..................21

Table 1.4: Effect of feeding level during the first five weeks of lactation .........................................................23

Table 1.5: The effects of two levels of feeding in 7th or 8th months of lactation on milk production ....................24

Table 1.6: Estimated values for the amounts of extra milkfat produced if an extra 14 kg of pasture DM is fed at different times of the year (Holmes, 1982) .................................................................26

Table 1.7: The data for genetic improvement in NZ dairy cows ..............................................................................33

Table 1.8: Rank of total butter fat and protein yield for 10 strains of Friesian cows ..................................................34

Table 2.1: Number of animals in each treatment for grazing trials .................................................................39

Table 3.1: Lactation performances of the High and Low BI cows, total yield for 1982/83 season ......................46

Table 3.2: Fatty acid composition of milk of High and Low BI cows and Fat and Thin cows generously fed ....53

Table 3.3: Milk yield during pre-experimental period ..........55

Table 3.4: Milk yield due to differential feeding, all values have been covariance adjusted .........................57

Table 3.5: Milk fat yield during pre-experimental period ........58

Table 3.6: Milk fat yield due to differential feeding, all values have been covariance adjusted ................60

Table 3.7: Pre-experiment milk protein yield, kg/cow/day ....61

Table 3.8: Protein yield due to differential feeding, all
values have been covariance adjusted ..........................63

Table 3.9: Pre-experimental milk fat concentration ..................64
Table 3.10: Milk fat concentration due to differential feeding, all values have been covariance ......66
Table 3.11: Milk protein concentration, pre-experimental ......67
Table 3.12: Milk protein concentration due to differential feeding, all values have been covariance ......69
Table 3.13: Milk fat composition due to differential feeding and the significant values of F .................71
Table 3.14: Cows' liveweight and liveweight changes due to differential feeding ..........................74
Table 3.15: Cows' condition score and condition score changes due to differential feeding .....................76
Table 3.16: The herbage allowance, and herbage intake by grazing dairy cows in the experiment ...............77
Table 3.17: Estimated herbage intake during preliminary experiment early lactation ..........................79
Table 3.18: Herbage intake estimate by chromic oxide technique, when the cows were on differential ......80
Table 3.19: The herbage allowance, and herbage intake by grazing dairy cows estimated by the sward-cutting and chromic oxide technique ......81
Table 4.1: Production of High BI and Low BI cows calving at two levels of body condition..................85
Table 4.2: Effect of feeding level during 3 weeks early lactation on milkfat production and body condition score ..................................................94
LIST OF FIGURES

Figure 3.1: Milk Yield (A) High BI and Low BI cows (C) Fat and Thin cows FCM Yield (B) High BI and Low BI cows (D) Fat and Thin cows
Figure 3.2: Fat Yield (A) High BI and Low BI cows (B) Fat cows and Thin cows
Figure 3.3: Protein Yield (A) High BI and Low BI cows (B) Fat cows and Thin cows
Figure 3.4: Fat Concentration (A) High BI and Low BI cows (B) Fat cows Thin cows
Figure 3.5: Protein Concentration (A) High BI and Low BI cows (B) Fat and Thin cows
Figure 3.6: Liveweight (A) High BI and Low BI cows (C) Fat and Thin cows Condition Score (B) High BI and Low BI cows (D) Fat and Thin cows
Figure 3.7: Milk yield due to differential feeding (A) Generous and Restricted Feeding (B) For the four main treatments
Figure 3.8: Fat yield due to differential feeding (A) Generous and Restricted Feeding (B) For the four main treatments
Figure 3.9: Protein yield due to differential feeding (A) Generous and Restricted Feeding (B) For the four main treatments
Figure 3.10: Fat concentration due to differential feeding (A) Generous and Restricted Feeding (B) For the four main treatments
Figure 3.11: Protein concentration due to differential feeding (A) Generous and Restricted Feeding (B) For the four main treatments
Figure 3.12: Fatty acid composition of milk due to differential feeding (A) Fatty acid yield (B) Mole
Figure 3.13: Changes of fatty acid of milk due to differential feeding. (A) Short chain fatty acids (B) Medium chain fatty acids (C) Long
Figure 3.14: (A) Liveweight and (B) Condition score due to differential feeding .......................... 72
Figure 3.15: (A) Liveweight and (B) Condition score due to differential feeding .......................... 73
Figure 3.16: The relationships between herbage DM intake and (A) Herbage intake (B) Residual herbage mass. .......... 78
Figure 4.1: The relationships between BI values and (first 5 week) (A) Milk, (B) FCM (C) Fat yield, (D) Protein yield (E) Fat concentration (F) Protein concentration.............................. 83
Figure 4.2: The relationship between cows' liveweight and condition score changes. .............................. 84
Figure 4.3: Fatty acid composition of milk due to differential feeding (A) Fatty acid yield (B) Mole
Figure 4.4: The covariance adjusted milk yield due to differential feeding. ......................................... 94
LIST OF APPENDICES

APPENDIX I. Lactation Performances of High and Low BI Cows 1982/83 .......................................................105

APPENDIX II. Milk, Fat and Protein Yield (kg/cow/day); and Fat and Protein Concentration (g/kg milk) of High BI (HBI) and Low BI (LBI) cows 1982/83 season ..................................................107

APPENDIX III. Covariance adjusted milk yield due to differential feeding (week 7-10 of lactation) ..........109

APPENDIX IV. Fatty acid composition of milk changes due to differential feeding (week 7-10 of lactation) ....111

APPENDIX V. Results for Sward-Cutting When CR 0 Technique Was Tested ..................................................114

APPENDIX VI. The response to feeding by High and Low BI cows and by Fat and Thin cows. .........................116