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THE RESPONSE BY GRAZING DAIRY COWS TO SUPPLEMENTARY FEEDS

A thesis presented in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In Animal Science

Institute of Veterinary, Animal and Biomedical Sciences,
Massey University
Palmerston North

JOHN WILLIAM PENNO
2002
This thesis is dedicated to my Grandparents

William James and Nancie Julia Penno
ABSTRACT

Many experiments have measured the responses of grazing dairy cows to various forms of supplementary feed, but few have studied the reasons for the large differences in responses between experiments. Two short-term, and one long-term supplementary feeding trials were designed to help understand the reasons for wide variation in responses that have been reported, and to develop a biophysical framework to improve the prediction of the response by grazing cows to supplementary feeds.

Two grazing trials (trial 1 in year 1; trial 2 in year 2) were conducted with groups of cows in early, mid and late lactation in spring, summer, autumn and winter, in a partially complete Latin Square arrangement. At each stage of lactation, and in each season of the year, cows were offered either a restricted pasture allowance (25 to 35 kg DM/cow/day), or the restricted pasture allowance plus supplements offered at 50 MJME/cow/day in trial 1 and 80 MJME/cow/day in trial 2. The supplements were either rolled maize grain (MG) or a mixture of feeds formulated to nutritionally balance the diet (BR). Supplemented cows at each stage of lactation and during each season of the year were compared to their respective control groups, which received only the restricted pasture allowance.

In both trials 1 and 2, offering MG and BR supplements resulted in large increases in DMI. At a restricted metabolisable energy (ME) allowance, offering supplementary feeds increased ME intake by 0.65 MJME/MJME offered. This highly significant linear relationship was consistent across the different seasons and did not diminish at higher ME allowance. Between stages of lactation, substitution rates (SR) ranged from 0.1 to 0.3 (±0.1) during trial 1, and 0.1 to 0.5 (±0.1) during trial 2, however differences were not closely associated with either stage of lactation, season of the year or type of supplement offered. The pasture dry matter intake of the unsupplemented
cows (PDMI) was closely associated with SR, with SR increasing from 0.0 to 0.6 kg as the PDMI increased from 1.5 to 3.5% of liveweight.

In trial 1, the immediate responses ranged from 2.0 to 5.6g milksolids (MS)/MJME and from 0.3 to 11.1g liveweight/MJME. In trial 2, the immediate responses ranged from 0.3 to 3.3g MS/MJME and from 1.9 to 6.4g liveweight/MJME. The immediate MS responses were consistently smaller during spring than in other seasons of the year. The carryover responses (measured during the four weeks following supplementary feeding) were about 0.5 times the immediate effects in both trials 1 and 2. In trial 1 there was no difference (P>0.10) between the total milksolids responses (immediate plus carryover responses) of early and mid lactation cows, whereas in trial 2 mid lactation cows demonstrated larger (P<0.05) total milksolids responses than early lactation cows. In trial 1 the total milksolids responses measured in spring, summer autumn and winter were 6.4, 6.9, 3.6 and 7.5 (±1.17) g MS/MJME, respectively. During trial 2 the total milksolids responses measured in spring, summer autumn and winter were -0.1, 3.4, 3.6 and 4.7 (±0.74) g MS/MJME, respectively. There was no difference in the total milksolids response resulting from MG or BR in trial 1, whereas during trial 2 the milksolids response from MG and BR were 1.9 and 3.9 (±0.52) g MS/MJME, respectively.

Stage of lactation and season of the year accounted for little of the variation in the magnitude of the marginal milksolids response from feeding supplementary feeds. The factor that was of greatest importance was the relative feed deficit (RFD) measured by the reduction in milksolids yield (kg MS/cow/day) of the respective control groups that had occurred when the feeding treatments had been imposed. Total marginal milksolids responses were greatest when severe feed restrictions, relative to the current feed demand, resulted in large reductions in milksolids yield of the control groups. Total marginal milksolids response increased (P<0.01) by 0.9g MS/MJME offered as supplement per 0.1 kg MS/cow/day RFD. Total marginal milksolids responses also declined (P<0.01) by 0.2g MS/MJME offered as supplement as pasture allowance increased by 10 MJME/cow/day.
In the long-term trial, five spring-calving pasture-based farmlet systems were compared with the objective of measuring the long-term effects of offering large quantities of three types of supplementary feed within dairying systems. Four of five farmlets (5.67 ha) were stocked with 25 high genetic merit Friesian cows (4.41 cows/ha) and one farmlet was stocked with 19 cows (3.35 cows/ha) calving between 12 July and 31 August in each year, for three complete years. Herds on the higher stocked (HS) farmlets were offered either no supplementary feed from off farm sources (Control), or supplementary feeds of rolled maize grain (MO), or whole maize crop silage (WCS), or a nutritionally balancing ration (BR). The herd grazing the lower stocked farmlet (LS) was offered supplementary feed of pasture silage that had been conserved on that farmlet from surplus spring pasture.

The high stocking rate and early calving date of the supplemented herds resulted in low pasture allowances at most times of the year, requiring the use of 1.1 to 1.7 t DM/cow/year as supplementary feed. While some pasture substitution may have occurred, there was no difference between the annual pasture dry matter intake (DMI) of the supplemented and control herds. Feeding treatments of MO, WCS, BR and LS increased annual milksolids (MS) yield from 269 (Control herd) to 400, 363, 408 and 361 (±15.8) kg/cow, respectively. Differences in total dry matter and metabolisable energy intake per cow explained most of the differences in MS yield per cow between the five farmlets. Marginal responses from the MO, WCS, BR, and LS treatments averaged 7.3, 7.6, 7.8, and 6.6g MS/MJME over the three years of the experiment. Cows in the HS supplementary feeding herds and the LS herd calved in fatter condition and maintained higher DMI in early spring, and had shorter post partum anoestrous interval and a lower incidence of anoestrous than those in the HS control herd.

A model based on the data derived from the two short-term trials used RDF, pasture allowance, supplement intake and stage of lactation to predict much of the variability between some published short-term experiments, and closely agreed with the milksolids responses measured during the long-term trial.
ACKNOWLEDGEMENTS
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Like all successful human endeavors, a Ph.D. project is a team effort. The scale and nature of the experiments reported in this thesis are such that it seems unjust that most of the credit is ultimately bestowed upon one person. For significant periods of time during the experimental work, all of the people, land and cows at the DRC No 2 and No 3 Dairies were devoted to these experiments. I fully acknowledge that there is probably nobody who has worked at the Dairying Research Corporation, or indeed there is probably nobody who has spent much time with me over the past 5 years, who has not contributed to the completion of this project.

Firstly I must thank the DRC for providing the opportunity and financial support for me to undertake this project. Much of the credit belongs to Sir James Graham, Ken Jury and Arnold Bryant, the men who provided the vision of what the DRC could become if it chose the right people, developed them, provided them with opportunities and expected much from them. I do not believe I could have had a better mentor early in my career than Arnold. Working beside him was an unearned privilege, and without doubt provided the inspiration and encouragement to embark on this project. My thanks must also go to Rob Pringle and Dave Clark for sending me away for 12 months to write up – without which this project would not be finished yet.

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<tbody>
<tr>
<td>AA</td>
<td>Amino acids</td>
</tr>
<tr>
<td>ADF</td>
<td>Acid detergent fibre</td>
</tr>
<tr>
<td>ADFIP</td>
<td>Acid detergent fibre insoluble protein</td>
</tr>
<tr>
<td>AP</td>
<td>Ad libitum pasture</td>
</tr>
<tr>
<td>ARDOM</td>
<td>Apparently rumen digested organic matter</td>
</tr>
<tr>
<td>ATP</td>
<td>Adenosine triphosphate</td>
</tr>
<tr>
<td>BOH</td>
<td>Beta hydroxy butyrate</td>
</tr>
<tr>
<td>BR</td>
<td>Nutritionally balancing ration</td>
</tr>
<tr>
<td>CNCPS</td>
<td>Cornell Net Carbohydrate and Protein System</td>
</tr>
<tr>
<td>CP</td>
<td>Crude protein</td>
</tr>
<tr>
<td>DIM</td>
<td>Days in milk</td>
</tr>
<tr>
<td>DM</td>
<td>Dry matter</td>
</tr>
<tr>
<td>DMI</td>
<td>Dry matter intake</td>
</tr>
<tr>
<td>DOMD</td>
<td>Digestible organic matter in dry matter</td>
</tr>
<tr>
<td>eNDF</td>
<td>Effective neutral detergent fibre</td>
</tr>
<tr>
<td>FCM</td>
<td>Fat corrected milk (4%)</td>
</tr>
<tr>
<td>HS</td>
<td>High stocking rate</td>
</tr>
<tr>
<td>LCFA</td>
<td>Long chain fatty acids</td>
</tr>
<tr>
<td>LS</td>
<td>Low stocking rate</td>
</tr>
<tr>
<td>ME</td>
<td>Metabolisable energy</td>
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<td>MEA</td>
<td>Metabolisable energy allowance</td>
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<td>MEI</td>
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<td>MF</td>
<td>Milkfat</td>
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<td>NDF</td>
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List of Abbreviations

NDFIP Neutral detergent fibre insoluble protein
NEFA Non-esterified fatty acids
NPN Non protein nitrogen
OM Organic matter
OMD Organic matter digestibility
PDMI Pasture dry matter intake of unsupplemented cows
r.s.d. Residual standard deviation
RDP Rumen degradable protein
REML Residual maximum likelihood
RFD Relative feed deficit
s.e.d. Standard error of the difference
SOLCHO Soluble carbohydrate
SR Substitution rate
UDP Rumen undegradable protein
VFA Volatile fatty acids
WCS Whole crop silage (Maize silage)