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## Adapting the MOLLY cow model to fit production data from New Zealand animals

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### ABSTRACT

To assist in the planning of farm systems trials, Dexcel is developing a computer model of a pasture-based, rotationally grazed dairy system. The model includes published component models (or submodels) for cow metabolism and pasture growth, as well as climate and management information. It is currently being evaluated against production data obtained from the Whole Farm Efficiency Trial at Dexcel No 2 Dairy. The cow component being used is MOLLY, a dynamic model based on the underlying processes of ruminant digestion and metabolism. The parameters of MOLLY are based on animals that are efficient on high-energy diets. To make the computer model more accurate as a predictive tool for use in NZ, some of the parameters of the MOLLY submodel have been adjusted to fit the production data of NZ dairy cows on pasture, namely bodyweight changes and daily milk yields. MOLLY initially under-predicted by approximately 20% the body weight of older cows (>4 years) for the pre-calving and early lactation periods. Resetting some parameters in MOLLY significantly improved the prediction of these bodyweight changes: to 2% for the pre-calving period and 14% for early lactation. Milk yield per cow was under-predicted in early lactation by MOLLY but the fit for each cow was improved by entering the observed peak daily milk value, although further fitting is required. We conclude that MOLLY is suitable for use as a research tool to gain insights into changes in metabolism of NZ cows grazed on pasture.

**Keywords:** computer model; body weight; milk yield.

### INTRODUCTION

A computer model of a whole farm system (Whole Farm Model WFM) is being developed at Dexcel to assist in the planning of farm systems trials (Sherlock *et al.*, 1997; Sherlock & Bright, 1999; Bright *et al.*, 2000). The model consists of a framework, submodels for cow metabolism and pasture growth, and information on climate and management policies. The WFM is currently being evaluated against data obtained from a trial at No 2 Dairy studying changes in efficiency and profitability of milksolids (milk fat plus milk protein) production when dry matter allowance per cow is increased (McGrath, 1998). Evaluation of the WFM involves fitting the component models for animal and pasture production to the observed data. Once data are fitted, the WFM can be used for prediction and design of farm systems.

Development of the WFM (Sherlock *et al.*, 1997; Sherlock & Bright, 1999), use of the WFM, and initial fitting to pasture data has been described previously (Bright *et al.*, 2000). This paper focuses on the cow component of the WFM. The most complex cow model used in the WFM currently is MOLLY, a dynamic model developed over the last 30 years at the University of California, Davis (Baldwin, 1995). It is mechanistic in that the equations are based on knowledge of the underlying processes of ruminant digestion and metabolism.

This paper describes how live body weight and daily milk yield for one season were fitted by the WFM by adjusting input parameters of MOLLY. We describe the adjustment of these parameters so that the fit between observed and predicted values is improved, particularly in relation to the body weights of older cows (> 4 years of age).

### METHODS

#### Farm Trial

The Whole Farm Efficiency trial at Dexcel (previously

Dairying Research Corporation, DRC) No 2 Dairy consists of 10 farmlets, each with 18-20 animals and stocking rates of 2.2-4.3 cows/ha. Each farmlet is stocked with high-genetic-merit Friesian cows. We modelled one farmlet, farmlet 3, during the 1998-99 season. This herd consisted of 19 cows ranging in age from 2-8 years, with 10 cows being older than 4 years of age. The observed data were collected from the beginning of July 1998 to the end of May 1999. Data consisted of cow body weights (kg) and milk yield (litres) measured weekly, as well as pasture growth.

#### Data Fitting

The farmlet data were fitted by solving the WFM using the MOLLY cow submodel, the pasture growth model of McCall (1984) and a management policy that tracked each event on the farmlet (e.g., when the herd went into and left a particular paddock, when silage was fed out). In the WFM, feed demand was calculated within MOLLY, and the animals then 'grazed' the available pasture, or were given supplements, based on the actual farm events recorded.

MOLLY requires various estimates of body weight as a basis for calculating metabolism and production. Empty body weight (EBW) refers to body weight less digesta or gut-fill. IEBW (initial empty body weight) is calculated by subtracting the weight of digesta from the initial body weight (IBW) and is given by the following equation (Williams *et al.*, 1989):

$$\text{IEBW} = (\text{IBW} - 25)/1.09 \quad (1)$$

Using IBW, IEBW is calculated using Equation (1) and then entered into MOLLY. Mature body weight (MatBW) refers to the mature body weight including digesta and does not require adjustment prior to being entered into MOLLY.

UCELLS is a parameter used by MOLLY to measure a cow's genetic potential (ability to produce milk). It is linked empirically to milk yield by the equation.

$$\text{UCELLS} = 179.1 \exp(0.053 \times \text{MPDM}) \quad (2)$$

where MPDM is the mature peak daily milk yield measured in litres. Using MPDM, UCELLS is calculated using Equation (2) and then used by MOLLY. Equation (2) was derived by performing a series of fully-fed MOLLY runs in isolation from the WFM framework, UCELLS being adjusted to fit MPDM.

**Assumptions**

Initial fitting of MOLLY within the WFM to actual bodyweight changes and milk production data.

1) Values of IBW, MatBW and MPDM were set according to the age of the cow:

For cows > 3 years of age, IBW = 450 kg and MatBW = 470 kg.

For cows < 3 years, IBW = 400 kg and MatBW = 420 kg.

For cows > 4 years, MPDM = 25 litres

For cows 3- 4 years, MPDM = 23 litres

For cows < 3 years MPDM = 20 litres

2) Weight changes due to pregnancy and calving were not included in the bodyweight calculations in MOLLY. (Currently, MOLLY does not model the metabolic and weight changes associated with pregnancy).

The fit of MOLLY to the cow data was evaluated graphically and quantitatively by calculating the % deviation of the model-calculated values from the observed data. This quantitative comparison involved calculating the average percentage underprediction and/or overprediction for each cow using the following formula:

$$\text{Underprediction (or overprediction)} = 100(\text{PBW} - \text{OBW})/\text{OBW}$$

where PBW and OBW are predicted (by the model) and observed (actual) body weights respectively. Model fits are based on early lactation (from calving to 100 days lactation), mid lactation (from 100 to 200 days lactation) and late lactation (from 200 days lactation to dry-off or culled date).

**RESULTS AND MODEL REVISION**

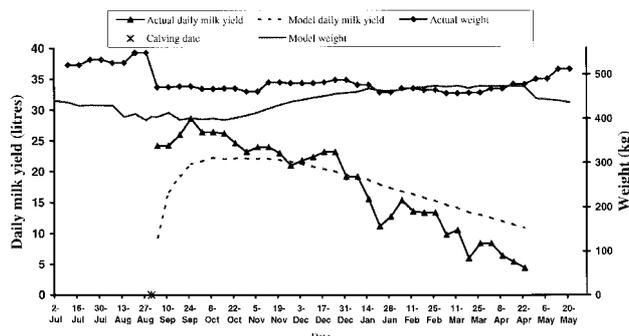
Initial fit weight predictions for the younger cows ( $\leq 4$  years), were close to observed values (data not shown). Predictions were less accurate for older cows (>4 years), especially during the pre-calving period and early lactation and this group is the focus of this paper. Using values for body weight and production as discussed above (Methods, Assumptions) resulted in low estimates of the body weight of older cows (Figure 1). Body weights were underpredicted by an average of 22% for the pre-calving period and by an average of 19% for early lactation, with an average overprediction of 5% in early lactation (Table 1). After dry-off date, the actual cow's weight increased (see Figure 1), whereas the model calculates the weight decreasing.

The milk yield for each cow, regardless of age, was underpredicted during early lactation, as shown for a typical older cow (Figure 1).

**Revised fit**

To improve the accuracy of the model results, two changes were made: i) IBW, MatBW and MPDM values were revised and set to (observed) values for each cow and ii) functions were introduced to account for the bodyweight changes due to pregnancy and calving.

**FIGURE 1.** Predicted (model) and observed (actual) body weights (kg) and daily milk yields (l) of a typical older cow (> 4 years) in Herd 3. The input to MOLLY is based on cow age (weight changes due to pregnancy and calving are not included).



**TABLE 1:** Average (over 10 cows in Herd 3 with age > 4 years) of the average percentage prediction errors and standard deviations of live body weights for each cow over the season. Input parameters to MOLLY were based either on (i) Initial fit: cow age (weight changes due to pregnancy and calving not modelled), or (ii) Revised fit: actual data (weight changes due to pregnancy and calving are modelled). Average underprediction (overprediction) = 100(PBW - OBW)/OBW where PBW and OBW are predicted (model using MOLLY as the cow component) and observed (actual) live body weights in kg respectively. Input parameters are IBW (the initial body weight in kg), MatBW (the mature body weight in kg) and MPDM (the mature peak daily milk in litres).

Period		(i) Initial fit	(ii) Revised fit
Pre-calving	Underprediction	-22 (7)	-2 (1)
	Overprediction	0 (0)	2 (0)
Early lactation (to 100 days lactation)	Underprediction	-19 (6)	-14 (4)
	Overprediction	5 (3)	7 (3)
Mid lactation (100 - 200 days lactation)	Underprediction	-11 (6)	-9 (4)
	Overprediction	3 (3)	2 (1)
Late lactation (200 days to dry-off or culled date)	Underprediction	-5 (5)	-4 (2)
	Overprediction	2 (3)	1 (1)

Initial body weight (IBW): Body weight data on 10 July 1998 were used, all the cows in Herd 3 were pregnant by this time. However, the current version of MOLLY does not model a pregnant cow, IBW needs to have the conceptus weight (foetus plus foetal fluids plus foetal membranes) subtracted from it. The weight of conceptus was estimated by the following equation from Ferrell *et al.* (1976):

$$CW = 470.1[\exp(0.0217-0.0000161t)] \quad (3)$$

where CW is conceptus weight and t is day of gestation. Therefore

$$IEBW = [(IBW - CW) - 25]/1.09 \quad (4)$$

When a cow calves CW becomes zero and remains so until she becomes pregnant again.

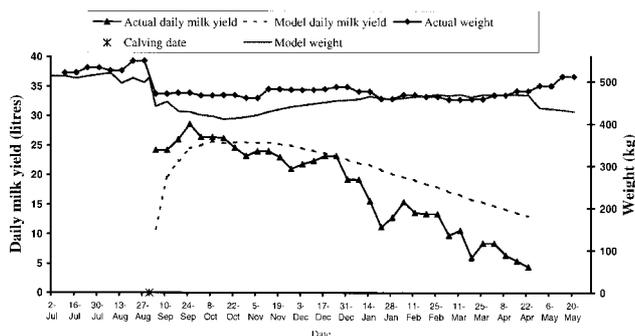
Mature body weight (MatBW) set to the observed weight at dry-off or culling date and Mature Peak Daily Milk (MPDM) was set to the observed peak daily milk value that occurred during lactation.

Body weight: Resetting the inputs to MOLLY improved the bodyweight fits (Figure 2). The fit was improved from underprediction of 22% to 2% in precalving, from 19% to

14% in early lactation, with little improvement in mid and late lactation (Table 1).

Milk yield: Increasing MPDM shifted the model milk yield curve upwards (Figure 1 MPDM = 25 litres, Figure 2 MPDM = 28.6) so that the actual data is more closely modelled in early lactation (compare Figures 1 and 2), but the model milk yield curve overpredicts in mid and late lactation, see Figures 1 and 2.

**FIGURE 2.** Predicted (model) and observed (actual) body weights (kg) and daily milk yields (l) of a typical older cow (> 4 years) in Herd 3. The input to MOLLY is based on actual data (weight changes due to pregnancy and calving are modelled).



## DISCUSSION

Using actual data to calibrate MOLLY for body weights and genetic potential for each cow improved the accuracy of the MOLLY submodel to predict bodyweight changes during the season, especially in the pre-calving and early lactation periods. The improvement in fits to body weight for the pre-calving period was due to inclusion of the bodyweight changes of pregnancy and calving. Even though MOLLY does not currently model metabolic and weight changes associated with pregnancy, weight changes due to pregnancy and calving can be modelled adequately 'outside' MOLLY by using growth functions. However, if parameters within MOLLY were modified so that metabolic changes associated with pregnancy were modelled, weight changes associated with pregnancy may then be accounted for within MOLLY.

Weight loss during early lactation is still underpredicted by MOLLY. Identifying and adjusting some parameters within MOLLY may resolve this. Alternatively, if the pasture growth component model of the WFM is underpredicting pasture growth during this period, MOLLY may be 'underfed' during early lactation. There may not be enough feed available in order for MOLLY to maintain the observed body weights. The reasons for MOLLY predicting weight loss after drying-off or culling still need to be elucidated.

Revision of the inputs into MOLLY did not resolve the deviations in milk production. The lactation curve is the wrong shape, with milk yield in early season being under predicted, and yield in late season being overpredicted. Further work is required to adjust some of the milk parameters within MOLLY so that the model lactation curve more closely follows the shape of a NZ cow's lactation curve.

Once there is good agreement between the observed and predicted milk yields and body weights, we plan to

investigate the possibility of setting the MOLLY inputs (IBW, MatBW, and MPDM) using breeding worth and/or body condition score. It may also be that we can use the cow's age, but using a better correlation between age and the input parameters. That is, the WFM may be able to predict the milk yield and body weight over a season from breeding worth, age and/or body condition score early in the season. This would enable the WFM, and the MOLLY submodel, to be used for predictive purposes.

## ACKNOWLEDGEMENTS

To Julia Lile for the graphs, and the staff at No 2 Dairy for data collection.

## REFERENCES

- Baldwin, R.L. 1995: Modeling ruminant digestion and metabolism. London, Chapman & Hall
- Bright, K.P.; Sherlock, R.A.; Lile, J.; Wastney, M.E. 2000: Development and use of a whole farm model for dairying. *In: Halloy, S.; Williams, T. ed. Applied complexity—from neural nets to managed landscapes*, Christchurch, New Zealand, New Zealand Institute for Crop and Food Research. Pp. 382-389
- Ferrell, C.L.; Garrett, W.N.; Hinman, N. 1976: Growth, development and composition of the udder and gravid uterus of beef heifers during pregnancy. *Journal of animal science*, 42: 1477-1489
- McCall, D.G. 1984: A systems approach to research planning in North Island hill country, Palmerston North, New Zealand, Massey University
- McGrath, J. 1998: Whole farm efficiency trial, Hamilton, New Zealand, Dairying Research Corporation Ltd.
- Sherlock, R.A.; Bright, K.P. 1999: An object-oriented framework for farm system simulation. *In: Oxley, L.; Scrimgeour, F.; Jakeman, A. ed. MODSIM 99 International Congress on Modelling and Simulation Proceedings*, Hamilton, New Zealand, Modelling and Simulation Society of Australia and New Zealand Inc. Pp. 783-788
- Sherlock, R.A.; Bright, K.P.; Neil, P. G. 1997: An object-oriented simulation model of a complete pastoral dairy farm. *In: McDonald, A.D.; McAleer, M. ed. MODSIM 97 International Congress on Modelling and Simulation*, Hobart, Tasmania, Modelling and Simulation Society of Australia Inc. Pp. 1154-1159
- Williams, C.B.; Oltenacu, P.A.; Sniffen, C.J. 1989: Refinements in determining the energy value of body tissue reserves and tissue gains from growth. *Journal of dairy science*, 72: 264-269.