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Description and evaluation of the Herd Dynamic Milk (HDM) Model on different herbage allowance, concentrate supplementation and milk yield potential

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Introduction

Modelling of biological systems is complicated due to the interaction of numerous variables, which is particularly the case in grass-based dairy systems. However, a well developed and calibrated model can be used to simulate the impact of different management (e.g. feeding levels) on cow milk production and subsequent fertility performance. While there are considerable amounts of these models available in the literature, most of them have been parameterised and optimised for the conditions where they were developed. The objective of this study was to develop a model that was able to accurately simulate animal performance under various grazing conditions.

Materials and methods

The Herd Dynamic Milk (HDM) model is a dynamic stochastic and agent-based model developed using the programming language C++. Animals in the model are described individually from birth to death. The HDM model is able to take into account the impact of the genotype of the animal, diet, and management decisions on milk production and body condition score. This model is also able to model both indoor and grazing systems. The main daily outputs of the HDM model are dry matter feed intake, milk yield, body condition score (BCS) for every animal for every day of the year. The intake of the animal is calculated using the French model for nutrition (Faverdin *et al*., 2011) and the GrazIn (Delagarde *et al.*, 2011) intake model for cows at grazing. The daily milk production is calculated depending on the energy intake, the milk potential and BCS change of the cow. The sensitivity of the model was evaluated by testing the responses to various scenarios and by comparing the model outputs in terms of milk production and BCS with data available from the literature. Variation around the milk yield potential (30, 40 and 50 kg of milk per cow per day at peak), the daily herbage allowance (14, 18 and 22 kg of DM per cow per day) measured to 4cm and the concentrate allocation (0 or 4kg of concentrate per cow per day) were simulated resulting in 18 different scenarios. The simulations were carried out for a full 12 month period (starting on the first of January) allowing the observation of the whole lactation and it was assumed that the cows were at grazing for the whole period. Grass quality was held constant throughout the simulation and was based on published experiments.

Results and Discussion

The output of the model resulted in an average milk yield through the lactation of 6,012kg, 7,246kg and 8,391kg for the cows with 30, 40 and 50kg of potential milk respectively. Body condition score nadir was 3.29, 2.77 and 2.25 for the 30, 40 and 50kg milk groups respectively. The impact of the genetic potential for milk production was shown in the model through an average increase of 0.44kg of milk per day per cow per increase of 1 kg of potential milk production and a decrease of 0.03 units of BCS at nadir. Over the entire lactation the 50 kg of milk group produced 1,147 kg and 2,375 kg more milk than the 40 and 30kg groups, respectively. A herbage allowance increase of 1kg per cow per day resulted in an average increase of 0.20kg of standard milk per cow per day and an increase of the BCS nadir of 0.01 points. The response to an increase of herbage allowance ranged from 0.13 to 0.28 kg for the 30 kg and 50kg potential group of cows. The impact of the increase of 1kg of herbage allowance is higher at 14 herbage allowance (0.25kg per cow per day) while at 18 the response was 0.16kg per cow per day. Herbage allowance did not have a big impact on BCS loss irrespective of the genetic profile of the cows and whether they were offered supplementary feed or not (overall variation from 0.02 to 0.04 units at nadir due to herbage allowance).

On average the impact of 1kg of concentre resulted in an increase of 0.8kg of standard milk per day per cow and an increase of the nadir BCS of 0.05 units. Once again the response to the addition of concentrate increases with the milk potential (from 0.58 for the 30kg genetic group to 0.94 for the 50kg genetic groups). The impact of the concentrate supplementation decreases with an increase in herbage allowance as shown by McEvoy *et al.* (2008). The impact of offering 4 kg of concentrate results in a higher increase of the nadir for the 30kg potential cow (increase of 0.21 unit) than the 50kg cow (increase of 0.16 unit). All model outputs were in the range of published experiments (McEvoy *et al.*, 2008; McCarthy *et al.*, 2007).

Conclusion

The model is able to respond in a realistic way when subjected to various scenarios. The model outputs are in the range of outputs from the literature.

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