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An empirical model for forecasting wheat quality. P. S. KETTLEWELL[1], M. D. ATKINSON[1], P. D. HOLLINS[1] and D. B. STEPHENSON[2]. [1]*Crop and Environment Research Centre, Harper Adams University College, Newport, Shropshire TF10 8NB, UK*, [2]*School of Engineering, Computing and Mathematics, University of Exeter, Harrison Building, North Park Road, Exeter EX4 4QF, UK*

Specific weight (weight per unit volume) of harvested wheat grain is a criterion of quality used in trading. It is linearly related to the preceding winter index of the North Atlantic Oscillation (NAO), a large-scale atmospheric pressure difference between Iceland and the Azores (Kettlewell *et al*. 1999). The mechanism underlying the association appears to be through a lag relationship of the winter NAO index with the following summer sunshine duration and rainfall, both of which affect grain specific weight (Kettlewell *et al*. 2003; Atkinson *et al*. 2005). A linear regression model of national mean specific weight, weighted with sample number, on winter NAO index has been developed to forecast wheat quality well in advance of harvest.

The optimal NAO index for forecasting, calculated from gridded pressure data, involves too much computation for regular annual forecasts and, although less correlated with specific weight, the pre-calculated Climate Prediction Centre (CPC) index is now used. There is little evidence of serial correlation in either the specific weight or the CPC NAO time series over the period for which national specific weight data is available (1974 onwards), indicating the validity of a simple regression model. Cross-validation over the years 1974–2007 indicates that the model is likely to correctly forecast whether specific weight is above or below the long-term mean with an accuracy of 71% compared with 50% by chance ($\chi^2 = 5{\cdot}40$, 1 d.f., $P = 0{\cdot}02$).

Studies with historical data from the Broadbalk Wheat Experiment have shown that the model is temporally unstable. Running correlations of the NAO with the contemporary national data used for forecasting indicate that the association may have weakened slightly in recent years. Investigating spatial stability has proved more difficult due to lack of georeferenced specific weight data. Gridded correlations of the winter NAO with summer rainfall, representing one of the underlying mechanisms, indicate that the model is most applicable in Eastern England. Fortuitously, this is where most of the UK wheat is grown. Annual forecasts are posted in spring at: http://www.harper-adams.ac.uk/groups/crops/wheat/

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Comparison of three requirements-based energy evaluation systems and a mechanistic model for estimating nutritional requirements for milk production from grass-based diets fed to dairy cattle. J. DIJKSTRA[1], L. A. CROMPTON[4], E. KEBREAB[7], A. BANNINK[3], S. LÓPEZ[5], P. A. ABRAHAMSE[1], P. CHILIBROSTE[6], J. FRANCE[2] and J. A. N. MILLS[4]. [1]*Wageningen Institute of Animal Sciences, Animal Nutrition Group, Wageningen University, Marijkeweg 40, 6709 PG Wageningen, The Netherlands*, [2]*Centre for Nutrition Modelling, Department of Animal and Poultry Science, University of Guelph, Guelph, Ontario N1G 2W1, Canada*, [3]*Animal Sciences Group, Nutrition and Food, P.O. Box 65, 8200 AB Lelystad, The Netherlands*, [4]*Animal Science Research Group, School of Agriculture, Development and Policy, University of Reading, Whiteknights, Reading RG6 6AR, UK*, [5]*Department of Animal Production, University of Leon, 24007 Leon, Spain*, [6]*Facultad de Agronomia, Estacion Experimental M.A. Cassinoni, Ruta 3 km 363, CP 60000, Paysandu, Uruguay*, [7]*Department of Animal Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada*

UK dairy systems rely heavily on grass-based diets to support milk production, particularly throughout the summer months. On such diets the supply of glucogenic nutrients may be limiting to production. Existing feed evaluation systems are used widely to estimate the requirement for energy under grazing conditions to support a given level of milk yield. However, these systems assess the animal's requirements according to metabolizable energy (ME) or net energy (NE) and do not consider the characteristics of the energy delivering nutrients. Unlike their empirical alternatives, mechanistic models take into account the site of digestion, the type of nutrient absorbed and the type of nutrient required for production of milk constituents. The objective of this study was to compare energy or nutrient supply on grass-based diets with the energy or nutrients required for observed milk production calculated from empirical energy systems and from a mechanistic model. The energy systems investigated were the AFRC ME system, the Feed Into Milk (FIM) system and the Dutch NE system. The mechanistic model was based on Dijkstra *et al*. (1996) and Mills *et al*. (2001). The dataset for evaluation consisted of 41 records from 11 experiments of grass-based diets (at least 75% grass on dry matter basis) that had sufficient information to calculate supply and requirement according to each model. Assessment of the error of energy or nutrient supply relative to requirement was made by calculation of the mean square prediction error (MSPE). In the mechanistic model, the supply of glucogenic nutrients was always more limiting to milk production than the supply of aminogenic nutrients or the supply of energy. The residual MSPE (expressed as a percentage of the supply) was lowest for the mechanistic model (6·1%), followed by the Dutch NE system (8·2%), FIM ME system (9·7%) and AFRC ME system (11·8%). In all models, the observed energy or nutrient supply exceeded the calculated energy or nutrient requirement. For the energy evaluation systems, the error due to overall bias of prediction dominated ($>50\%$) the MSPE, whereas for the mechanistic model, 76% of MSPE was due to random variation. The FIM ME system gave a slightly improved prediction of requirements than the AFRC ME system. Analysis of the difference between supply and requirement indicated a relationship with the protein content of the grass for the Dutch NE system, but this relationship was absent for the other models. The grass dry matter intake level was positively related to the difference between supply and requirement for all models, in particular the mechanistic model and the ME systems. In conclusion, current requirements-based energy evaluation systems overestimate energy supply relative to energy requirement on grass-based diets for dairy cattle. The mechanistic model predicted glucogenic nutrients to limit milk production. The model overestimated dietary nutrient supply especially at higher intakes but overall it proved to be more reliable than the empirical energy systems.

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Modelling the carbon footprint of dairy cows. J. A. N. MILLS and L. A. CROMPTON. *Animal Science Research Group, School of Agriculture, Development and Policy, University of Reading, Whiteknights, Reading RG6 6AR, UK*

Ruminant livestock have been highlighted as a source of greenhouse gas emissions resulting from the production of methane during anaerobic fermentation in their digestive tract (Johnson & Johnson 1995). Several studies have described attempts to reduce methane emissions through nutritional or pharmacological means with varying degrees of success. However, these studies have tended to ignore the contribution of exhaled carbon dioxide (CO_2) to the animal's carbon footprint. The aims of this research were to determine the relative importance of exhaled CO_2 and methane to the carbon footprint of lactating dairy cows and to examine their relationship to dietary intake. A locally derived database comprising 186 individual measurements of respiratory exchange and methane emission from lactating dairy cows was analysed. The mean dry matter intake (DMI) was 18·4 kg/d (range 10–28 kg/d) from a broad range of diet types based on grass silage, maize silage or fresh grass. As shown in earlier studies, methane was closely related to DMI. Carbon dioxide output also showed a strong linear correlation with DMI. In order to estimate the carbon footprint of each animal, 1 kg methane was assumed to yield a CO_2 equivalent of 25 kg (Forster *et al*. 2007). The carbon footprint of each animal was assumed to be a function of exhaled carbon dioxide and methane emissions combined. Emissions from manure were not included in this analysis. Methane accounted for a mean of 0·44 of each animal's carbon footprint with a range of 0·34–0·50. This variation in methane emissions as a proportion of total CO_2 equivalent output was not associated with the level of DMI. National greenhouse gas inventory data tend to limit their focus to methane output. If an estimate of CO_2 output were added to the inventory for the UK's 2 million lactating dairy cattle this would be an annual CO_2 emission of approximately 6·5 million tonnes. This would be in addition to the 0·2 million tonnes of methane from these cattle annually (equivalent to 4·2 million tonnes of CO_2 equivalents). This study shows the importance of a broader scope to include CO_2 from respiratory exchange, its contribution being greater than that of methane from the digestive tract. Mitigation strategies aimed at reducing methane emissions should be set in this context.

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