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Requirements for zero energy balance of nonlactating, pregnant dairy cows fed fresh autumn pasture are greater than currently estimated

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ABSTRACT

Fifty-three nonlactating, pregnant Holstein-Friesian and Holstein-Friesian × Jersey cross dairy cows were grouped into 4 cohorts (n = 15, 12, 13, and 13) and offered 1 of 3 allowances of fresh, cut pasture indoors for 38 ± 2 d (mean ± SD). Cows were released onto a bare paddock after their meal until the following morning. Animals were blocked by age (6 ± 2 yr), day of gestation (208 ± 17 d), and body weight (BW; 526 ± 55 kg). The 3 pasture allowances [low: 7.5 kg of dry matter (DM), medium: 10.1 kg of DM, or high: 12.4 kg of DM/cow per day] were offered in individual stalls to determine the estimated DM and metabolizable energy (ME) intake required for zero energy balance. Individual cow DM intake was determined daily and body condition score was assessed once per week. Cow BW was recorded once per week in cohorts 1 and 2, and 3 times per week in cohorts 3 and 4. Low, medium, and high allowance treatments consumed 7.5, 9.4, and 10.6 kg of DM/cow per day [standard error of the difference (SED) = 0.26 kg of DM], and BW gain, including the conceptus, was 0.2, 0.6, and 0.9 kg/cow per day (SED = 0.12 kg), respectively. The ME content of the pasture was estimated from in vitro true digestibility and by near infrared spectroscopy. Total ME requirements for maintenance, pregnancy, and limited activity were 1.07 MJ of ME/kg of measured metabolic BW per day. This is more than 45% greater than current recommendations. Differences may be due to an underestimation of ME requirements for maintenance or pregnancy, an overestimation of diet metabolizability, or a combination of these. Further research is necessary to determine the reasons for the greater ME requirements measured in the present study, but the results are important for on-farm decisions regarding feed allocation for nonlactating, pregnant dairy cows.

Key words: maintenance energy, cattle, body weight gain, pregnancy

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INTRODUCTION

The ME and net energy requirements for cow maintenance, activity, reproduction, and productive purposes have been estimated and are published in energy accounting systems (ARC, 1994; NRC, 2001; CSIRO, 2007). However, recommendations are not always consistent. For example, the NRC (2001) estimates maintenance to be approximately 0.54 MJ of ME/kg of $BW^{0.75}$ for mature lactating cows, assuming a conversion of ME to net energy (the efficiency of use of ME for maintenance; $\mathbf{k_m}$) of 0.62. This includes an additional allowance of 10% of maintenance for normal activity that is not expended when fasting heat production is measured (i.e., cows in calorimeters). In contrast, the ARC (1994) reported lower ME requirements from fasting heat production experiments with estimated maintenance values for a 500-kg cow of 0.45 to 0.47 MJ of ME/kg of $BW^{0.75}$, at a diet metabolizability of 0.70 or 0.60, respectively. The CSIRO (2007) developed a more complex prediction equation, incorporating species, sex, age, BW, potential milk production, k_m, energy requirements for grazing activity, and energy expenditure for ambient temperatures below the animal's lower critical temperature. However, actual requirements were not greatly different from those in NRC (2001); for example, a 6-yr-old dairy cow (500 kg of BW) in thermoneutral conditions would require 0.56 MJ of ME/kg of $BW^{0.75}$. The CSIRO (2007) values were used to predict the ME requirements of grazing dairy cows (Nicol and Brookes, 2007).

In addition to variations between nutrient requirement systems, Yan et al. (1997a,b) reported that ME requirements for maintenance in nonlactating and lactating cows were 12 to 15% greater than in the studies used to formulate the existing recommendations. These results support the reports by Garrett (1971) and Ferrell and Jenkins (1984) that maintenance ME requirements increase with genetic merit for milk production. Because of this, Nicol and Brookes (2007) increased the ME requirements for milk production in grazing dairy cows, leaving maintenance at previously recommended levels. Such a change would increase the total ME requirements of lactating cows, but would not adjust ME requirements in nonlactating cows. This is not consistent with Roche et al. (2005), who reported that ME requirements for maintenance, pregnancy, and activity in nonlactating pregnant dairy cows during the last month of gestation were greater than recommended, at 1.05 MJ of ME/kg of $BW^{0.75}$. Holmes and Grainger (1982) and Grainger et al. (1985) also reported greater requirements for cows grazing autumn pasture in mo 7 precalving (210 to 215 d of gestation) of up to 1.02 MJ of ME/kg of $BW^{0.75}$, indicating that ME requirements for maintenance, pregnancy, and activity in nonlactating, grazing cows may be greater than currently recommended. However, in these studies, DMI was only estimated from pre- and postgrazing residuals, and the reported energy requirements were, therefore, only estimates.

The objective of the present study was to determine the ME requirements for zero energy balance of pregnant, nonlactating, grazing dairy cows 2 mo precalving, by accurately measuring DMI, while still exposing cows to conditions similar to those found in grazing systems (i.e., cows were kept on a bare paddock in the afternoon and night).

MATERIALS AND METHODS

Trial Design and Measurements

As part of a larger experiment undertaken over 2 yr, 53 nonlactating, pregnant Holstein-Friesian and Holstein-Friesian × Jersey-cross dairy cows were offered 1 of 3 daily pasture allowances for 38 ± 2 d (mean ± SD) in 4 cohorts (n = 15, 12, 13, 13) at the DairyNZ Calan Gate (American Calan, Northwood, NH) freestall facility (Hamilton, New Zealand). The 4 cohorts were required because of space limitations in the indoor feeding facilities. Fresh autumn pasture offered was as follows: low = 7.5 kg of DM/cow; medium = 10.1 kg of DM/cow, and high = 12.4 kg of DM/cow. The low allowance was intended to provide the recommended requirements for maintenance based on the measured BW (0.55 MJ of ME/kg of $BW^{0.75}$; NRC, 2001; Holmes et al., 2002), with an additional allowance of 20 MJ of ME/d for pregnancy and activity (Bell et al., 1995; NRC, 2001).

Before treatment allocation, cows were blocked by age, day of gestation (**DOG**), and BW. On average, DOG was 208 ± 17 d, and BW and age were 526 ± 55 kg and 6 ± 2 yr, respectively. Cows were previously trained to the Calan Gate freestall facility, and all procedures were approved by the Ruakura Animal Ethics Committee. In total, 19, 17, and 17 cows were allocated to the low, medium, and high treatment groups, respectively.

Fresh autumn pasture was cut daily and offered to each cow at 0800 h. Cows had access to the pasture for approximately 7 h, after which they were released onto a neighboring, bare paddock (within 200 m of the feeding facilities) until the following morning. The amount of daily pasture offered and refused was recorded for individual cows, and representative pasture samples were dried in triplicate at 95°C for 48 h to determine DM content. Individual DMI was calculated as pasture DM offered (kg) minus DM refused (kg). A second sample of offered pasture was dried at 60°C for 72 h, ground to pass through a 2.0-mm sieve (Christy Lab Mill, Suffolk, UK), bulked weekly, and analyzed for feed composition and in vitro true DM digestibility (DairyOne, Ithaca, NY). Pasture ME content was estimated from in vitro true DM digestibility: ME = DM digestibility × 0.172 − 1.707 (CSIRO, 2007), as well as determined by near infrared spectroscopy (**NIRS**) at Hills Laboratory (Hamilton, New Zealand). Feed quality values are reported in Table 1.

In all experimental cohorts, individual BCS (Roche et al., 2004; 10-point scale) was recorded once per week by one experienced assessor. Individual BW was recorded once per week in cohorts 1 and 2 and 3 times per week in cohorts 3 and 4 (Gallagher Smart Scale 500, Hamilton, New Zealand). Calf birth weights were also recorded.

Table 1. Mean (±SD) composition (% DM, unless otherwise stated) in fresh autumn pasture

Item	Mean	SD
ME[1] (MJ/kg of DM)	12.4	0.66
ME[2] (MJ/kg of DM)	11.3	0.60
In vitro true digestibility, 24 h	82.0	3.81
CP	21.7	1.68
Crude fat	4.1	0.92
ADF	27.8	3.89
NDF	47.4	5.21
NDF digestibility, 24 h (% of NDF)	61.8	8.19
Lignin	4.9	1.67
Starch	1.2	0.99
Ethanol-soluble carbohydrates	7.8	2.87
Ca	0.7	0.30
P	0.4	0.09
Mg	0.2	0.02
K	3.1	0.38
Na	0.3	0.15
S	0.4	0.07
Fe (mg/kg)	221.0	147.60
Zn (mg/kg)	37.9	7.27
Cu (mg/kg)	7.0	1.02
Mn (mg/kg)	69.9	17.71
Mo (mg/kg)	0.8	0.93
Ash	10.2	1.30
DCAD (mEq/100 g)	31.6	13.05

[1]Estimated using in vitro true digestibility (wet chemistry: DairyOne, Ithaca, NY).

[2]Determined by near infrared spectroscopy.