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Animal performance and production efficiencies of Holstein-Friesian, Jersey and Jersey × Holstein-Friesian cows throughout lactation

R. Prendiville [a,b], K.M. Pierce [b], L. Delaby [c], F. Buckley [a,*]

[a] Teagasc, Animal and Bioscience Research Department, Animal and Grassland and Innovation Centre, Moorepark, Fermoy, Co. Cork, Ireland
[b] School of Agriculture, Food Science & Veterinary Medicine, UCD, Belfield, Dublin 4, Ireland
[c] INRA, UMR 1080, Production du Lait, F-35590 St Gilles, France

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ABSTRACT

The objectives of this study were to examine changes in a number of measures of feed and production efficiency over the course of lactation; to investigate the consistency of breed differences over lactation, to determine the repeatability of each measure over lactation, and to evaluate the impact of the dry period (full lactation cycle) on efficiency measures over an entire lactation cycle. A total of 535 records, from 110 cows, were available for analysis; 37 Holstein-Friesian (HF), 36 Jersey (J) and 37 Jersey × Holstein-Friesian (F_1) cows under pasture based seasonal production systems. Animal measurements included milk production, body weight (BW), body condition score and individual dry matter intake (DMI). Estimates of DMI were available across six stages of lactation and during the subsequent dry period. Breed group had a significant effect on milk yield, fat and protein content, milk solids (MLKS) yield, BW and body condition score. Production efficiency variables included DMI/100 kg BW, MLKS/100 kg BW, net energy intake (NEI)/MLKS, residual feed intake (RFI) and the proportion of energy available for milk production having accounted for maintenance, NEL/(NEI-NEM). Efficiency, in general, tended to be highest in early lactation and declined as lactation progressed. The proportion of energy assigned to milk production NEL/(NEI-NEM) was highest in early lactation. Overall there were few incidences of breed by stage of lactation interactions observed. Repeatability estimates for DMI and efficiency variables were high, comparable in magnitude to that of milk yield. Rank correlations were also high through lactation indicating consistency in relative performance differences among cows across time. Dry matter intakes during the dry period were highest with the HF, intermediate with the F_1 and lowest with the J: 11.9, 10.3 and 9.0 kg/d, respectively. Intake capacity (DMI/100 kg BW) during the dry period was similar across the breed groups. Correlations for DMI, intake capacity and RFI during the lactating vs. non-lactating period were weak to moderate, indicating increased DMI and intake capacity during the lactating period are driven predominately by increased energy requirements for milk production. Consequently, associations between lactation efficiency and total lactation cycle efficiency were high.

1. Introduction

Future low input production systems will be dependent on cows capable of efficiently converting pasture to product (Buckley et al., 2005). Feed or production efficiency is an important measure of both dairy and beef cattle and are already synonymous with some breeding indexes globally (Grainger and Goddard, 2007). Examples include the Australian Profit Ranking index, New Zealand Breeding Worth and the Irish economic breeding index. Unlike growing beef cattle, dairy cows undergo a cycle through lactation; going from rapid metabolism of body reserves immediately post partum to replenishment of reserves in late lactation and during the

* Corresponding author. Animal and Bioscience Research Department, Animal and Grassland Research and Innovation Centre, Teagasc, Moorepark, Fermoy, Co. Cork, Ireland. Tel.: +353 25 42393; fax: +353 25 42340.
E-mail address: frank.buckley@teagasc.ie (F. Buckley).

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non-lactating period (Berry, 2009). Typically, milk production is highest in early lactation resulting in an increase in dry matter intake (**DMI**) coinciding with an abrupt reduction in BW post partum as body reserves are mobilized to meet energy requirements (Shah and Murphy, 2006).

Measurements of feed conversion efficiency (**FCE**) vary greatly across experiments (using gross or net efficiency) but ultimately all efficiency measures relate inputs to outputs. Numerous studies have measured feed efficiency over a short time period (Rastani et al., 2001; Heins et al., 2008) and, in doing so fail to conclusively evaluate the usefulness and consistency of the means of appraising various feed efficiencies or indeed how reflective single measurements are of complete lactation efficiency. Buckley et al. (2007) and Heins et al. (2008) compared feed efficiency between various breeds and across breeds, estimated over short time periods. Both concluded that further investigations incorporating estimates of intake spanning a full lactation were essential to determine if short term measurements were truly representative of relative total lactation efficiency. A review by Grainger and Goddard (2007) comparing Holstein (**H**) and Jersey (**J**) cows across a range of studies identified FCE determined over 365 d as a key 'knowledge gap' warranting attention in future research. Prendiville et al. (2009) obtained estimates of DMI for Holstein-Friesian (**HF**), J and J×HF (**F_1**) cows five times during lactation and provided comparative mean values for a range of feed and production efficiency measures. Results from that study confirmed the superior intake capacity (DMI/100 kg BW) and production efficiency of J compared with HF cows. However, in that study the consistency of performance through lactation and the influence of the non-lactating period on total lactation efficiency were not considered.

Irrespective of the efficiency measure used, measurements should have a high degree of accuracy, have no adverse associations with other economically important traits and be repeatable throughout lactation (Berry, 2009). Repeatable estimates of efficiency measured over different stages of lactation reflect the consistency of the technique and help determine the optimum frequency of recording to reflect lactation performance. There appears to be a lack of information regarding the repeatability of DMI or more particularly feed and production efficiency over lactation. A meta-analysis conducted by Berry et al. (2007) reported repeatability estimates for DMI varying from 0.18-0.57 for cows in pasture based systems. A number of studies, however, have provided estimates of heritability for traits linked to intake and feed efficiency. Heritability provides a lower bound of the magnitude one can expect for repeatability. Heritability estimates for gross efficiency are moderately large, not dissimilar to that of milk yield (Persaud, 1990). Van Arendonk et al. (1991) and Veerkamp et al. (1995) reported heritability estimates of 0.14 and 0.32 for residual feed intake (**RFI**), respectively. More recently, Lopez-Villalobos et al. (2008) also reported heritability estimates for residual net energy intake for dairy cows at pasture (using the n-alkane technique) ranging from 0.08 to 0.38 from 8 to 296 DIM.

Feed and production efficiency is an important functional trait of dairy cows and is of considerable interest to dairy production systems globally. However, be it in indoor or grazing systems, substantial costs are incurred when determining estimates of feed/production efficiency. It is of significant interest to establish the consistency of performance over lactation and similarly determine if a particular period during lactation best reflects efficiency over a lactation cycle.

The objectives of this study were to examine changes in a number of measures of feed and production efficiency over the course of a lactation, to investigate the consistency of breed differences over lactation, to determine the repeatability among various stages of lactation, and also determine the impact of including information from the dry period (full lactation cycle) on efficiency over an entire lactation.

2. Materials and methods

Experimental data were generated at the 'Ballydague' research farm, part of the Teagasc Moorepark Dairy Production Research Center, during 2007. A more detailed description of the experimental animals, animal and sward management, chemical analysis and data collection is provided by Prendiville et al. (2009). Briefly, data were available for 110 cows: 37 HF, 36 J and 37 F_1. Sixteen HF, 10 J and 9 F_1 were first parity animals with the remainder in parity two. Mean calving date for these animals was February 18th. The majority of HF cows were sired by North American HF bulls. Jersey semen was of New Zealand and Danish origin. The F_1 cows were the result of mating J bulls to HF cows.

2.1. Animal Management

Cows were at pasture from early February to mid-November and managed under a rotational grazing system similar to that described by Dillon et al. (1995). Total concentrate supplementation for the year averaged 240 kg DM/cow. Cows resided in paddocks for a 24 h period with fresh pasture allocated each morning. Pre-grazing herbage yields (>4 cm) were maintained around 1400 kg DM/hectare (**DM/ha**) during the year. When necessary, calcined magnesite (Nutribio, Cork, Ireland) was dusted on the paddocks at a rate of 60 g/cow/day to prevent magnesium deficiency. Cows were milked twice daily at 0700 and 1545 h. Concentrate supplementation (when offered) was offered in equal feeds during each milking.

During the non-lactating period, cows were either housed in a conventional shed or randomly assigned to one of three types of out-wintering pad (**OWP**); an uncovered OWP, a covered OWP (both with a concrete feed face) or an uncovered OWP with a self-feed silage pit, as described by O'Driscoll et al. (2008). All animals were offered grass silage *ad libitum* and dry cow minerals at a rate of 100 g/cow/day.

2.2. Cow Measurements

Milk yield was recorded daily using electronic milk meters (Dairymaster, Causeway, Co. Kerry, Ireland) with milk constituents determined from successive morning and evening samples of milk taken weekly using a Milkoscan 203 (Foss Electric, DK-3400 Hillerød, Denmark).

Individual DMI measurements were carried out using the n-alkane technique, (Mayes et al., 1986) as modified by Dillon (1993), on each cow 5 times during lactation (with the exception of 10 late calving cows which had only 4 measurements during lactation and 5 cows in late lactation). This provided a total of 535 records and once during the