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BRIEF COMMUNICATION: Variation in feed conversion efficiency in Holstein-Friesian heifer calves

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INTRODUCTION

Feed conversion efficiency (FCE) is a measure of an animal's ability to convert feed into product and is a major determinant of profitability in livestock production. This study evaluated two determinants of FCE in Holstein-Friesian heifer calves, growth rate and residual feed intake (RFI).

The improvement in FCE, measured as feed intake per unit of liveweight gain (kg/kg), associated with increased growth rate is well known (see Archer *et al.*, 1999). It is measured when the energy costs of maintenance are relatively small compared to the energy intake that is partitioned into growth of animal tissues or lactation. This aspect of FCE may be captured in part through genetic improvement, notably in beef cattle, but less so in dairy breeds where selection on growth traits is not usually an objective.

RFI, measured as actual feed intake less predicted feed intake, is a phenotype that also contributes to FCE and is independent of production effects on FCE. RFI is usually determined as a residual from a multiple regression of dry matter (DM) intake on growth rate and live weight (Hegarty *et al.*, 2007). Monogastric species have been selected for RFI for many years but difficulties in accurate measurement of feed intake and live weight have delayed application in ruminants. RFI accounts for a portion of FCE over and above that related to growth rate in beef cattle and many studies have now validated the concept of RFI in growing beef cattle (see Herd *et al.*, 2004). In dairy cattle, there are similar data showing differences in RFI in growing animals (Nieuwhof *et al.*, 1992) but there is limited understanding of whether lactating animals exhibit this trait, largely because measurement of RFI requires accurate measurement of feed intake, liveweight change and milk production, over several weeks (Van Arendonk *et al.*, 1991; Lopez-Villalobos *et al.*, 2008). In the study of Nieuwhof *et al.* (1992) a genetic correlation between RFI of growing heifers and lactating heifers of 0.58 was determined, suggesting an association of RFI during growth on lifetime feed efficiency.

Genetic variation has been identified for feed efficiency traits. Arthur *et al.* (2001) showed genetic variation in RFI in beef cattle, and in growing dairy animals heritability estimates for RFI range from 0.00 to 0.38 (McNaughton & Pryce, 2007). The genetic relationships that exist between RFI, meat quality and other composition traits for beef cattle have been described (Herd *et al.*, 2003) and a relationship between RFI and methane production has also been demonstrated (Hegarty *et al.*, 2007).

The objective of the present study was to understand the relative contribution of RFI and growth rate to FCE in growing dairy cattle and, ultimately, the genetic and phenotypic relationships between efficiency traits in the growing animal and FCE in lactation.

MATERIALS AND METHODS

One hundred and fifty nine Holstein-Friesian heifer calves, with an expected breeding worth of between 180 and 200, were purchased from farms in the upper North Island as the first of a three-cohort study with 1,000 animals. Calves were reared on milk and concentrates to achieve a target weight of 95 kg before transfer at approximately 26 weeks of age to an outdoor facility at the Westpac Taranaki Agriculture Trust farm in Hawera, managed by DairyNZ.

The facility consists of 28 pens. Each pen was 42m² in area with post peelings for bedding, and contained a single enclosed feeding station so that only one animal could feed at a time. Each pen held eight heifers, all with electronic ear tags enabling individual identification when eating. The feeding station comprised a feed bin located on two load bars, with bin weights (SmartScale 300 weigh scale: Gallagher Ltd., Hamilton, New Zealand) measured 50 times a second and an average weight recorded each second. The feed bin was filled with lucerne cubes (Kapt-al, Vancouver, Canada). On entering the feeding station, the electronic identification tag was scanned (SmartReader R600 panel reader: Gallagher Ltd., Hamilton, New Zealand) and feed intake determined over the period the animal was eating for each feeding bout. Data were summed to determine daily intake and the number and duration

of feeding sessions were also recorded. Individual daily feed intakes and live weight, measured three times weekly, were recorded over the last 42 days of the trial, following a 50 day acclimatisation/testing period. Other work on statistical evaluation has been undertaken indicating that the optimum test length for RFI measurements is 70 days when live weight measurements are made every 14 days (Archer *et al.*, 1997). In simulation studies, we established that the standard error of the regression of live weight on time was similar in heifers weighed thrice weekly for 42 days or once every two weeks for 70 days.

RFI was measured by multiple regression of DM intake on growth rate (GR) (kg/d) and mean metabolic live weight ($LW^{0.75}$) ($kg^{0.75}$). The equation generated was Intake (kg/d) = 1.44 GR + 0.19 LW - 3.4 ($R^2 = 0.61$).

RFI was determined as the residuals from the regression, expressed as kg DM/d.

RESULTS AND DISCUSSION

The relationship between FCE and growth rate (kg/d) is shown in Figure 1. Growth rate ranged from 0.35 to 1.2 kg/d (0.89 ± 0.01 (Mean \pm SEM) (kg/d)). The mean feed intake of the group of animals over the 42 days of the trial was 9.1 ± 0.1 kg/d FCE, ranging from 8 to 22 kg DM/kg gain, with the majority of animals falling between 8 and 14 kg DM/kg gain. FCE was higher in faster growing animals with growth rate explaining over half (55%) of the variation in FCE. However, at any given growth rate, there was still variation in FCE (see Figure 1) of about 3 to 4 kg feed per kg gain.

RFI determined from the multiple regression is shown in Figure 2. The standard deviation was 0.54 with a range in RFI values from -2.25 kg DM/d (most efficient) up to +1.5 kg DM/d (least efficient). Animals that were more efficient ate less than predicted and, therefore, had a negative RFI. RFI explained 21% of the variation in FCE. In combination, RFI and growth rate explained 67% of the variation in FCE.

Growth rate and RFI are both heritable traits, however the physiological basis of RFI is poorly understood. Possibilities include variation in digestive ability, visceral/carcass mass ratios, metabolic differences in heat generating pathways such as protein turnover and variation in maintenance energy requirements per unit live weight (Archer *et al.*, 1999). If RFI is associated with variation in maintenance energy expenditure then it suggests that RFI may be a lifetime trait, functioning during both growth and lactation phases, as indicated by the results of Nieuwhof *et al.* (1992).

FIGURE 1: Feed conversion efficiency; feed per unit gain (kg DM/kg) versus growth rate (kg/d) in 159 young Holstein-Friesian heifers over a 42-day period.

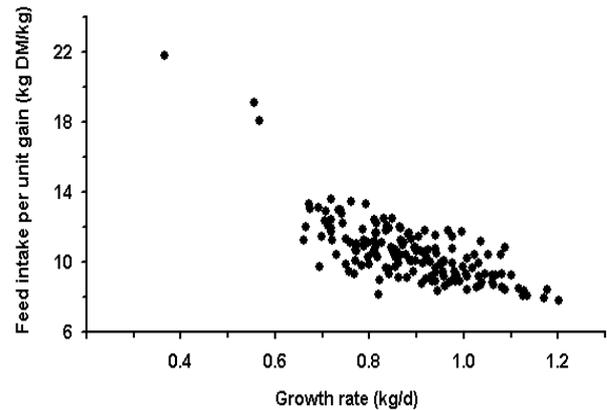
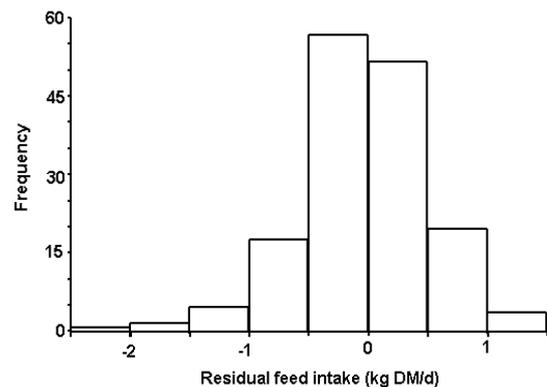


FIGURE 2: Distribution of residual feed intake values (kg DM/d) determined from multiple regression of feed intake on growth rate and live weight, in 159 young Holstein-Friesian heifers over a 42-day period.



In conclusion, there was marked variation in FCE associated with growth and RFI in Holstein-Friesian heifer calves. Given that the growth phase of dairy cows is about one-third of their lifespan, there is economic merit in attempting to capture improved FCE during heifer rearing through the genetics underpinning growth rate and RFI. Quantification of genetic correlations between growth rate, RFI, lactation performance and reproduction traits is also required.

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