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Dairy cow breed interacts with stocking rate in temperate pasture-based dairy production systems[1]

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ABSTRACT

Economic optimum stocking rates for grazing dairy systems have been defined by accounting for the pasture production potential of the farm [t of dry matter (DM)/ha], the amount of feed imported from outside the farm (t of DM/ha), and the size of the cow (kg). These variables were combined into the comparative stocking rate [CSR; kg of body weight (BW)/t of feed DM available] measure. However, CSR assumes no effect of cow genetics beyond BW, and there is increasing evidence of within-breed differences in residual feed intake and between-breed differences in the gross efficiency with which cows use metabolizable energy for milk production. A multiyear production system experiment was established to determine whether Jersey (J) and Holstein-Friesian (HF) breeds performed similarly at the same CSR. Fifty-nine J cows and 51 HF cows were randomly allocated to 1 of 2 CSR in a 2 × 2 factorial arrangement; systems were designed to have a CSR of either 80 or 100 kg of BW/t of feed DM (J-CSR80, J-CSR100, HF-CSR80, and HF-CSR100 treatment groups). Data were analyzed for consistency of farmlet response over years using ANOVA procedures, with year and farmlet as fixed effects and the interaction of farmlet with year as a random effect. The collated biological data and financial data extracted from a national economic database were used to model the financial performance for the different breed and CSR treatments. On average, annual and individual season pasture DM production was greater for the J farmlets and was less in the CSR100 treatment; however, the effect of CSR was primarily driven by a large decline in pasture DM production in the HF-CSR100 treatment (breed × CSR interaction). This interaction in feed availability resulted in a breed × CSR interaction for the per-cow and per-hectare milk production variables, with HF cows producing more milk and milk components per cow in the CSR80 treatment but the same amount as the J cows in the CSR100 treatment. On a per-hectare basis, HF cows produced the same amount of 4% fat-corrected milk and lactose as J cows in the CSR80 treatment, but less fat; at CSR100, J cows produced more 4% fat-corrected milk, fat, and protein per hectare than HF cows. Our results support a greater gross efficiency for use of metabolizable energy by the J cow; 11% less total metabolizable energy was required to produce 1 kg of fat and protein at a system level. Economic modeling indicated that profitability of both breeds was less at CSR100, but the decline in profitability with increasing stocking rate was much greater in the HF breed. Holstein-Friesian cows were more profitable at CSR80 but were less profitable at CSR100.
Key words: grazing, economics, energy-use efficiency

INTRODUCTION

There is irrefutable evidence that animal agriculture has increased in resource-use efficiency over the last 75 yr (Macdonald et al., 2008b; Capper et al., 2009; Roche et al., 2017a). Nevertheless, the requirement for food is predicted to increase by a further 75 to 100% over the next 35 yr (FAO, 2009; Godfray et al., 2010); this will increase the pressure on food production systems to become even more efficient. A significant portion of the historical increase in efficiency was a result of genetic selection for production-related traits. For example, Capper et al. (2009) reported that only 21% of cows are required today compared with 1944 to produce the same volume of milk. Similarly, Macdonald et al. (2008b) reported that genetic improvements within the Holstein-Friesian (**HF**) breed resulted in a 16% increase in milk yield, a 21% increase in milk fat production, and a 26% increase in milk protein between 1970 and 2000, with only a 2% increase in maintenance requirements. This improvement in production efficiency is

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particularly important in temperate grazing systems, as cow DMI is limited by time to graze and not the physical capacity of the cow (Sheahan et al., 2011).

Cow breed has also been reported to affect feed conversion efficiency (**FCE**) in grazing systems. For example, Prendiville et al. (2009) reported that Jersey (**J**) cows required 7 to 8% less total feed for every kilogram of milk fat and protein produced in a pasture-based dairy production system compared with HF cows. This is consistent with the reported differences in the mass of the gastrointestinal tract (i.e., 24% lighter in J cows; Beecher et al., 2014), a 2 to 3% greater digestibility of DM and NDF by J cows (Beecher et al., 2014), and the greater use of consumed ME for productive purposes by the J cow (L'Huillier et al., 1988) compared with HF cows. The improvement in the efficiency of ME use, however, was apparent only in a grazing environment with restricted DMI, where J cows produced 20% more milk/kg of DMI (L'Huillier et al., 1988); under ad libitum feeding, this ME conversion gain disappeared. This genetics × environment interaction was also reported by Bryant et al. (2006) when they identified that the milk production superiority of HF cows over J cows was greater in higher milk production environments, an indicator of higher feed allowances.

Based on their superior FCE, it would appear that in grazing systems, where DMI limits production (Kolver and Muller, 1998), the J may have a production efficiency advantage over HF due to their smaller size and less total maintenance requirement per cow. In almost all comparisons, however, the J cows produced less milk. Therefore, more J cows would be required for the equivalent per-hectare milk production of the HF. As between 50 and 60% of costs in a grazing system are associated with individual cows (Macdonald et al., 2011), having more J cows to produce the same volume of milk may negatively affect farm profitability, even if a greater proportion of consumed ME is partitioned to milk production. Nevertheless, the reported interaction between breed and FCE (L'Huillier et al., 1988) might indicate an advantage for J cows in farming systems that limit feed allowance per cow (e.g., high stocking rate; Macdonald et al., 2008a) and HF cows in production systems that provide a greater feed allowance per cow. To test this hypothesis, J and HF cows were compared in pasture-based systems over multiple lactations at either moderate or high stocking rates.

MATERIALS AND METHODS

The experiment was conducted over 3 lactations at No. 2 Dairy, DairyNZ (Hamilton, New Zealand; 37°47′ S, 175°19′ E, 40 m above sea level), between 1990 and 1993. However, based on recent component-study publications, it was deemed that the data were sufficiently relevant and important to present in a scientific journal. The permanent grassland area had pastures of predominantly ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens* L.), with evenly distributed soil type, specifically a Te Rapa peaty silt loam soil (known as a Humic Aquic Haplorthod in soil taxonomy or a Humose Groundwater-Gley Podzol in the New Zealand classification).

Experimental Design and Treatments

Fifty-nine J cows and 51 HF cows were randomly allocated to 1 of 2 comparative stocking rates (**CSR**; calculated as kg of BW/t of feed DM allowance; Macdonald et al., 2008a) in a 2 × 2 factorial arrangement; systems were designed to have a CSR of either 80 or 100 kg of BW/t of feed DM. This resulted in the **J-CSR80**, **J-CSR100**, **HF-CSR80**, and **HF-CSR100** treatment groups. Comparative stocking rate is a more complete measure of stocking rate than feed allowance per cow because it accounts for the number of cows per hectare (i.e., stocking rate), the BW of the cow (i.e., as a proxy for milk production potential), the pasture producing potential of the farm (t of pasture DM/ha), the amount of supplement imported from off the farm (t of DM/ha), and whether replacement stock are reared on the farm or on land remote from the milking platform (Macdonald et al., 2008a). From a profitability perspective, optimum CSR for grazing dairy systems with HF cows was reported to be 75 to 80 kg of BW/t of feed DM (Macdonald et al., 2011). Because of the different BW of J and HF cows, the number of cows was greater in the J treatment to ensure the same CSR as the HF treatment.

Historically, average pasture production on the experimental farm was 16.5 t of DM/ha (Macdonald et al., 2017) and cow BW was 360 and 420 kg of BW for J and HF cows, respectively (mid-lactation BW). To create the 80 and 100 kg of BW/t of feed DM CSR treatments for both breeds, J cows were managed at stocking rates of 3.6 and 4.5 cows/ha (26 and 33 cows, respectively), and HF cows were managed at 3.0 and 4.0 cows/ha (22 and 29 cows, respectively). This equated to 1,285, 1,631, 1,268, and 1,670 kg of BW/ha for the J-CSR80, J-CSR100, HF-CSR80, and HF-CSR100 treatment groups, respectively, and an expected feed allowance of 4.6 t of DM, 3.7 t of DM, 5.5 t of DM, and 4.1 t of pasture DM/cow in each of the 4 treatments, respectively.

The cows were selected from the research farm herd so that the genetic merit of the breeds was as similar as possible. Estimated breeding values and the genetic merit of the cows were recalculated in the most re-