J. Dairy Sci. 99:5681–5689
http://dx.doi.org/10.3168/jds.2015-10530

Milk production and fertility performance of Holstein, Friesian, and Jersey purebred cows and their respective crosses in seasonal-calving commercial farms

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ABSTRACT

There is renewed interest in dairy cow crossbreeding in Ireland as a means to further augment productivity and profitability. The objective of the present study was to compare milk production and fertility performance for Holstein, Friesian, and Jersey purebred cows, and their respective crosses in 40 Irish spring-calving commercial dairy herds from the years 2008 to 2012. Data on 24,279 lactations from 11,808 cows were available. The relationship between breed proportion, as well as heterosis and recombination coefficients with performance, was quantified within a mixed model framework that also contained the fixed effects of parity; cow and contemporary group of herd-year-season of calving were both included as random effects in the mixed model. Breed proportion was associated with all milk production parameters investigated. Milk yield was greatest for Holstein (5,217 kg), intermediate for Friesian (4,591 kg), and least for Jersey (4,230 kg), whereas milk constituents (i.e., fat and protein concentration) were greatest for Jersey (9.38%), intermediate for Friesian (7.91%), and least for Holstein (7.75%). Yield of milk solids in crossbred cows exceeded their respective parental average performance; greatest milk solids yield (i.e., fat kg + protein kg) was observed in the Holstein × Jersey first-cross, yielding 25 kg more than the mid-parent mean. There was no consistent breed effect on the reproductive traits investigated. Relative to the mid-parent mean, Holstein × Jersey cows calved younger as heifers and had a shorter calving interval. Friesian × Jersey first-cross cows also had a shorter calving interval relative to their mid-parent mean. Results were consistent with findings from smaller-scale controlled experiments. Breed complementarity and heterosis attainable from crossbreeding resulted in superior animal performance and, consequently, greater expected profitability in crossbred cows compared with their respective purebreds.

Key words: crossbreeding, Jersey, heterosis, Holstein, Friesian

INTRODUCTION

The process of producing more food while reducing environmental impact has become a global challenge and requires what has been referred to as "sustainable intensification" (Pretty, 1997) of global agricultural production. In this context, there is an increasing appreciation of the multifunctional characteristics and benefits of grassland farming (Jeangros and Thomet, 2004; Baumont et al., 2014; Taube et al., 2014) and previous studies have highlighted the potential for highly productive and environmentally benign grass-based milk production (Lyons et al., 2008; Peyraud et al., 2010; McCarthy et al., 2015). Although a diverse range of grazing systems are practiced internationally, many of which are economically competitive across a wide range of countries and climatic conditions (Soder and Rotz, 2001; Dillon et al., 2005; Roche et al., 2009), such systems represent only a small minority of global milk production (~10%; Steinfeld and Maki-Hokkonen, 1995). Furthermore, the biological and financial efficiency of milk production in predominantly grazing systems, such as those practiced in Ireland (where grazed pasture is the primary source of nutrients), is uniquely dependent on an integrated seasonal production model. A wide variety of factors such as stocking rate (McCarthy et al., 2013), concentrate supplementation rate (Kennedy et al., 2003), and animal genetic merit (McCarthy et al., 2007; Macdonald et al., 2008) affect grazing system performance.

The selection of appropriate animals for grazing systems is uniquely complicated by the elevated importance of reproductive performance in such systems to calve compactly at the beginning of the grass-growing

Received October 15, 2015.
Accepted March 15, 2016.
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season thereby having abundant high-quality pasture in early lactation and during rebreeding (O'Mara, 2008; Washburn and Mullen, 2014). To achieve this objective, the national economic breeding index (**EBI**) was developed in 2001 and reflects the profit per lactation of progeny within Irish dairy systems (Berry et al., 2014; Ramsbottom et al., 2015). The EBI currently includes 18 traits and the relative emphases on milk production and reproductive performance traits are 33 and 35%, respectively (Berry et al., 2014). In both controlled (Coleman et al., 2010) and commercial (Ramsbottom et al., 2012) evaluations, greater EBI has been associated with increased farm profitability compared with animals of lower EBI by virtue of increased productivity and improved reproductive performance. Previous studies both in experimental herds in Ireland (Buckley et al., 2007; Prendiville et al., 2009; Vance et al., 2012) and within larger population studies internationally (Falconer et al., 1996; Lopez-Villalobos et al., 2000a; Lopez-Villalobos and Garrick, 2002; Grainger and Goddard, 2004; Buckley et al., 2014) have demonstrated additional benefits of crossbreeding on animal performance and financial efficiency by exploiting both additive and nonadditive genetic effects (Ahlborn-Breier and Hohenboken, 1991). However, the extent of dairy crossbreeding on commercial farms in Ireland remains low, with crossbred cows accounting for just 5.2% of the Irish national dairy herd (Department of Agriculture, 2014).

The objective of the present study was to compare the biological performance of Holstein, Friesian, and Jersey purebred cows and Holstein × Jersey and Friesian × Jersey crossbred cows using a large data set of 40 commercial dairy herds practicing crossbreeding in Ireland over a 5-yr period. Results from this large study will be useful for dairy producers to evaluate the potential of crossbreeding strategies to maximize production efficiency and profitability within grass-based systems in the future.

MATERIALS AND METHODS

Information from the Irish Cattle Breeding Federation database on 11,808 cows from 40 spring-calving dairy herds that adopted crossbreeding between Holstein, Friesian and Jersey breeds for each of the years 2008 to 2012 inclusive were available. A spring-calving dairy herd was defined as a herd in which >80% of cows calved between January 1 and May 31 in each year of the study and represents the predominant herd type in Ireland (Berry et al., 2013). Thirty-nine of the herds contained some purebred Holstein-Friesian cows, and 5 of the herds contained some purebred Jersey cows; all herds contained Holstein-Friesian × Jersey crossbred cows. The number of cows, number of lactations, and average parity of each breed and cross are in Table 1. The cows included in the study were of high total genetic merit, with an average EBI of €159. Available data included milk production lactation performance [i.e., milk yield (kg), fat yield (kg), protein yield (kg), and SCC], date of birth, calving date, parity, service dates, and pregnancy diagnosis.

Table 1. Number of cows and lactation records and average parity for the different breeds and crosses used in the present study

Breed[1]	Cows	Lactations	Parity
HO	1,091	2,413	3.07
FR	16	53	2.91
JE	409	1,022	3.58
HO×FR	108	247	3.74
HO×JE	883	2,241	3.30
FR×JE	18	50	2.94
HO × HO×FR	3,951	8,716	3.08
FR × HO×FR	303	762	3.44
HO × HO×JE	3,757	8,427	2.96
JE × HO×JE	1,967	4,871	3.31
FR × FR×JE	52	138	2.89
JE × FR×JE	861	2,145	3.53
HO×FR × HO×FR	3,941	8,929	3.09
HO×JE × HO×JE	3,394	7,707	2.95
FR×JE × FR×JE	471	1,169	3.46

[1]HO = Holstein, FR = Friesian, JE = Jersey, HO×FR = Holstein-Friesian first-cross, HO×JE = Holstein-Jersey first-cross, FR×JE = Friesian-Jersey first-cross, HO × HO×FR = HO sire × HO×FR dam, FR × HO×FR = FR sire × HO×FR dam, HO × HO×JE = HO sire × HO×JE dam, JE × HO×JE = JE sire × HO×JE dam, FR × FR×JE = FR sire × FR×JE dam, JE × FR×JE = JE sire × FR×JE dam; a purebred animal was deemed to be ≥87.5% of the breed.

Milk Production

Data consisted of 305-d milk production yield (i.e., milk kg, fat kg, protein kg, and SCC) on 24,279 lactations from 10,593 cows. Obvious data errors were removed. Milk volume yields <2,000 or >12,000 kg were discarded. Milk fat yields or milk protein yields <100 and >500 kg were also discarded. Somatic cell count <1,000 or >999,000 cells/mL were discarded; SCC was transformed to SCS using the logarithm to the base 10.

Fertility

Calving dates of 24,706 lactations from 10,625 cows were available. A total of 70,645 service dates were also available. Age at first calving was defined as the age at which heifers first calved; only age at first calving records between 550 and 1,250 d were retained. Calving to first service interval was defined for all cows as the number of days from calving to first service; only calving to first service records between 10 and 250 d were retained. The start of a herd's calving season