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Genetic and environmental effects on early growth and performance in purebred Holstein, Jersey, and reciprocal crossbred calves

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ABSTRACT

For this designed experiment, Holstein × Holstein (n = 28), Jersey × Jersey (n = 10), Holstein × Jersey (n = 15), and Jersey × Holstein (n = 15) bull and heifer calves were compared for body weight (BW), dry matter intake, feed efficiency, hip height, BW gain to 42 and 56 d, and days to weaning from birth to 8 wk. All traits were examined for purebred, maternal, and heterotic genetic effects. Purebred genetic effects significantly favored the Holstein breed for BW, dry matter intake, hip height, and BW gain to 42 and 56 d. Heterotic genetic effects were present for dry matter intake and hip height. Calf sex affected BW and BW gain to 56 d. Our results indicate that early calf growth is influenced primarily by purebred effects favoring the Holstein breed and to a lesser extent heterosis.
Key words: crossbreeding, dairy calf, growth

INTRODUCTION

Crossbreeding in the commercial dairy industry is gaining popularity as producers try to maximize longevity, health, and economic efficiency of cows in their herds (Weigel and Barlass, 2003). Improved understanding of growth and performance of crossbred dairy calves may help producers use crossbreds more efficiently in commercial dairy systems. The economic benefits of using crossbreds in dairy systems are well documented (Touchberry, 1992; McAllister et al., 1994; Lesmeister et al., 2000; Lopez-Villalobos et al., 2000; Sørensen et al., 2008; Buckley et al., 2014), as are growth and performance traits for pureline and crossline animals (Batra and Touchberry, 1974; McDowell, 1982; Lee et al., 1988; Heins et al., 2008; Olson et al., 2009). A potential economic benefit of crossbreeding is earlier weaning because it allows producers to decrease labor costs and may aid in lowering feed costs (Davis and Drackley, 1998; Kehoe et al., 2007). Growth rates influence time of weaning, age at first calving (Heinrichs and Swartz, 1990; Cady and Smith, 1996), and subsequent milk production (Virtala et al., 1996). Whereas many of these studies focused on growth and performance traits for calves 3 mo of age and older, little is known about the very early growth and performance of purebred calves compared with crossbred calves. The objectives of this designed experiment were to compare growth and performance traits of purebred Jersey and Holstein calves with Holstein × Jersey and Jersey × Holstein F_1 crossbred calves from birth to 8 wk and estimate the purebred, maternal, and heterotic genetic effects on those traits.

MATERIALS AND METHODS

Animals

From January 2003 to January 2004, purebred Holstein and Jersey nulliparous heifers and primiparous and multiparous cows from the University of Kentucky research dairy herd were inseminated using heterospermic semen (Select Sires Inc., Plain City, OH) as part of a large, multiherd designed experiment (Olson et al., 2009). Straw composition was 50% Holstein semen and 50% Jersey semen from 4 Holstein and 4 Jersey bulls (Table 1), allowing for equal opportunity of fertilization (Kasimanickam et al., 2006). Holstein and Jersey bulls were chosen with the following criteria: (a) they were alive and producing semen; (b) the 4 sires chosen from each breed were in the top 50% of active AI sires for net merit at the time of selection in 2001, endeavoring to choose one bull each from the 90th, 80th, 70th, and 60th rank percentiles; and (c) the bulls chosen should be as unrelated to each other as was possible so that inbreeding in the pure genetic lines would not favor either breed. Matings were made to avoid close relationships between the purebred bulls and the purebred Holstein and Jersey cows to which they were mated. Females were randomly assigned to be inseminated with 1 of

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the 16 heterospermic combinations, except for avoidance of significant inbreeding of potential offspring. Approximately 1 wk before expected parturition, or as indicated by a drop in serum protein concentration and visual appraisal, a Foal Alert system (Foalert Inc., Acworth, GA) transmitter was attached to the vulva of each cow. The Foal Alert system notified researchers of the imminent birth of a calf. From November 2003 to December 2004, 68 bull and heifer calves born to cows inseminated using heterospermic semen were used with genetic groups representing purebred Holstein (n = 28, representing all 4 Holstein sires), Holstein × Jersey (n = 15, representing all 4 Holstein sires), Jersey × Holstein (n = 15, representing all 4 Jersey sires), and purebred Jersey (n = 10, representing 3 Jersey sires). The number of progeny by sire (Table 1) showed that all 4 Holstein sires had progeny in both the purebred Holstein and Holstein × Jersey groups and all 4 Jersey sires had progeny in the Jersey × Holstein group. Three Jersey sires had progeny in the purebred Jersey group. Only one Jersey sire had a single progeny, that being in the Jersey × Holstein group.

All experimental procedures followed University of Kentucky Institutional Animal Care and Use Committee guidelines. Newborn calves were removed from their dam immediately after birth to prevent maternal suckling and were weighed. To determine amount of colostrum needed, BW was recorded and rounded to the nearest 4.5-kg increment. Colostrum was fed at 5% of rounded BW within 3 h of birth. The colostrum used for this study was collected from all herd females that calved before and during the trial and tested for quality using a colostrometer. Colostrum with specific gravity greater than 60 mg of Ig per milliliter was used to create pooled lots. Lots of pooled colostrum (n = 6) were frozen at −20°C until feeding, at which time colostrum was warmed to at least 26.7°C. Twelve hours later, a second feeding of colostrum was again given at 5% of rounded birth BW. Because individual calves were fed from pooled lots of colostrum without regard to breed of contributing female, the effect of quality of colostrum on the calf performance traits measured did not reflect the maternal genetic differences of Holstein and Jersey dams.

Table 1. List of sires used in heterospermic semen combinations and the resulting number of progeny for each breed group

Breed and designation	Sire short name[1]	No. of progeny for each sire[2]			
		HH	HJ	JH	JJ
Holstein					
H1	Jasper	9	3	0	0
H2	Cooper	4	6	0	0
H3	Breton	1	2	0	0
H4	Dane	14	4	0	0
Jersey					
J1	Freedom	0	0	6	4
J2	Paramount	0	0	1	0
J3	Parade	0	0	3	1
J4	Elevation	0	0	5	5

[1]As given in Olson et al. (2009; Table 4).

[2]HH = purebred Holstein; HJ = Holstein × Jersey; JH = Jersey × Holstein; JJ = purebred Jersey.

Beginning at 24 h of age, calves were moved to individual hutches and fed whole milk at 5% of rounded BW twice daily. Calves leaving greater than 0.47 L of colostrum or milk were fed via an esophageal feeder. Water and a starter ration were provided beginning at 3 d of age. Calves were weighed weekly, and the amount of milk fed daily was adjusted to 10% of calf rounded BW through 3 wk of age. Calf weaning occurred once intake of starter ration was equal to or greater than 1% of BW for 3 d consecutively, and days to weaning (**DWN**) was recorded as the age of the calf in days when this occurred.

Fecal scores were based on the method of Larson et al. (1977) and obtained daily through 6 wk to determine general level of health. Scores were ranked on a 1-to-4 scale with normal receiving a score of 1 and severe scouring a 4. When fecal material was not present on a given day, an average was taken of the preceding and following days. Calves with fecal scores of 3 were fed electrolytes once daily (1.9 L), whereas calves with fecal scores of 4 were fed electrolytes twice daily (Merrick's Inc., Middleton, WI). Normal milk feeding continued during electrolyte supplementation.

Sample Collection and Analysis

Weekly BW (kg), milk intake (kg), and grain intake (kg) were measured through 8 wk. Dry matter was calculated as 13% of milk intake and 89% of grain intake. Growth measures BW gain to 42 and 56 d (**G42** and **G56**, respectively), weekly DMI and feed efficiency (**FE**) were calculated. Feed efficiency was defined as weekly BW gain divided by weekly DMI. Hip heights (cm) were obtained within 48 h of birth and again at 6 wk of age.

Statistical Analysis

Data were analyzed as a randomized incomplete split-plot design (Littell et al., 1996). All analyses were conducted using the PROC GLM or MIXED procedures in SAS (v. 9.0, SAS Institute Inc., Cary, NC). Dependent variables were analyzed using PROC MIXED when repeated measures for a response variable were present (e.g., BW, DMI, FE, and hip height). For mixed models, calf represented the random effect and day was