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Article

Low Birthweight Beef Bulls Compared with Jersey Bulls Do Not Impact First Lactation and Rebreeding of First-Calving Dairy Heifers—A Case Study in New Zealand

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Abstract: Dairy heifers in New Zealand are typically naturally mated by Jersey bulls to produce low-value non-replacement offspring sold for slaughter a few days after birth. Producing a beef-sired calf from a dairy heifer will increase the value of these calves for beef production but may compromise the subsequent career of the animals, in terms of milk production, rebreeding success, health, or survival of the heifer. This study aimed to determine the impact of low birthweight Angus and Hereford bulls versus breed-average Jersey bulls on the reproduction and production traits of first-calving dairy heifers. The experiment included 304 heifer-calf pairs over 2 years. Calves sired by Angus and Hereford bulls were 3.5–4.4 kg and 3.7–6.8 kg heavier than Jersey-sired calves and had a 4.2% and 9.3% incidence of assistance at birth for normally presented calves over the 2 years, respectively. No normally presented Jersey-sired calves were assisted. There was no difference in body condition score, pre-calving live weight, milk production, pregnancy rate, inter-calving interval, re-calving day, and 21-day re-calving rate of heifers mated to the different breeds of bulls. The results indicate that the Angus and Hereford bulls with low birthweight and high direct calving ease estimated breeding values (EBV) can be used to produce calves of greater value than Jersey-sired calves without impacting dairy heifer production. However, a small increase in assistance at calving could be expected.

Keywords: Angus; birth weight; calving; dairy-beef; beef-on-dairy; heifer; Hereford; Jersey; milk production; rebreeding

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1. Introduction

The production of beef from calves born in the dairy industry has been identified as a useful strategy to reduce methane emissions from beef cattle in New Zealand [1]. However, dairy farmers need more information regarding the impact of beef bulls on their dairy cows before adopting the increased use of beef semen in dairy herds. In New Zealand, dairy farms and beef farms are typically stand-alone businesses, allowing beef farmers little influence on decisions made on dairy farms, other than through variation in the price paid for surplus calves sold for rearing. Beef-cross-dairy calves sold for rearing are currently worth around NZD 150 to NZD 200 compared to only NZD 25 for Jersey-sired calves sold for slaughter [2].

Holstein–Friesian–Jersey-crossbred cows are the most prevalent cow type in New Zealand. Dairy farms operate pasture-based systems where the milking herd is grazed on high-cost, high-producing pastureland, and replacement heifers are grazed elsewhere, on lower-cost land that often has limited infrastructure and accessibility to the heifers. This limited accessibility to the heifers means that the artificial breeding of 15-month-old heifers is often impractical. Thus, bulls are used to naturally mate these heifers with the objective of initiating lactation without intending to retain daughters for herd replacements. The seasonal calving pattern requires heifers to calve at 22–24 months of age [3,4], when they are still growing, and their smaller size puts them at increased risk of dystocia. Jersey bulls are commonly used to ensure an easy calving for these primiparous animals [5,6]. The resulting Jersey-sired calves are not suitable as replacements because they are not sired by high-merit dairy bulls and are not suitable for beef production because they have low potential for growth. Instead, these calves are processed (slaughtered) within 14 days of age and are estimated to comprise almost half of the 1.7 million calves processed in New Zealand each year [6–9]. Calves born to first-calving heifers present the greatest challenge in terms of addressing consumer concerns about the practice of slaughtering young calves and the greatest opportunity in terms of increasing the production of beef from dairy-origin calves to address the methane reduction targets for New Zealand. Alternative options besides Jersey bulls for breeding first-calving dairy heifers should be explored.

The income from calf sales makes up only around 5% of the income on a dairy farm in New Zealand. The sale of milk is the primary source of income, and the impact of any changes in management on milk production is of primary importance to the profitability of the farm. New Zealand's seasonal, pasture-based dairy system requires heifers to rebreed at around 27 months of age to remain in the herd for a subsequent calving. Ensuring high reproductive success at the second mating of heifers with a dairy breed bull (usually via artificial breeding) is also important to produce superior genetic merit replacement calves to improve herd genetics [9]. However, there is a high wastage of dairy heifers due to low rebreeding success [10,11], which is typically associated with heifers not being fully grown [4,9,12–15]. In addition, difficult calving is known to have negative follow-on effects on rebreeding performance and milk production [14–20]. Therefore, increases in calving difficulty or impacts on rebreeding or milk production from using beef bulls over dairy heifers could easily outweigh the increased value of the calf.

Angus and Hereford are the most common beef breeds in New Zealand [21], and recorded bulls from these breeds have performance-based estimated breeding values (EBV) published by BreedPlan [22]. Beef bulls with lighter birthweight EBV and greater direct calving ease EBV could be selected for use over dairy heifers, which allow an increased production of calves suitable for rearing for beef production whilst managing the risk of calving difficulty. However, the impact of such bulls on the milk production and rebreeding of the heifers should be quantified to allow informed decisions regarding the impact on the dairy farm from using such bulls.

The aim of this study was to determine the impact of low birthweight EBV Angus and Hereford bulls compared with Jersey bulls on the birth weight of calves, and the reproduction and production traits of first calving Holstein–Friesian–Jersey-crossbred heifers.

2. Materials and Methods

This study was conducted at Limestone Downs dairy farm, 16 km south of Port Waikato, New Zealand (latitude: 37.49 S, longitude: 174.77 E). The study and all handling procedures were approved by the Massey University Animal Ethics Committee (15/65). Animal management and sampling methodology were the same as those described previously by Coleman [23,24], who reported on sire effects for mixed-aged cows and their progeny in the same herd.

2.1. Animals

This case study included 304 first-calving heifers and their singleton calves born in the spring of two consecutive years (Y1 = 2016, n = 183; Y2 = 2017, n = 121). The heifers were Holstein–Friesian–Jersey crossbred. However, the breed proportions of individual heifers were not known.

The heifers were the complete cohort of replacement heifers from the Limestone Downs dairy herd in Y1 and were those heifers weighing more than 270 kg at mating in Y2. A 270 kg minimum weight threshold was imposed in the Y2 breeding period, where only heifers meeting the weight threshold were included in the study. This threshold was imposed because the herd was well behind target for live weight at mating (300 kg), so the requirement of a minimum live weight of within 10% of the target live weight brought the herd in line with industry norms. No minimum live weight threshold was imposed in Y1, but 90% of the heifers in Y1 weighed at least 270 kg.

A control group of Jersey bulls was selected in each year that had live weight (mature cow live weight equivalent) and gestation length EBV consistent with the average EBV for the Jersey breed for those traits (calculated by New Zealand Animal Evaluation [25]). Angus and Hereford yearling bulls were selected based on BreedPlan EBV for low birth weight and high direct calving ease. The EBV for birth weight, gestation length, and direct calving ease for Angus and Hereford bulls, together with the gestation length and live weight for Jersey bulls, are presented in Table 1. Data from this study did not contribute to the calculation of the EBV for these bulls. Each bull selected for mating was DNA profiled for parentage assignment at calving time (Zoetis, Dunedin, New Zealand).

Table 1. Estimated breeding values (EBV) mean, range, accuracy, and fit within percentile bands for direct calving ease, birth weight, and gestation length for six Angus and six Hereford bulls (updated in October 2021 [22]) and live weight and gestation length for seven Jersey bulls (updated in October 2021 [25]) that had been naturally mated to maiden heifers in either of the two consecutive years (Y1 = 2016; Y2 = 2017).

Breed	EBV	Direct Calving Ease (%)	Live Weight (kg) [1]	Gestation Length (Days)
Angus	Mean (Y1/Y2)	7.9/7.7	0.8/1.1	−3.6/−3.5
	Range	3.3 to 11.1	−1.0 to 3.9	−6.8 to 0.3
	Accuracy	50 to 54%	72 to 74%	63 to 83%
	Bands [2]	0 to 40%	0 to 45%	5 to 99%
Hereford	Mean (Y1/Y2)	8.4/12.2	1.2/−0.8	0.4/−1.3
	Range	6.7 to 13.5	−1.5 to 2.0	−1.6 to 4.0
	Accuracy	46 to 51%	73 to 74%	43 to 58%
	Bands [2]	0 to 20%	0 to 20%	20 to 100%
Jersey	Mean (Y1/Y2)		−47.0/−49.2	−1.7/−1.7
	Range		−54.6 to −44.0	−2.5 to −1.1
	Accuracy		35 to 39%	42 to 65%
	Breed average [3]		−45.7	−1.3

[1] Live weight is birthweight EBV for Angus and Hereford bulls and mature cow live weight EBV for Jersey bulls. [2] Percentile band spread indicating where the EBV for the bulls used in this study sit within the 2019 born calves' population of New Zealand- and Australian-recorded Angus or Hereford cattle, respectively. [3] Breed average for the 2019 born Jersey calves.

2.2. Management

2.2.1. Mating

Heifers were managed under commercial farming conditions and were randomly allocated to mobs for mating with each breed. In Y1, 84, 74, and 79 maiden heifers were naturally mated to yearling Angus (n = 4), Hereford (n = 4), and Jersey (n = 4) bulls, respectively. The bulls were grazed with the heifers in separate mobs for 69 days. In Y2, 57, 56, and 23 maiden heifers were naturally mated to yearling Angus (n = 2), Hereford (n = 2), and Jersey (n = 4) bulls, respectively. For ease of management in Y2, 73 light heifers (excluded from the experiment) were mated in the same group as the experimental heifers bred to Jersey bulls. Thus, a smaller proportion of experimental heifers was required to be allocated to the Jersey bulls. In Y2, the bulls were grazed with the heifers in separate mobs for 54 days, and then all of the heifers were grazed in one mob with all 8 bulls for 12 days.

Heifers were pregnancy tested 137–140 days following the start of mating. Empty heifers, heifer–calf pairs from twin births, or where calf parentage could not be assigned were excluded from the study (n = 68).

2.2.2. Calving and Calves

Heifers that were due to calve were checked at least twice daily, with assistance provided at the discretion of the farm staff. Guidance for provision of assistance included to assist at the first sign of malpresentation or to assist after 4 h of the heifer attempting to calve herself; however, this was difficult to apply in practice given the time that sometimes elapsed between observations. Calves were collected once daily, and heifers that had calved in the previous 24 h moved from the calving herd to the milking herd at this time. Heifers were milked twice-a-day at least until after the rebreeding period. Once-a-day and 16 h milking were implemented in response to feed availability near the end of lactation.

Live calves were tagged with a visual and electronic tag upon arrival at the calf shed and were fed 2 L of first-milking colostrum within 24 h. Jersey-sired calves were removed from the study after arrival in the calf shed and were sold as bobby calves at 4 days of age, while the Angus- and Hereford-sired calves were reared for beef production.

In Y1, 68 of the earliest born Angus- and Hereford-sired calves were sent offsite for rearing due to constraints on rearing capacity at Limestone Downs. The remaining calves born in Y1 and all of the calves born in Y2 were reared at Limestone Downs. Calves were reared in group housing and fed 4 L milk per calf per day under commercial conditions according to the practices of each farm and were weaned at a target live weight of 75 kg for the off-site calves and at 85 kg for the calves at Limestone Downs [23].

2.2.3. Rebreeding

Rebreeding was managed according to the farm's usual practices. An artificial breeding (AB) period began 92 days after the planned start of calving for the heifers. For the Y1 heifers, there was a 10-week AB period followed by 5 weeks of natural mating, and for the Y2 heifers, there was a 5-week AB period followed by 5 weeks of natural mating. No pre-mating heats were recorded.

An estrous synchrony program using progesterone-controlled internal drug release inserts (CIDR) was used in 28 (2016; Cue-Mate 1.56 g progesterone, Bayer Animal Health, Auckland, New Zealand) and 17 (2017; DIB-H 0.5 g Progesterone, Agri-health, Auckland, New Zealand) cows. The CIDRs were removed after 7 days, and insemination occurred 3 days after removal. Injections of GnRH and $PGF_{2\alpha}$ were administered alongside the CIDRs as per recommended practice.

2.3. Measurements

2.3.1. Heifers

The body condition score (BCS) was recorded six times during each season: at first mating (September/October), pregnancy detection (February), prior to first calving (June), prior to rebreeding (September), mid-late lactation (February), and prior to drying off (April). The BCS was assessed by the same certified assessor each time on a 1–10 scale [26,27].

Live weight was measured in a crate using a Tru-test weigh head (EziWeigh7i; Tru-Test, Auckland, New Zealand) and load cells, at mating, pregnancy detection, and prior to calving.

An ear-punch tissue sample for DNA profiling for parentage assignment was taken from each heifer prior to calving (Zoetis, Dunedin, New Zealand).

Heifer milk production data were collected using herd tests performed by LIC (Hamilton, New Zealand) three (Y1) or four (Y2) times during lactation in September, December (Y2 only), January, and March (Y1) or April (Y2). Milk yield was measured using a milk meter, and a sample was collected for lab analysis. Fat and protein percentages were analysed using an infrared milk analyser (FTIR, Foss Electric, Hillerød, Denmark). Fat and protein yields were calculated as milk yield x fat or protein percentage, respectively; milksolids yield was calculated as fat yield + protein yield.

Pregnancy diagnosis was carried out in late December and repeated in mid-February each year for heifers that were not detectably pregnant in December by means of a transrectal ultrasound by a veterinarian (Franklin Vets, Pukekohe, New Zealand). The date of the second calving was recorded in the following season.

2.3.2. Calves

Assistance at birth was scored by the farmer as being not assisted, assisted with a normal presentation, or assisted with an abnormal presentation.

Date of birth was recorded as the date on which the calf was brought into the rearing shed, and all calves were weighed, tissue sampled, and had their sex recorded upon entry to the shed. Calves that died before entry to the shed also had this information recorded before disposal. Tissue samples were genotyped to assign a sire and dam to each calf (Zoetis, Dunedin, New Zealand).

Date and live weight at weaning were recorded for the Angus and Hereford calves.

2.4. Statistical Analysis

2.4.1. Data Cleaning and Calculations

Total milk, fat, protein and milksolids production for each heifer was standardised to a 254-day lactation. This lactation length was determined by the herd test data that spanned days 21–275 of lactation. Daily production was predicted using a third-order orthogonal polynomial. A single-trait animal model was fitted to the milk, fat, protein, and milksolids yield data in ASReml, version 4 [28]. The dataset consisted of the herd test data against the number of days in milk at each test and included 950 records from 294 heifers. Three Y1 heifers were excluded from the analysis of milk production due to the low milk volumes collected at herd tests, which led to negative predicted milk production. The regression coefficients generated from the models were used to calculate predicted daily values.

For the analysis of other traits, pre-calving BCS was grouped into $\leq$4.5 and $\geq$5.0, and rebreeding BCS was grouped into $\leq$4.0, 4.5, $\geq$5.0 due to few heifers at the extremes. Calving and re-calving day was expressed as days from the planned start of calving in the relevant year, and deviation from the median day of calving (DOC deviation) was calculated within year. Pregnancy rate was calculated as the number of heifers pregnant after rebreeding divided by the number of heifers present at pregnancy diagnosis. The inter-calving interval was calculated as the number of days between the first and second calving. A 21-day re-calving rate was calculated as the percentage of heifers that calved at 3 years of age that did so within 21 days of the planned start of calving for that season.

For calves, age at weaning (days) was calculated as the number of days between birth and weaning. Average daily gain (ADG) to weaning was calculated as weaning weight minus birth weight divided by the age at weaning.

2.4.2. Statistical Models

Data were analysed using SAS (Version 9.4, SAS Institute Inc., Cary, NC, USA). The dataset of heifers comprised all heifers that produced a calf (n = 183 in Y1 and n = 121 in Y2). Body condition score, live weight, milk production (days in milk and 254-day milk, fat, protein, and milksolids yield), calving day, re-calving day, and inter-calving interval were analysed using mixed models. Models included the breed of the bull and the year as fixed class effects. The interaction between the breed of bull and year was considered but removed, as it was not significant for any trait ($p > 0.05$). The effects of DOC deviation, pre-calving and rebreeding BCS (grouped as explained in the previous section), and pre-calving live weight were considered where appropriate and removed if not significant ($p > 0.05$). The models for pre-calving live weight, inter-calving interval, and days in milk included DOC deviation as a covariate. Pre-calving BCS was included as a fixed effect in the models for milk yield, fat yield, protein yield, milksolids yield, inter-calving interval, and re-calving day. Pregnancy rate and 21-day re-calving rate (binomial traits) were analysed using logit mixed models. These models included the breed of the bull and year as fixed class effects. The interaction between the breed of the bull and the year was considered but excluded because it was not significant ($p > 0.05$). The model for 21-day re-calving rate also included grouped pre-calving BCS as a fixed effect.

Heifers that were not in the herd at pregnancy detection (n = 11) were not included in the pregnancy rate analysis. Heifers that were not pregnant or that did not have a recorded calving in the following season (n = 97) were excluded from the analysis of the inter-calving interval. There was no association between CIDR allocation and BCS or day of calving; therefore, cows treated with a CIDR were not excluded from the measures of reproductive success.

Calf birth weight was analysed using a linear mixed model that included the breed of the bull, the sex of the calf, year, and the interaction between the breed of the bull and the year as fixed effects. Age at weaning and pre-weaning ADG were analysed using a linear mixed model that included the breed of the bull, the sex of the calf, and rearing group (2016-reared on farm; 2016-reared off farm, or 2017-reared on farm) as fixed effects, and weaning weight was considered as a covariate. The interaction between the breed of the bull and the rearing group was considered but removed because it was not significant ($p > 0.05$).

Assistance at birth was analyzed for all calves and for normally presented calves only using Fisher's exact test to compare the incidence of assistance among breeds. Where the breed effect was significant, pairwise comparisons between breeds were made using Fisher's exact test.

3. Results

3.1. Heifers

3.1.1. Body Condition Score and Live Weight

There was no difference in the BCS at any measurement for heifers mated to Angus, Hereford, or Jersey bulls ($p > 0.05$; data not shown). The Pre-calving BCS (least squares means ± standard error) was 4.88 ± 0.02 in Y1 and 4.69 ± 0.03 in Y2, whilst the BCS at re-breeding was 4.29 ± 0.02 in Y1 and 4.42 ± 0.03 in Y2. Live weight was similar at all time points measured among heifers mated to Angus, Hereford, or Jersey bulls ($p > 0.05$; data not shown). The least-squares means for live weight of the heifers that calved in 2016 was 305 ± 2 kg at mating and 435 ± 3 kg at calving. The heifers that calved in 2017 had least-squares means for live weight of 296 ± 2 kg at mating and 473 ± 3 kg at calving.

3.1.2. Milk Production

The days in milk and the predicted 254-day milk production of the heifers did not differ among those mated to Angus, Hereford, or Jersey bulls ($p > 0.05$; Table 2).

Table 2. Days in milk and predicted 254-day milk production (milk, fat, protein, and milksolids yield) from first-calving heifers mated to Angus, Hereford, or Jersey bulls. Values are least squares means ± standard error.

Measurement	*n*	Angus	Hereford	Jersey	*p*-Value
Heifers (n)	294	118	106	70	-
Days in milk (days)	294	274.1 ± 2.5	277.2 ± 2.6	277.6 ± 3.2	0.592
Milk yield (L)	293	2963 ± 36	2900 ± 38	2897 ± 47	0.375
Fat yield (kg)	293	140.3 ± 1.5	136.0 ± 1.6	136.9 ± 2.0	0.124
Protein yield (kg)	293	111.0 ± 1.2	109.7 ± 1.3	109.2 ± 1.6	0.613
Milksolids yield (kg)	293	251.3 ± 2.6	245.7 ± 2.7	246.1 ± 3.4	0.266

3.1.3. Rebreeding

There were no differences in the pregnancy rate, inter-calving interval, re-calving day, or 21-day re-calving rate of heifers mated to Angus, Hereford, or Jersey bulls ($p > 0.05$; Table 3). Heifers bred to Angus bulls tended to calve 3–5 days earlier than heifers bred to Hereford or Jersey bulls ($p < 0.1$).

Table 3. First calving day (as a 2-year-old) and rebreeding performance (pregnancy rate, inter-calving interval, re-calving day as a 3-year-old, and proportion of 3-year-old heifers that calved within 21 days of the planned start of calving for that season) of heifers previously mated to Angus, Hereford, or Jersey bulls. Values are least squares means ± standard error.

Measurement	*n*	Angus	Hereford	Jersey	*p*-Value
Heifers (n)	304	122	111	71	-
Calving day (2-year-old) [1]	304	12.9 ± 1.3	16.2 ± 1.4	17.7 ± 1.7	0.055
Pregnancy rate (%)	293	69.2 ± 4.3	75.1 ± 4.2	76.41 ± 5.1	0.465
Inter-calving interval (days)	196	385.3 ± 2.6	385.1 ± 2.6	383.0 ± 3.3	0.849
Re-calving day (3-year-old) [1]	196	24.1 ± 2.7	25.9 ± 2.7	24.8 ± 3.5	0.885
21-day re-calving rate (%) [2]	196	49.9 ± 6.0	46.2 ± 6.0	52.8 ± 7.6	0.789

[1] Day of calving expressed as days from the planned start of calving. [2] The 21-day re-calving rate expressed as the proportion of heifers that calved at 3 years of age that did so within 21 days of the planned start of re-calving.

3.2. Calves

No significant differences were observed among the sire breeds in the percentage of calves assisted at birth ($p > 0.05$; Table 4), although the rate was numerically greatest in the Hereford-sired calves and least in the Jersey-sired calves in both years. When malpresented calves were excluded, the difference in the assistance rate was significant for Hereford-sired calves compared with Jersey-sired calves ($p < 0.05$). The only assistance in the Jersey-sired calves was for two malpresented calves in Y1, whereas some normally presented Hereford- and Angus-sired calves required assistance in both years. There was an interaction between the sire breed and the year for birth weight (Table 4; $p < 0.05$), such that Hereford-sired calves were heavier than the Angus-sired calves in year 1 but not in year 2. Jersey-sired calves were the lightest in both years. There was no difference in the age at weaning, or pre-weaning ADG of calves born to heifers mated to Angus or Hereford bulls ($p > 0.05$).

Table 4. Assistance, birth weight, age at weaning, and pre-weaning average daily gain (ADG) of calves born to heifers in year 1 (2016) or year 2 (2017). Values are least squares means ± standard error.

Measurement	*n*	Angus	Hereford	Jersey	*p*-Value
Calves (n)	304	122	111	71	-
Assistance at birth (all calves; %)	304	5.7	11.7	2.8	0.074
Assistance at birth (normal presentation; %) [1]	297	4.2 ^{ab}	9.3 ^{b}	0.0 ^{a}	0.016
Birth weight (kg) [2]					<0.001
Year 1	183	33.7 ± 0.5 ^{b}	36.1 ± 0.5 ^{c}	29.3 ± 0.6 ^{a}	
Year 2	121	34.9 ± 0.5 ^{b}	35.1 ± 0.6 ^{b}	31.4 ± 0.8 ^{a}	
Age at weaning (days)	200	82.0 ± 0.9	80.6 ± 0.9	-	0.265
Pre-weaning ADG (kg/day)	200	0.72 ± 0.01	0.71 ± 0.01	-	0.418

[1] Excludes malpresented calves. [2] There was a significant ($p < 0.05$) year by breed interaction for birth weight, so values are presented for each year. [a,b,c] Values within row with different superscripts are significantly different at $p < 0.05$.

4. Discussion

A major concern for New Zealand dairy farmers is that using beef bulls could result in difficult calving and an impairment of the subsequent career of the heifer, which could outweigh any benefits from producing a higher value calf. This case study demonstrated that bulls with high direct calving ease and low birthweight EBV (similar to those used here) can be mated to dairy heifers with no effect on the BCS, live weight, milk production, or rebreeding performance of the first-calving heifers. Nevertheless, there was an increase in the assistance rate, which would require increased farm labour and skill, creating a consequent economic cost to the farmers.

The Angus and Hereford bulls sired heavier calves than the Jersey bulls, and the difference in the birth weight of the Jersey-, Angus-, and Hereford-sired calves in this study is in agreement with previous research [5,29–33]. Some of the calves born to Angus and

Hereford bulls had to be assisted at birth, and this coincided with a 4–7 kg greater birth weight compared with the Jersey-sired calves. The difference in the assistance rate was only statistically significant for normally presented Hereford-sired versus Jersey-sired calves. However, at a time of year when labour resources are usually fully utilized, even small increases in the workload due to an increased rate of assistance can become problematic on-farm, so the numerical increase in the assistance rate should be viewed with caution.

For Hereford bulls, the mean EBV for direct calving ease was 4.7% greater, and the mean EBV for birth weight was 1.8 kg lighter in Y2 compared with Y1. Consequently, in Y2 compared with Y1, Hereford-sired calves were born 1 kg lighter from heifers that were 44 kg heavier, and the percentage of normally presented calves requiring assistance at birth decreased from 12.7% to 4.4% for that breed (data not shown). The current results indicate a favourable correlation between bull EBV for birth weight and progeny birth weight and calving ease, and this is supported by previous reports indicating a strong relationship between birth weight and calving ease [16,34–37]. Birthweight EBV should be considered when choosing beef bulls to mate maiden dairy heifers. Specifically, very low-birthweight EBV are necessary to minimise assisted calvings in primiparous heifers.

Jersey bulls produced the lightest calves that required few calving interventions. The Jersey breed is the most commonly used breed for mating dairy heifers because of their calving ease [5,6], but their progeny is usually sold at ~4–10 days of age as bobby calves and are of low value [5,7,8]. The numerical difference in assistance at birth did not result in a difference in the milk production or the rebreeding success of the heifers. This case study suggested that using beef bulls with a very low birthweight EBV (Angus: <3.8 kg, Hereford: <1.9 kg) and high direct calving ease EBV (Angus: >4.1%, Hereford: >5.9%) to mate well-grown dairy heifers should result in calves that are born with similar rates of assistance to those reported in the industry (5–15%) for dairy heifers [16,38,39]. Therefore, decisions related to bull choice for dairy heifers should consider whether there is a large enough on-farm capacity to accommodate a small increase in the assistance rate for first-calving heifers if selected beef bulls are used.

There was no difference in the pre-weaning growth of calves sired by Angus or Hereford bulls. This is in contrast to the limited literature published, which reported that straight-bred Angus calves tended to grow faster than Hereford calves during the pre-weaning period [31]. However, the results agree with Coleman [23], who found no difference in artificially reared Angus- and Hereford-cross-dairy calves born to mixed-aged cows. The lack of difference between the beef-cross calves could be due to the differences in rearing system compared to previous literature, as artificially rearing calves reflects a restricted growth system where the genetic potential for growth cannot be fully expressed [40].

No literature was found determining a possible effect of the birth weight of the calf or the breed of the bull on the BCS or milk production of first-calving heifers. There is, however, some evidence in mature cows that indicates that producing a heavier calf influences the physiology of the mammary gland and increases the early milk production of the cow [41,42]. The increased milk production may contribute to an energy deficit and may indirectly influence the BCS through a drain on energy reserves [19,43,44]. However, there was neither a difference between bull breeds in the BCS nor in the milk production of the heifers in either year of the study, even though there were differences across bull breeds in the birth weight of the calves.

The industry liveweight target for dairy heifers in New Zealand is 60% of mature weight at first mating and 90% at first calving [12,13]. The industry average mature weight for a Holstein–Friesian–Jersey crossbred cow is 451 kg [45], giving a pre-mating target of 271 kg and a pre-calving target of 406 kg. From the heifers in this case study with live weight records (87.2% with record prior to mating, 90.8% prior to calving), 94.3% of the heifers met the pre-mating target, and 88.8% met the pre-calving target live weight. Despite this, 92% of the heifers in the study were below the BCS target of 5.5 pre-calving [46].

The below-target BCS at first calving was countered by a better-than-target BCS in early lactation, so the heifers were, on average, at target for mating.

No literature was found that suggested a direct effect of the bull on rebreeding success. However, rebreeding success may be indirectly affected by a service sire through the calving pattern (product of gestation length differences), as later-calving heifers are less likely to be cycling at the beginning of the breeding period [6,44]. The tendency for heifers mated to Angus bulls to calve earlier was likely due to their calves having a shorter gestation. However, the advantage was only 4 days, so the similar rebreeding success (pregnancy rate, inter-calving interval, re-calving day or 21-day re-calving rate) between the bull breeds was expected.

This case study was limited by the lack of information of the breed proportions of the individual heifers. The heifers were Holstein–Friesian–Jersey crossbred, but breed recording on the farm was not complete; therefore, individual proportions of Holstein–Friesian and Jersey could not be accounted for. The literature suggests a difference in live weight, milk production (particularly fat), and rebreeding success between Holstein–Friesian and Jersey cows [47–54]. As the heifers were randomly allocated to each mating mob and the heifers in each mating mob had the same average live weight and milk composition (fat percentage, data not presented) throughout the study, there was no indication of a heifer breed bias between the bull breed groups.

5. Conclusions

Using Angus, Hereford, and Jersey bulls over maiden dairy heifers resulted in heavier calves born to heifers mated to Angus and Hereford bulls compared to those born from heifers mated to Jersey bulls. There was no effect of the service sire breed on the heifer's milk production, BCS, or rebreeding success. Therefore, Angus and Hereford bulls with very low birthweight and high direct calving ease EBV, as in this case study, can be used over dairy heifers provided that there is a large enough on-farm capacity to allow for a small increase in assistance at calving.

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Institutional Review Board Statement: The study was conducted in accordance with the guidelines of the Massey University Code of Ethical Conduct for the Use of Animals for Research, Testing and Teaching, and approved by the Animal Ethics Committee of Massey University, New Zealand (protocol code 15/65 approved on 21 August 2015).

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