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Milk production and rebreeding performance of mixed-aged dairy cows mated to Angus or Hereford bulls

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Abstract

Approximately 72% of New Zealand dairy cows are artificially mated to generate replacement heifers. There is an opportunity to mate the remaining dairy cows to beef bulls, generating a calf that has value as a beef-cross-dairy animal. Angus and Hereford are the predominant beef breeds in New Zealand, with Hereford the most common beef breed used in the dairy industry. The aim of this experiment was to determine whether there was a difference in milk production and rebreeding performance of mixed-aged dairy cows producing a calf sired by an Angus or Hereford bull, and if calf birth weight influenced these parameters. Cows were artificially bred to Angus or Hereford bulls. Service sire-breed had no effect on milk production in early lactation. Cows producing Angus-sired calves had a 2.4 kg greater 253-day protein yield ($P<0.05$) than did cows producing Hereford-sired calves, however, there was no effect of calf sire-breed on the 253-day yields of milk, fat and milksolids. The in-calf rate and inter-calving interval did not differ between service sire-breed. There was no effect of calf birth weight on milk production, in-calf rate or inter-calving interval. The results of this experiment suggest that there are no negative effects associated with artificially breeding cows to Angus compared to Hereford bulls.

Keywords: beef-cross-dairy; dairy; Angus; Hereford; milk; rebreeding

Introduction

In most New Zealand dairy herds, approximately 72% of cows are artificially bred to superior dairy-breed bulls to produce replacement heifers (Back 2017; DairyNZ 2018; Holmes et al. 2007). The remaining cows therefore are available to mate to beef bulls to generate beef-finishing cattle, generating a calf with value as a beef animal. These cows are typically the later-mated cows as farmers ensure replacements are generated from cows inseminated at the start of the mating season.

Beef bulls are used to produce a calf of greater value than that of a calf sired by a dairy bull (Hickson et al. 2015). However, to be profitable for the dairy herd, the beef bulls need to perform equitably relative to dairy bulls in terms of the impact on the cow at calving, subsequent milking and rebreeding, and by producing calves with comparable birth weights to dairy calves (Hickson et al. 2015). Angus and Hereford are the predominant beef breeds in New Zealand (Beef+LambNZ 2018), with Hereford bulls used more commonly in the dairy industry than Angus (DairyNZ 2018). This at least in part due to the Hereford-cross calves being easily identified due to the characteristic white head of the calf.

Milk production is the primary source of income for the dairy farm (Holmes et al. 2007). In New Zealand farmers get paid for milksolids production, representing ~93% of dairy farm income (Cook 2014). In order to lactate in the following season, and survive in the herd, the cow needs to get pregnant again within a short timeframe (Holmes et al. 2007). Poor reproductive performance delays the mean calving date and decreases the days in milk and milk production in the subsequent lactation (Grosshans et al. 1997; Roche et al. 1992; Xu & Burton 1996).

The aim of this experiment was to determine whether there was a difference in the milk production and rebreeding performance of mixed-aged dairy cows producing a calf sired by an Angus or Hereford bull and if there was an influence of calf birth weight on these parameters.

Materials and methods

This experiment was conducted with approval from the Massey University Ethics Committee at the C Alma Baker Limestone Downs dairy farm (coordinates 37.28 S 174.45 E).

Animals

Lactating mixed-aged cows were artificially bred (AB) to Angus (n=31) and Hereford (n=34) bulls over two consecutive years (2015 and 2016). Records from 953 individual lactations (682 cows) were analysed. Cows were managed on a commercial dairy farm and calved in 2016 or 2017. Cows were predominantly Holstein-Friesian or Holstein-Friesian-Jersey crossbred. Only data from cows that produced a singleton calf which was DNA-parentage verified to a sire and dam were included in the analysis.

Methodology and measurements

Cows were bred over a 63- and 54-day period in 2015 and 2016 respectively. Bulls used in each year were allocated to a mating team (2015 n=8, 2016 n=7), and were rotated each day of mating. Cows submitted for insemination were allocated at random to the bulls in the team assigned for that day.

Parentage of the calf (Zoetis, Dunedin, New Zealand) was used to determine the successful mating date. Deviation from median mating date of the herd (DOMdev) was calculated within each year for each cow. Gestation length (GL) of the calf was recorded as the period between successful date of mating and date of calving. Date of calving was recorded at the day on which the calf was removed from the dam. Deviation from median date of calving (DOCdev) was calculated within each year for each cow. Calf birth weight (BWT), calf sex and calf sire-breed were recorded when the calf was removed from the dam. Cow age at calving was recorded; cows aged seven years and older were grouped together.

Cow body condition score (BCS) was recorded pre-calving (BCS – PC) and at rebreeding (BCS – RB) by a qualified assessor on a 1-10 scale (DairyNZ 2012). Rebreeding body condition scores were grouped into ≤3.5, 4, 4.5, 5 and ≥5.5. Mean post-calving live weight (LWT) was calculated using post-milking weights (Protrack walk-over-scale) recorded over 30 days after calving. Live weights (n=153,973) were edited to remove outliers by calculating the mean and standard deviation for each cow within year. Any recorded weight that fell outside of the mean ± 3 standard deviations (n=946) was excluded from the recalculation of mean cow post-calving live weight.

Cows were herd tested by LIC (Hamilton, New Zealand) either three (2016) or four (2017) times during the lactation. Milk (MY), fat (FY), protein (PY) and milksolids (MS) yields were obtained from LIC herd test data.

The rebreeding performance of the cows was recorded for the subsequent breeding period following calving. Rebreeding in the first year of the experiment was used to generate calves for the second year of the experiment and began with the AB period (2016) mentioned above. Following AB to beef bulls, short-gestation-length Holstein-Friesian-Jersey crossbred bulls (LIC 2012) were used for 17 days (10 weeks total AB). In the second year following the first AB period, all cows were AB to Holstein-Friesian-Jersey crossbred bulls for five weeks. Following the end of the AB periods in both years, cows were naturally mated for five weeks. A progesterone CIDR (controlled intravaginal drug release) programme was used in 118 (2016) and 83 (2017) cows, with the CIDRs removed after seven days and insemination occurring 10 days after insertion. Pregnancy detection by trans-rectal ultrasound was carried out by a veterinarian in late December and mid-February. In-calf rate (ICR) was calculated as the number of pregnant cows divided by the number of cows having calved. Inter-calving interval (ICI) was recorded as the period between the first date of calving and the date of calving in the following year.

Statistical analysis

Lactation curves for MY, FY, PY and MS for each lactation were modelled using a random regression model fitting a third-order orthogonal polynomial in the ASReml package (Gilmour et al. 2009) of VSN International Ltd. The dataset consisted of the individual herd test data with the number of days in milk at each test (specific for each cow within year) and included 2949 records from 909 cow lactation records. Regression coefficients were used to generate predicted yields for each day of lactation within limits of prediction (15-267 days in milk) as determined by the timing of the herd tests. The daily yields were used to calculate a 253-day yield.

Early lactation yield (first herd test), 253-day lactation yields using the MIXED procedure of SAS version 9.4 (SAS Institute Inc., Cary, NC) with linear mixed models.

The models for early lactation MY, FY, PY and MS included the fixed effects of calf sire-breed, year of calving and cow age, the random effects of bull (nested within breed) and cow, and the interaction of calf sire-breed and calving year. Effects of GL, DOMdev and LWT were evaluated as covariates in the model, covariates were removed if the effect was not significant. Gestation length was not significant therefore, GL and date of mating deviation were removed from the FY model and replaced with DOCdev. The models for 253-day lactation MY, FY, PY and MS included the fixed effects of calf sire-breed, year of calving and cow age, the random effects of bull (nested within breed) and cow, and the interaction of calf sire-breed and calving year. Post-calving LWT was included as covariate when it had a significant effect.

Body condition score at pre-calving and rebreeding were analysed using the MIXED procedure of SAS with linear mixed models. The models for BCS – PC and BCS – RB included the fixed effects of calf sire-breed and year of calving, the random effects of bull (nested within breed) and cow, the interaction of calf sire-breed and calving year and the covariate of DOCdev. The model for BCS – PC included LWT as a covariate.

The proportion of cows receiving CIDR treatment and the in-calf rate were analysed using the GLIMMIX procedure of SAS with a linear mixed model, specifying a binomial distribution and a logit transformation. Inter-calving interval was analysed using a linear mixed model with the MIXED procedure. Both the ICR and ICI models were analysed excluding records from cows which had received CIDR treatment. All models included the fixed effects of calving year and calf sire-breed, and the interaction of calf sire-breed and calving year. The model for CIDR treatment included the covariate of DOCdev. The models for ICR and ICI included the covariates of DOMdev, GL, and rebreeding grouped BCS. The model for ICR included cow age as a fixed effect.

Additional models that excluded calf sire-breed and the interaction between sire-breed and calving year, and included birth weight of the calf as a covariate were used to examine the relationships between birth weight and milk production and rebreeding success.

Results

There was no difference in the 253-day lactation MY, FY and MS between cows mated to Angus or Hereford bulls. However, cows mated to an Angus bull produced a 2.4 kg greater PY (P=0.046, Table 1). Cows calving in 2017 had greater component yields than cows calving in 2016 (P<0.001, Table 1). Cows which were heavier at calving

Table 1 Least-squares means (± SEM) for milk production predicted to a 253-day lactation (15-267 days) for mixed-aged dairy cows producing Angus- or Hereford-sired calves in 2016 or 2017.

	MY (L)	FY (kg)	PY (kg)	MS (kg)
n [1]	893	909	893	909
Calf sire breed				
Angus	3404.0±26.1	158.1±1.19	130.9±0.92 [b]	289.0±2.00
Hereford	3348.9±24.5	155.8±1.12	128.5±0.86 [a]	284.4±1.89
P value	0.090	0.139	0.046	0.073
Calving year				
2016	3146.3±24.8 [a]	149.6±1.11 [a]	124.0±0.88 [a]	274.3±1.87 [a]
2017	3606.6±24.7 [b]	164.3±1.10 [b]	135.3±0.87 [b]	299.1±1.86 [b]
P value	<0.001	<0.001	<0.001	<0.001
P values				
Age of cow	0.020	<0.001	<0.001	<0.001
Live weight	<.0001		<0.001	
Breed*year interaction	0.427	0.711	0.677	0.763

MY: milk yield; FY: fat yield, PY: protein yield, MS: milksolids yield; Live weight: mean 30 day post-calving live weight within year.
[1] Differences in number of cows included in analysis due to 16 cows not having live weight records. [ab] differing superscripts within a column and variable denote significantly different means (P>0.05).

Table 2 Mean days in milk and the least-squares means (± SEM) for milk production in early lactation and pre-calving body condition score (BCS – PC) for mixed-aged dairy cows producing Angus- or Hereford-sired calves in 2016 or 2017.

	DIM	MY (L)	FY (kg)	PY (kg)	MS (kg)	BCS – PC
n [1]	885	813	885	813	813	925
Calf sire breed						
Angus	59.1±1.3	18.74±0.23	0.82±0.01	0.67±0.01	1.48±0.02	4.51±0.02
Hereford	57.9±1.2	18.37±0.22	0.80±0.01	0.65±0.01	1.46±0.02	4.50±0.02
P value	0.477	0.236	0.304	0.126	0.350	0.722
Calving year						
2016	55.9±1.1 [a]	16.39±0.21 [a]	0.75±0.01 [a]	0.59±0.01 [a]	1.34±0.02 [a]	4.48±0.02 [a]
2017	61.1±1.1 [b]	20.71±0.22 [b]	0.87±0.01 [b]	0.73±0.01 [b]	1.60±0.02 [b]	4.53±0.02 [b]
P value	<0.001	<0.001	<0.001	<0.001	<0.001	0.029
P values						
Age of cow		0.001	<0.001	<0.001	<0.001	
Gestation length		0.001		0.011	0.036	
DOM deviation		<0.001		<0.001	<0.001	
DOC deviation			<0.001			0.028
Live weight		<0.001		<0.001	0.006	<0.001
Breed*year interaction		0.989	0.807	0.699	0.657	0.263

DIM: days in milk; MY: milk yield; FY: fat yield, PY: protein yield, MS: milksolids yield; Live weight: mean 30 day post-milking live weight within year; DOM deviation: deviation from median date of mating; DOC deviation: deviation from median date of calving within year. [1] Differences in number of cows included in analysis due to the recording of live weight and mating records (consequently gestation length) was incomplete. [ab] differing superscripts within a column and variable denote significantly different means (P>0.05).

produced 2.02 L (per 1 kg increase) greater MY, and 0.05±0.02 kg greater PY over the total lactation (P<0.001). Calf birth weight (mean 36.9 kg, range 23.9-53.5 kg) had no effect on the predicted 253-day component yields. There was no effect of the GL of the calf on the 253-day yield milk production.

At the earliest herd test (58.3±17.1 days post-partum) there was no effect of calf sire breed or calf birth weight on the early lactation milk production (Table 2). Cows having calved in 2017 had greater early lactation yields and were tested 5.2 days later than cows calving in 2016 (P<0.001, Table 2). Cows having produced a calf with a longer GL produced 0.11 kg greater MY, 0.003 kg greater PY and 0.005 kg greater MS (P<0.05) per additional day of gestation. In early lactation, FY was not influenced by calf GL. However, cows calving later (per day) in the season had a greater FY (0.003 kg/d, P<0.001). Heavier cows had greater MY, PY and MS (P<0.01) per day later calving.

Body condition score pre-calving and at rebreeding did not differ between cows producing Angus- or Hereford-sired calves (P>0.05, Table 2 and 3). Cows calving in 2017 had a greater pre-calving BCS than in 2016 (0.05 of a score, P=0.029), however the difference between calving years was not seen at rebreeding (P>0.05).

There was no effect of calf sire-breed on the proportion of cows that received CIDR treatment, that were successful in getting pregnant (ICR) or on the ICI (P>0.05, Table 3). The ICR was greater and ICI was smaller in 2017 compared

Table 3 Proportion of cows receiving CIDR treatment, rebreeding in-calf rate (ICR, proportion of cows calved), inter-calving interval (ICI) and rebreeding body condition score (BCS – RB) for mixed-aged dairy cows, artificially bred to Angus, Hereford bulls and calving in 2016 or 2017. Values are least-squares mean ± SEM.

	CIDR (%)	ICR (%)	ICI (days)	BCS – RB
n [1]	952	655	459	894
Calf sire breed				
Angus	0.19±0.02	0.84±0.02	369.8±1.5	4.04 ± 0.03
Hereford	0.22±0.02	0.85±0.02	371.2±1.5	4.03 ± 0.03
P value	0.392	0.551	0.534	0.650
Calving year				
2016	0.24±0.02 [b]	0.77±0.03 [a]	374.6±1.4 [b]	4.05 ± 0.02
2017	0.18±0.02 [a]	0.90±0.02 [b]	366.4±1.4 [a]	4.02 ± 0.02
P value	0.019	<0.001	<0.001	0.315
P values				
DOC dev	0.029			0.003
DOM dev		<0.001	<0.001	
Gestation length		0.024	<0.001	
Body condition score		<0.001	0.016	
Age of cow		0.019		
Breed by year interaction	0.280	0.112	0.653	0.469

DOM deviation: deviation from median date of mating; DOC deviation: deviation from median date of calving within year; body condition score: grouped pre-rebreeding body condition score. [1] Analysis of ICR and ICI did not include cows which received CIDR treatment. [ab] Differing superscripts indicate significantly different means within column.

to 2016, indicating improved reproductive performance (P<0.05, Table 3). There was no interaction between calf sire-breed and calving year for any of the parameters (P>0.05, Table 3).

The proportion of cows receiving CIDR treatment was influenced by the deviation from median date of calving in that cows were 0.01% more likely to have received treatment if they calved later (per day) in the season (P=0.029, Table 3). Cows producing calves with a longer GL (P<0.05) and that were mated later in the previous season (P<0.001) had a lower ICR and shorter ICI (Table 3). Cows which had a greater BCS prior to mating had better reproductive success in that the ICR was greater (P<0.001) and ICI was shorter (P<0.05).

Discussion

Little literature is available on the impact on milk production and rebreeding when mating dairy cows to beef bulls. A Finnish survey (Lindstrom 1979) examined the use of beef bulls in dairy herds, and also reported no difference in the milk production or pregnancy rate of cows mated to Hereford, Angus or Charolais bulls.

Contrary to published literature (Gillespie et al. 2017; Græsbøll et al. 2015; Hess et al. 2016; Hinde et al. 2014), there was no influence of calf sex on the milk production in the present study. The sex-biased milk production in literature is conflicted between studies as to whether it favours heifer or bull calves. However, a New Zealand study of seasonal calving cows suggests a small production advantage from cows producing a heifer calf (Hess et al. 2016). In a New Zealand seasonal calving system, the shorter GL of heifer calves likely results in extra days in milk of the cow, and therefore, greater MY over the lactation (Hess et al. 2016). The absence of a difference seen in the present experiment may be due to a combination of the differences in birth weight between bull and heifer calves and the unbalanced calf-sex ratio in this dataset (bull calf biased), offsetting any heifer-biased production difference (data not presented).

The effects of calf sire-breed and birth weight did not have significant effects on milk production or rebreeding success, however year of calving was significant. The difference between the two years indicates that the difference is likely due to management. Nutrition has an influence on milk production and the likelihood of becoming pregnant; with better nutrition, milk production tends to increase, as does the likelihood of becoming pregnant (Buckley et al. 2003), however BCS in the present experiment does not reflect a difference in nutrition between year of calving.

In conclusion, there was no difference in the milk production or rebreeding performance of cows producing an Angus or Hereford-sired calf, or calves of different birth weights. The milk composition differed slightly by calf sire-breed but there was no effect on MS. The results from this experiment indicate there are no negative impacts of calf sire-breed or calf birth weight on the milk production or rebreeding performance of cows mated to Angus compared to Hereford bulls.

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