The percentage of spring-calving carryover cows in New Zealand dairy herds and their milk production, compared to heifers, age-matched and lactation-matched non-carryover cows

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Abstract

Non-pregnant cows are generally culled from dairy herds and replaced with heifers. Alternatively, non-pregnant cows can be dried-off at the end of lactation, retained for one year (carried over), before being mated and returned to a milking herd in the following year. The aim of this study was to estimate the percentage of spring-calving carryover cows in New Zealand dairy herds and to compare their milk production with that of heifers, lactation-matched and age-matched non-carryover cows. Results showed that 2.5% of spring-calving cows had experienced a previous carryover period. The majority (43%) of carryover cows had failed to conceive during their first lactation. Most (69%) dairy herds contained less than 5% carryover cows and 17% had zero carryover cows. Second-lactation carryover cows produced 4778.1±6.3 L milk, 228.7±0.3 kg fat, 182.0±0.2 kg protein, and had a somatic cell score (SCS) of 6.31±0.01, which was greater ($P<0.001$) than the milk production of heifers that produced 3514.5±5.9 L milk, 168.3±0.3 kg fat, 134.0±0.2 kg protein, and had a SCS of 5.89±0.01. Carryover cow milk production was also greater ($P<0.001$) than that of lactation-matched and age-matched non-carryover groups. The results of this study will aid on-farm culling decisions.

Keywords: Carryover cows; spring-calving; milk production

Introduction

In New Zealand, 95% of dairy herds calve during the spring period to optimise pasture utilisation (Blackwell et al. 2010; Holmes et al. 2002). Maximising reproductive performance and overall farm efficiency is a key goal for spring-calving dairy herds. Maintaining an annual calving pattern requires the average calving interval, which is the number of days between each consecutive parturition date, to remain close to 365 days (Holmes et al. 2002). Due to the calving-interval time constraint, in combination with farm management practices and cow genetics, annually between 5% and 17% of New Zealand dairy cattle fail to conceive (Xu & Burton 2003). In general, non-pregnant cows are culled and replaced by two-year-old heifers. Alternatively, non-pregnant cows can be dried off at the end of lactation, carried over for one year, before being mated and returned to a milking herd in the following year (Pangborn & Woodford 2010). In the dairy industry, these cows are referred to as carryover cows.

Previous studies conducted in the Canterbury region, have shown that carryover cows have greater milk production when compared to non-carryover herd-mates and heifers (Pangborn & Woodford 2010; Pangborn & Woodford 2013). To the authors knowledge, there is no published literature on the frequency with which non-pregnant cows are carried over, before being mated and returned to a New Zealand dairy herd. Analysis of a large dataset, across several years, regions of New Zealand and cow breeds will increase the body of knowledge on carryover cows, which is of value to aid on-farm culling decisions and for the wider dairy industry. Accordingly, the objectives of this study were to estimate the percentage of spring-calving carryover cows in New Zealand dairy herds on a per season, cow age and herd basis and to compare the milk production of carryover cows with that of heifers, lactation-matched and age-matched non-carryover cows.

Materials and methods

Data

Twenty million lactation records and animal information for dairy cows born between 2003 and 2013 were extracted from the Livestock Improvement Corporation (LIC) animal database. The lactation records were sourced from five and a half million dairy cows that were a part of 15,692 herds. Only cow records that were from herds that had at least three herd tests per year were retained to ensure sufficient milk production data was included in the dataset. The records in the dataset included information on lactation yields ((milk yield (MY), fat yield (FY) and protein yield (PY)), and herd-test records for somatic cell count (SCC) corresponding to the lactation, as well as breed proportions, ancestry information, animal movement and parturition dates. Each herd-test SCC record was converted to somatic cell score (SCS) using $SCS = \log_2(SCC)$, and was averaged for each lactation year.

Lactation records from cows that had spring-calving parturition dates (between June and November) were retained. Lactation records from cows that had parturition dates in June were grouped with lactation records from cows that had parturition dates in July. Similarly, lactation records from cows that had parturition dates in November were grouped with lactation records from cows that had parturition dates in October, to balance the number of lactation records in each month.

Calving interval was calculated as the number of days between consecutive parturition dates (PD) for each cow, and the value was attached to the most recent of the two records. Records with a calving interval less than 270 days

or greater than 913 days were discarded. Cows with at least one calving interval record that fell between 547 days and 913 days, with no extended lactation (>305 days in milk) for their previous lactation record, were identified as carryover cows. The calving interval limit accounted for cows that calved late in one year (PD_1 = 31st November), were carried over for one year as a non-lactating cow and calved early in the following year (PD_2 = 1st June), or vice versa, for a cow that calved early then late in the calving period. Cows that had calving intervals that were consistently between 270 days and 547 days, throughout their lifetime, were classified as non-carryover cows.

Age at parturition (AP) was rounded and lactation number was estimated for each record. Lactation number (LN) was estimated as LN = AP – 2 for carryover records, or for records from a cow with a previous carryover record, whereas, lactation number was estimated as LN = AP – 1 for non-carryover records with no previous carryover records.

Breed proportions of Holstein-Friesian and Jersey for each cow, sire and dam were extracted from the database. The coefficient of heterosis for each cow was calculated using the formula $h_{FJ} = \alpha_{sF}\alpha_{dJ} + \alpha_{sJ}\alpha_{dF}$, where h_{FJ} was the coefficient of expected heterosis between fractions of Holstein-Friesian (F) and Jersey (J) in the cow, α_{dF}, α_{dJ}, α_{sF} and α_{sJ} was the proportion of F and J in the dam (d), and sire (s), respectively (Dickerson 1973).

Statistical analysis

Population statistics

All statistical analysis were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). The number of carryover cows was expressed as a percentage of all productive cows in that year. The percentage of carryover cows for each year was averaged between the 2008 and 2015 years. Additionally, the percentage of carryover cows returning to a dairy herd at four, five, six and greater than seven years of age was determined.

A total of 11,419 dairy herds were selected from the dataset on the basis that they contained a total of at least 70 cows per herd. The percentage of carryover cows per herd was calculated. The results were categorised into three groups; herds that comprised of zero, less than 5% and greater than 5% carryover cows. Additionally, of herds that contained carryover cows, the percentage of herds that contained greater or less than 5% carryover cows were determined.

Milk production

Lactation records from cows that had greater than 81.25% Holstein-Friesian or Jersey breed proportions were retained for comparisons between milk production. This breed limit ensured that Holstein-Friesian, Jersey and Holstein-Friesian x Jersey cows were included in the dataset. The dataset was grouped into seven data tables; one for second-lactation carryover-cow records and heifer lactation records, and the remaining six for carryover and non-carryover cows of the same lactation (second, third or fourth lactation) and/or the same age (four, five or six-years-old). For each data table, owner participant codes (herd) and year were combined to form contemporary herd-year groups. For each distinct herd-year group, a total of 50 lactation records, consisting of at least two carryover lactation records were required to be eligible for each data table. Table 1 summarises the number of non-carryover and carryover lactation records in each data table used for the milk production comparison between carryover cows and heifers, lactation-matched and age-matched non-carryover cows.

Table 1 The number of non-carryover and carryover lactation records (also expressed as a percentage of the total) analysed in the milk production comparison between heifers and second-lactation carryover (SL CO) cows, as well for lactation-matched (two, three and four) and age-matched (four, five and six) carryover and non-carryover groups.

Group	Lactation record type	
	Non-carryover	Carryover
Heifer and SL CO cows	838,028	60,193 (7%)
Lactation two	590,079	47,242 (8%)
Lactation three	279,342	20,275 (7%)
Lactation four	115,343	7,211 (6%)
Age four	446,496	41,950 (9%)
Age five	206,715	17,793 (12%)
Age six	78,316	5,808 (7%)

Linear mixed models in SAS were used to obtain the least-square means for milk production (MY, FY, PY) and average SCS of carryover and non-carryover lactation records for each data table. The model included the random effect of the herd-year contemporary group, the fixed effect of carryover and parturition month class and, proportion of Friesian, heterosis and days in milk as co-variates with linear effects.

Results

Population statistics

Figure 1 shows the distribution of calving interval for all lactation records in the dataset. Non-carryover lactation records had calving intervals that were between 547 days and 913 days. Carryover lactation records had calving intervals that were between 547 days and 913 days. On average, 2.5% of dairy cows in spring-calving herds had experienced a previous carryover period. The percentage of carryover cows ranged between 2.2% and 3.1% for the 2014 and 2009 years, respectively. The majority of carryover cows (43%) returned to a milking herd at four years old, after failing to conceive during their first lactation. The percentage of carryover cows returning to a milking herd at five, six, seven and greater than eight years old was 27%, 15%, 8% and 7%, respectively. Between 2008 and 2015, the average percentage of dairy herds that contained zero, less than 5% and greater than 5% carryover cows were 17%, 69% and 14%, respectively. Of herds that contained carryover cows, the majority (82%) contained less than 5% carryover cows.

Figure 1 The calving-interval distribution for all lactation records in the study. The calving interval for non-carryover lactation records are between 270 days and 546 days and the calving interval for carryover lactation records are between 547 days and 913 days.

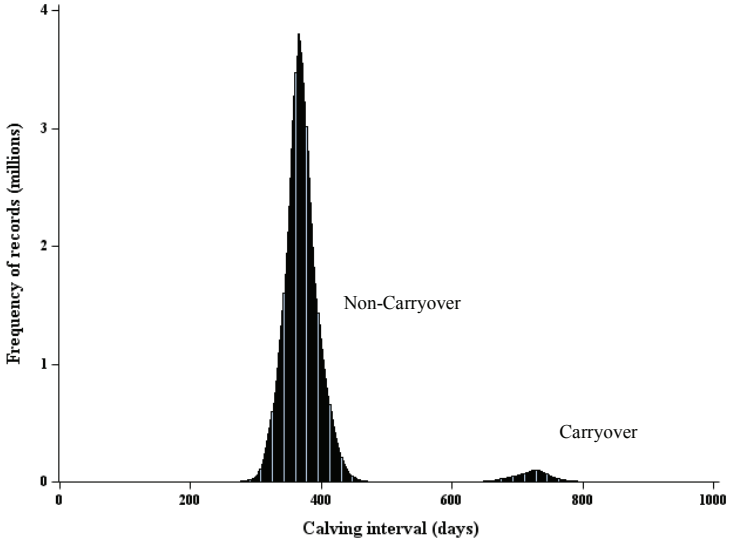

Table 2 Milk yield, fat yield, protein yield and somatic cell score for non-carryover and carryover cows in lactation two, three and four. Milk production values are expressed as least-square means (±standard error of the mean).

Lactation number	Trait	Cow type		P values
		Non-carryover	Carryover	
Two	Milk yield (L)	4,175.2 ± 7.5	4,740.6 ± 8.1	<0.001
	Fat yield (kg)	199.5 ± 0.3	227.2 ± 0.4	<0.001
	Protein yield (kg)	160.8 ± 0.3	180.7 ± 0.3	<0.001
	Somatic cell score	5.75 ± 0.01	6.29 ± 0.01	<0.001
Three	Milk yield (L)	4,635.4 ± 10.7	5,032.0 ± 11.8	<0.001
	Fat yield (kg)	222.0 ± 0.5	242.6 ± 0.5	<0.001
	Protein yield (kg)	179.3 ± 0.4	192.1 ± 0.5	<0.001
	Somatic cell score	5.89 ± 0.01	6.43 ± 0.01	<0.001
Four	Milk yield (L)	4,879.9 ± 16.0	5,164.0 ± 18.3	<0.001
	Fat yield (kg)	234.4 ± 0.7	250.3 ± 0.8	<0.001
	Protein yield (kg)	189.6 ± 0.6	198.4 ± 0.7	<0.001
	Somatic cell score	6.04 ± 0.02	6.56 ± 0.02	<0.001

Table 3 Milk yield, fat yield, protein yield and somatic cell score of four, five and six-year-old non-carryover and carryover cows. Milk production values are expressed as least-square means (±standard error of the mean).

Age (years)	Trait	Cow type		P values
		Non-carryover	Carryover	
Four	Milk yield (L)	4,580.9 ± 8.4	4,745.14 ± 9.1	<0.001
	Fat yield (kg)	219.0 ± 0.4	227.6 ± 0.4	<0.001
	Protein yield (kg)	176.7 ± 0.3	181.4 ± 0.4	<0.001
	Somatic cell score	5.94 ± 0.01	6.27 ± 0.01	<0.001
Five	Milk yield (L)	4,812.5 ± 12.0	5,030.9 ± 13.2	<0.001
	Fat yield (kg)	230.6 ± 0.5	242.8 ± 0.6	<0.001
	Protein yield (kg)	186.0 ± 0.5	192.7 ± 0.5	<0.001
	Somatic cell score	6.10 ± 0.01	6.41 ± 0.02	<0.001
Six	Milk yield (L)	4,970.4 ± 18.9	5,213.1 ± 21.5	<0.001
	Fat yield (kg)	236.9 ± 0.8	250.4 ± 1.0	<0.001
	Protein yield (kg)	192.4 ± 0.8	200.3 ± 0.8	<0.001
	Somatic cell score	6.26 ± 0.02	6.52 ± 0.03	<0.001

Milk production

Second-lactation carryover cows (four years old) produced 4778.1±6.3 L milk, 228.7±0.3 kg fat, 182.0±0.2 kg protein, and had a SCS of 6.31±0.01. The milk production (MY, FY, PY and SCS) of second-lactation carryover cows was greater (P<0.001) than the milk production of heifers that produced 3514.5±5.9 L milk, 168.3±0.3 kg fat, 134.0±0.2 kg protein and had a SCS of 5.89±0.01. In terms of milksolid (kg MS) (protein yield and fat yield) production, a carryover cow produced 108.4 kg MS more (P<0.001) than did heifers.

Carryover cows that returned to a milking herd in second-lactation had greater (P<0.001) MY, FY and PY than that of lactation-matched non-carryover cows (Table 2). The milk production advantage for carryover cows, compared to non-carryover cows, was also evident for those returning to a milking herd during their third and fourth lactation (Table 2). However, the production advantage for MY, FY and PY of carryover cows decreased by 50%, 57% and 44%, respectively for fourth-lactation cows, compared to the production advantage for carryover cows returning to a milking herd in their second lactation.

Four-, five- and six-year-old carryover cows also produced more (P<0.001) MY, FY and PY than that of age-matched non-carryover cows (Table 3). In contrast to lactation-matched cows, the production advantage for MY, FY and PY increased as cow age increased up to six years old. The respective MY, FY and PY production advantage for a six-year-old carryover cow, compared to a six-year-old non-carryover cow was 68%, 64% and 59% greater than the production advantage between a four-year-old carryover and non-carryover cow.

Carryover cow SCS was consistently greater (P<0.001) than the SCS for lactation-matched and age-matched non-carryover cows (Table 2 and 3). Somatic cell score increased as cow age and lactation number increased, regardless of cow type (Table 2 and 3).

Discussion

This study was conducted to estimate the percentage of spring-calving carryover cows in the New Zealand dairy herd and to compare their milk production with that of two-year-old heifers, lactation-matched and age-matched non-carryover cows. To obtain these answers, calving interval was used as an indication of cows that had an extended (one-year) non-lactating period, before returning to a milking herd in the following year.

The results of this study quantified the prevalence of carryover cows that returned to a milking herd each year, as a percentage of all productive (lactating cows) for that year. The majority of carryover cows failed to conceive after their first lactation, and returned to a milking herd for their second-lactation at four years old. The percentage of carryover cows that returned to milking herds was lower in older cows. New Zealand dairy cows reach maximum milk production between five and six years old (LIC & DairyNZ 2016). Thus, a non-pregnant cow that is carried over at greater than four years old will return to a milking herd after her peak milk production. This may negatively influence the decision to carryover older, non-pregnant cows, as an alternative to culling them and introducing a heifer. Management differences among herds that comprise of zero carryover cows and those that contain either less than or greater than 5% carryover contribute to the frequency with which non-pregnant cows are carried over. However, from the information included in the dataset, it is difficult to determine the impact of these management differences.

The difference between the MY, PY and FY of lactation-matched carryover and non-carryover cows decreased as lactation number increased. In contrast, the difference the MY, PY and FY of age-matched carryover and non-carryover cows increased as cow age increased. According to the New Zealand dairy statistics, a four-year-old Holstein-Friesian x Jersey cow is expected to produce 372 L, 17 kg fat and 14 kg protein more than a three-year-old cow of the same breed (LIC & DairyNZ 2016). Positive production differences also occur between five- and four-year-old cows, but at a decreasing rate (LIC & DairyNZ 2016). Thus, it is possible that age trends for milk production have influenced the diminishing carryover effect on milk production in the comparison between lactation-matched carryover and non-carryover cows that have a one-year age difference. However, regardless of these trends, it is evident that a carryover cow will produce more milk than a non-carryover cow of the same age or lactation number.

The milk-production advantage shown for carryover cows, compared to non-carryover cows is consistent with two previous studies conducted on a herd in Canterbury (Pangborn & Woodford 2010; Pangborn & Woodford 2013)**.** It was shown that carryover groups produced an extra 128 kg MS compared to two-year-old heifers (Pangborn & Woodford 2010), which is greater than that that estimated in the current study (108 kg MS). Also, carryover cows produced 41 kg MS (Pangborn & Woodford 2010) and 81 kg MS (Pangborn & Woodford 2013) more than mature-aged (>four years old) non-carryover herd-mates. It is difficult to compare these values with the current results, as milk production was compared between mature-aged carryover and non-carryover cows, rather than age-matched and lactation-matched groups. However, across all studies, carryover cows consistently produced greater MY, FY and PY than did non-carryover groups.

In general, it can be expected that a carryover cow, that has not been lactating in the previous year will be of higher body condition than a non-carryover cow (Pangborn & Woodford 2010). Furthermore, recent work has shown that carryover cow breeding values for milk traits (MY, FY, PY and SCC) are higher than those of non-carryover cows (Unpublished data). These body condition score and genetic merit differences may account for the greater milk production of carryover cows when compared to non-carryover counterparts.

Carryover cow SCS was consistently greater than the SCS for non-carryover groups. Accordingly, the SCS of carryover cows should be monitored by the farmer once they return to a milking herd. Further study is required to determine the reasons for the SCS difference between carryover and non-carryover groups and whether the difference is large enough to have an economic impact.

It is evident from the current study that a proportion of spring-calving cows that fail to conceive, experience a prolonged non-lactating period, before returning to a herd in the following year. The reported milk production advantage of carryover cows, compared to non-carryover cows, will aid on-farm culling decisions. The results of this study, in combination with further work that determines the milk production and survival of carryover cows in subsequent years, could be used to evaluate the economic feasibility of carrying over a non-lactating cow, versus purchasing an age-matched non-carryover cow, or raising a heifer.

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