MILK PRODUCTION AND FERTILITY OF SPRING-CALVED HOLSTEIN-FRIESIAN, JERSEY AND CROSSBRED COWS MILKED ONCE DAILY OR TWICE DAILY IN NEW ZEALAND

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SUMMARY

In New Zealand about 55% of dairy herds are milked twice daily (TAD) and about 9% of herds are milked once daily (OAD) for their entire lactation, with the balance of herds using variable milking frequencies across lactation. The objective of this study was to investigate fertility of spring-calved Holstein-Friesian (F), Jersey (J) and crossbred of Holstein-Friesian × Jersey cows (F×J) milked either OAD or TAD from 2015-2016 to 2017-2018 in New Zealand using data provided by Livestock Improvement Corporation. The dataset comprised 113 OAD and 531 TAD herds. Eight fertility traits were evaluated: submission in the first 3 weeks (SR21) and 6 weeks (SR42) of mating, in-calf in the first 3 weeks (PR21) and 6 weeks (PR42) of mating, conception to first service (PRFS), not in-calf at end of the breeding season (NIC), 3-week calving (CR21) and 6-week calving (CR42) rates. Cows milked TAD produced greater milk, fat, protein and lactose yields than cows milked OAD, but fat (FP) and protein percentages (PP) were lower in cows milked TAD. Cows milked OAD had better fertility with a higher SR21, PR21, PR42, PRFS, CR21, CR42 and a lower NIC than cows that were milked TAD. Breeds differed in fertility traits in both milking regimens. Jersey and F×J cows had higher SR21, SR42 and PRFS than F cows in OAD milking herds, whereas J cows were mated earlier in the mating season than F and F×J cows in TAD. Fertility of F×J cows was better than purebred cows in both milking populations, evidenced by these cows having the highest PR21, PR42, PRFS, CR21, CR42 and lowest NIC. Once daily milking herds benefited from higher FP and PP and better fertility than TAD herds.

INTRODUCTION

Once-daily milking is becoming popular among New Zealand dairy farmers because it benefits the farmers lifestyle, animal welfare, management of feed shortfalls and reduces the cost of labour (Bewsell *et al.*, 2008). In the production year 2015-2016, about 9% of herd-tested herds milked OAD for the whole lactation in New Zealand (Edwards 2018). Improved reproductive performance was reported with spring-calved cows milked OAD for the entire lactation compared to cows milked TAD for the entire lactation in New Zealand (Jayawardana *et al.* 2022).

The New Zealand dairy herd is comprised of crossbreed of F×J cows (49.6%), F (32.5%), J (8.2%), other breeds and crosses (9.3%) and a small proportion of Ayrshire (0.4%), (LIC and DairyNZ, 2021). Grosshans *et al.* (1997) reported breed differences in reproductive performance of New Zealand dairy cows, including shorter intervals from calving and mating to first service and conception, and higher 6-wk in-calf rates in J cows compared to their F counterparts. Lembeye *et al.* (2016) reported J cows milked OAD for their entire lactation were more efficient per kg of live weight than F and F×J cows milked OAD, but suggested that F×J cows are more suitable for OAD milking due to greater total milk solids production, intermediate feed conversion efficiency and biological efficiency. The information of breed differences in reproductive performance in OAD milking system is scare at cow level. The objective of present study was to evaluate the reproductive performance of F, J and crossbred F×J cows milked either OAD or TAD in New Zealand using data from a national herd-testing database.

MATERIALS AND METHODS

Data. Herd test milk yields, calving, mating, and pregnancy diagnosis information of spring-calved dairy cows from 2015-2016 to 2017-2018 production seasons were obtained from the animal database of Livestock Improvement Corporation. Selected herds had at least 50 cows per herd, herd tested four or more times per lactation, pregnancy test results recorded for at least 80% of cows that calved in the 12-month period, and "early aged pregnancy testing" (tested on or between 35 and 122 days of pregnancy) and fetal age estimated for at least 80% of cows in the herd. Herd test-day milking frequency was used to classify herds into OAD or TAD. If more than 90% of the tested cows on a herd-test date were milked either OAD or TAD in a herd, then it was classified as OAD or TAD milking herd on that herd-test date. Likewise, all herd tests were classified. If all herd tests were OAD throughout the season, then the herd was identified as an OAD milking herd. Likewise, if all herd tests were classified as TAD, then the herd was identified as a TAD herd. Finally, 113 OAD and 531 TAD herds were identified. Herds that were OAD at some herd tests and TAD at other herd tests were excluded.

Breeds. Information of breed composition (expressed in sixteenths) for each cow was used to classify the cows into 3 breed categories; F, J, and crossbred of F×J. Herds without F, J or crossbred of F×J cows were excluded. Cows with either less than 100% known breed proportions or more than 12.5% of any breed other than F or J were excluded. Cows were classified as F or J if they had breed compositions of F ≥14/16 or J ≥14/16, respectively and remaining cows were classified as crossbred of F×J.

Production traits. Milk production data included yields of (MY), fat (FY), protein (PY), lactose (LY) and percentages of fat (FP), protein (PP), and lactose (LP). Lactation records with days in milk ranging 150-305 days were analysed.

Fertility traits. Eight fertility traits were defined: submission for artificial insemination in the first 3 weeks (SR21) and 6 weeks (SR42) of the breeding season, in-calf in the first 3 weeks (PR21) and 6 weeks (PR42) of the breeding season, conception to the first service (PRFS), not in-calf at end of the breeding season (NIC), calving by first 3 weeks (CR21) and 6 weeks (CR42) from the planned start of the calving. Conception dates were calculated as the date of pregnancy diagnosis minus the estimated foetal ages with a pregnancy status of 'pregnant'. If the estimated foetal ages were not available but cows calved in the following season, their conception date was calculated as calving date in the following season minus 282 days. Submission by 3 weeks or 6 weeks of the breeding season was coded as 1 if the first mating date was in the first 21 days or 42 days from the start of mating date, respectively, otherwise coded as 0. Likewise, in-calf by 3 weeks or 6 weeks of the breeding season was coded as 1 if the cow was pregnant in the first 21 days or 42 days from the start of breeding season, respectively, otherwise coded as 0. The variable PRFS was only calculated for cows whose first service was to artificial breeding, and was coded as 1 for cows where date of first service equalled date of conception, and 0 otherwise. Pregnancy status at the last pregnancy testing after the end of the breeding period was used to classify the NIC, cows with pregnancy status 'empty' were coded as 1 whereas cows with pregnancy status 'pregnant' were coded as 0. Cows with last pregnancy status as doubtful but calved in the subsequent season were coded as 0, otherwise 1. Planned start of calving date was obtained for a herd by adding 282 d to the herd's mating start date in each calving season. If a cow calved in the first 3 weeks or 6 weeks from the planned start of calving date then it was coded as 1, otherwise 0. The detailed description of editing the fertility traits and calculation of conception in the present study was described in Jayawardana *et al.* (2023). Cows in their first four parities were considered separately and cows of parity five and above were combined into one category.

Statistical analysis. The statistical analyses were undertaken using SAS version 9.4 software. The production traits were analysed using HPMIXED procedure and all fertility traits with binomial distribution were analysed using the GLIMMIX procedure after a logit transformation. Contemporary groups were defined as the group of cows calving in the same herd and year. The model included the fixed effects of milking regimen, breed, parity, interaction of milking regimen and breed, linear and quadratic effects of deviation of calving date from the herd median calving date (within-herd in each calving year) as covariates, and the random effects of herd-year and residual. Least-squares means with logit scale were back-transformed into the nominal scale for interpretation of the results.

RESULTS AND DISCUSSION

Cows milked TAD produced greater yields of milk, fat, protein and lactose and higher LP than cows milked OAD, but had lower FP and PP and poor fertility outcomes. Results indicate that a higher proportion of cows milked OAD were mated (by 4.6%) in the first 3 weeks of the breeding season, conceived in the first 3 weeks (by 10%) and 6 weeks (by 8.6%) of the breeding season, pregnant to their first service (by 6.8%), calved by 3 weeks (by 6.2%) and 6 weeks (by 4.6%) of the following calving season with a lower percentage not in-calf (by 3.7%) at end of the breeding season compared with TAD milking cows. The better reproductive performance of OAD milking cows is hypothesised to be due to OAD milking reducing the extent of negative energy balance in the early lactation cows (Kay *et al.* 2013).

Table 1: Least-squares means of milk production and fertility traits of Holstein-Friesian (F), Jersey (J) and their crossbred cows (F×J) milked in once daily (OAD) or twice daily (TAD)

Traits[1]	OAD	TAD	OAD			TAD			P-value		
			F	J	F×J	F	J	F×J	MF	Breed	MF × Breed
MY(kg)	3291	4708	3595^{a}	2936^{c}	3368^{b}	5115^{d}	4102^{f}	4828^{e}	<.001	<.001	<.001
FY(kg)	170.4	228.9	171.1^{b}	165.2^{c}	175.9^{a}	230.1^{e}	220.4^{f}	235.2^{d}	<.001	<.001	<.001
PY(kg)	134.6	182.1	141.2^{a}	125.3^{c}	138.8^{b}	190.6^{d}	166.7^{f}	187.1^{e}	<.001	<.001	<.001
LY(kg)	162.1	236.4	176.4^{a}	145.5^{c}	166.4^{b}	255.6^{d}	207.1^{f}	242.6^{e}	<.001	<.001	<.001
FP(%)	5.29	4.98	4.82^{c}	5.68^{a}	5.28^{b}	4.55^{f}	5.51^{d}	4.93^{e}	<.001	<.001	<.001
PP(%)	4.13	3.91	3.95^{c}	4.29^{a}	4.14^{b}	3.75^{f}	4.10^{d}	3.89^{e}	<.001	<.001	<.001
LP(%)	4.94	5.03	4.90^{c}	4.96^{a}	4.94^{b}	5.00^{f}	5.06^{d}	5.04^{e}	<.001	<.001	<.001
SR21(%)	85.3	80.7	83.9^{b}	86.6^{a}	86.8^{a}	78.5^{e}	82.5^{c}	81.2^{d}	<.001	<.001	0.30
SR42(%)	93.9	93.7	92.4^{b}	94.8^{a}	94.7^{a}	92.4^{e}	94.9^{c}	94.0^{d}	0.65	<.001	0.11
PR21(%)	55.4	45.4	53.7^{b}	55.7^{b}	57.8^{a}	43.8^{e}	45.1^{d}	47.1^{c}	<.001	<.001	0.94
PR42(%)	76.5	67.9	74.1^{c}	77.1^{b}	78.9^{a}	65.9^{f}	67.8^{e}	69.7^{d}	<.001	<.001	0.28
PRFS(%)	62.1	55.3	60.0^{b}	62.9^{a}	63.5^{a}	54.4^{d}	54.5^{d}	56.6^{c}	<.001	<.001	0.06
NIC(%)	9.8	13.5	10.5^{a}	9.5^{a}	8.6^{b}	14.8^{c}	13.4^{d}	12.4^{e}	<.001	<.001	0.92
CR21(%)	64.2	58.0	64.0^{a}	64.1^{a}	65.8^{a}	57.0^{c}	57.0^{c}	59.6^{b}	<.001	<.001	0.69
CR42(%)	86.6	82.0	85.7^{b}	86.5^{b}	87.9^{a}	81.0^{d}	82.2^{c}	82.9^{c}	<.001	<.001	0.35

[a-f] Means with different superscripts in the same row are significantly different across milking regimen and breeds (P < 0.05).

[1]MY = milk yield; FY = fat yield; PY = protein yield; LY = lactose yield; FP = fat percentage; PP = protein percentage; LP = lactose percentage; SR21 = cow inseminated in the first 3 weeks from the start of mating; SR42 = cow inseminated in the first 6 weeks from the start of mating; PR21 = cow conceived in the first 3 weeks from the start of mating; PR42 = cow conceived in the first 6 weeks from the start of mating; PRFS = cow conceived to first service; NIC = cow not in-calf at end of the breeding season; CR21 = cow calved in the first 3 weeks from the planned start of the calving; CR42 = cow calved in the first 6 weeks from the planned start of the calving; MF= milking frequency.

In both milking systems, F cows had greater MY, PY and LY compared with J and F×J cows, but FY was higher for crossbred F×J cows than purebred F and J cows. Jersey cows were less affected than F and F×J cows by OAD milking with a reduction in MY, PY and FY ranged 25-28%, whereas in F and F×J cows the reduction ranged between 26% to 30%. Fat, protein and lactose percentages were higher in J cows and lowest in F cows in both milking populations. Sneddon *et al.* (2015) reported that J milk was most valuable per litre in New Zealand under the milk product portfolios of whole-milk powder, skim-milk powder, cheese and butter. Milk from J milked OAD has the highest value per litre, due to the increase in fat and protein percentage. Significant interactions were found between milking frequency and breed for milk production traits in this study. However, no milking frequency × breed interactions were detected for any fertility traits. Similarly, in the experimental study by Clark *et al.* (2006), J and crossbred F×J cows were submitted for mating at similar rates, but F×J cows had superior PR42 and NIC rates than J cows. This suggests that conception rates were higher in F×J cows than J cows. Jayawardana *et al.* (2023) reported that heterosis effects of F×J cows for SR21 was lower than PR21 and PR42 in OAD (SR21=2.8% vs PR21=5.5% and PR42=4.1%) and TAD (SR21=3.1% vs PR21 and PR42=5.8%) milking systems. Across both milking regimens crossbred F×J cows had the best overall reproductive performance, and F cows had the worst reproductive performance.

CONCLUSIONS

Cows milked OAD for the entire lactation had higher FP, PP and better fertility outcomes than cows milked TAD during the entire lactation. Fertility differed among breeds in both milking systems. Jersey cows were presented earlier for mating than F cows. Crossbred F×J cows had better fertility than purebred F and J cows, they became pregnant sooner in the mating season, and calved earlier in the following season than F and J cows in both milking populations.

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