Implications of using an extended lactation to change from a spring-calving to an autumn-calving farm system in South Taranaki

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Abstract

Recent changes to pasture-supply curves in South Taranaki, and the availability of winter milk premiums have increased farmer interest in changing from a spring-calving to an autumn-calving farm system. One approach to changing the season of calving from spring to autumn is to extend the calving interval (CI) by delaying the mating period by ~8 months, so that they next calve in autumn and undertake an extended lactation [>305 days in milk (DIM)]. A large-scale farmlet experiment was established in South Taranaki to investigate the production and reproduction responses of cows using this approach. In June 2017, 602 spring-calving cows were allocated to two farmlets. In one farmlet (SPR) 301 cows were mated in October to maintain a 12-month CI spring-calving pattern. In the other farmlet (AUT, n=301 cows), mating was delayed for eight months, and cows underwent an extended lactation (mean DIM, 488; max DIM, 577) to calve next in autumn 2019. The experiment analysed two lactations for the AUT farmlet and two and a half lactations for the SPR farmlet. Across the total experimental period, milksolids (MS) production was similar between farmlets (1,194 *vs.* 1,174 kg MS/cow), however, cows in the AUT farmlet were fed more supplementary feed [2,371 *vs.* 1,951 kg dry matter (DM)/cow]. The extended lactation changed the relationship between feed supply and herd demand, which led to excessive BCS gain and ryegrass staggers for AUT farmlet cows. Further research is required to examine grazing management during extended lactations and to assess the economic implications of this approach.

Keywords: autumn calving; spring calving; extended lactation

Introduction

In South Taranaki, there is increasing farmer-led interest in changing season of calving from spring to autumn in response to climatic constraints and milk-price incentives. There is evidence that the minimum daily temperature during winter, and thus, the number of growing degree days for pasture, has increased in South Taranaki in the past 39 years (J. Jarman, Unpublished data). Combined with more sporadic rainfall (Baldi & Salinger 2008) and low soil moisture causing variable summer pasture growth (Roberts & Thomson 1984), this has resulted in increased pasture-growth rates (PGR) in winter relative to summer (J. Clough, unpublished data). Autumn calving is expected to mitigate the impact of low summer PGR and exploit greater winter PGR (relative to summer) by shifting the herd feed-demand profile to better match the pasture-growth profile. Furthermore, international market demand for short-shelf-life products (e.g., ultra-heat-treated milk and cream) has led to milk-processing companies requiring greater milk supply during winter (Chikazhe et al. 2017), and consequently, to offer a ‘winter milk premium’, in addition to the farmgate milk price, for milk produced between May 15th-July 15th (Spaans et al. 2019). As a result, autumn-calving systems may receive greater revenue from milk sales compared with that from spring-calving systems, assuming the production of MS is similar.

Autumn-calving system performance has been compared with spring-calving systems in farm-system experiments (Fulkerson et al. 1987; Garcia et al. 2000; Pacheco-Navarro 2000; Ryan et al. 1998; Spaans et al. 2019). However, these previous results, as well as two modelling studies (Chikazhe et al. 2017; Figueredo 2003), assume both calving systems are operating in a steady state, and they do not account for the management decisions and implications to the farm system when changing the season of calving.

Many different approaches exist to change from spring to autumn calving, including selling the spring-calving herd, or first adopting split calving. Another common approach is to change the whole herd in one and a half years by extending the CI from 12 months (e.g., calving every July) to ~20 months, so that the herd next calves in autumn, and returning to a 12-month CI thereafter (calving every March). Consequently, the herd undergoes an extended lactation (>305 DIM) between their last calving in spring and their first calving in autumn.

Grainger et al. (2009, p 1419) reported that “no studies have been conducted on subsequent lactations with cows that have initially had an extended lactation and been managed under pasture-based systems”. Therefore, it is important to understand the implications of the extended lactation required to change season of calving on the subsequent lactation and farm-system performance. It is hypothesised that extending the CI for one lactation, to change season of calving from spring to autumn, will have farm-system implications that carry over when the herd returns to a 12-month CI. This paper reports the production and reproduction responses of cows that change from spring to autumn calving using an extended lactation.

Materials and methods

Animal and paddock allocation

In June 2017, 602 spring-calving cows were managed as one herd according to best-management practice of NZ pasture-based systems (Macdonald & Penno 1998) at Kavanagh Farm, Hawera, Taranaki (39°36'34" S, 174°17'21" E). On October 1st 2017, all cows were randomly allocated, balanced for age, breeding worth, DIM, live weight (LWT), body condition score (BCS) and current MS production, into one of two farmlets (autumn calving, AUT; spring calving, SPR) to form two equal herds of 301 cows. On the same day heifers and yearlings, currently grazing off the milking platform, were randomly allocated to each farmlet, balanced for LWT. Subsequent mating dates were altered so heifers in the AUT farmlet returned to the milking platform to calve in February 2019 (~30 months old), while in the SPR farmlet they returned to calve in June 2018 and June 2019 for lactation two and lactation three (~23 months old), respectively. Paddocks were randomly allocated to the farmlets, balanced for area, distance from the milking parlour, pasture species and age, previous cropping history and effluent application. Thirty paddocks (total area = 104.8 ha) were assigned to the AUT farmlet and 29 paddocks (total area = 104.0 ha) to the SPR farmlet. Stocking rate (SR; cows/ha) at the commencement of the experiment was approximately 2.9 cows/ha for both farmlets.

Initiation of the change of calving season

AUT farmlet cows were withheld from mating over October -December 2017, and instead, were mated at 311 ± 30 DIM, beginning June 2018 to achieve a planned start of calving (PSC) of March 15th 2019. SPR farmlet cows were mated beginning October 1st 2017, and every year thereafter.

Farmlet management

Each farmlet was managed as a closed system and daily operational decisions were made for each farmlet independently based on the same pre-written set of decision rules, similar to those described by Macdonald and Penno (1998). Briefly, cows in both farmlets were milked through the same milking parlour twice a day for the majority of each lactation. During the first, second and third lactations (L1, L2 and L3, respectively) for the SPR farmlet, and L2 for the AUT farmlet, drying off and mating protocols were the same. During L1 (extended lactation) for the AUT farmlet, cows producing <10 L milk/day at monthly herd testing were dried off. Both farmlets targeted 1,500-1,600 kg DM/ha post-grazing residuals for lactating cows and 2,200-2,400 kg DM/ha average pasture cover (APC) at PSC.

Unwell or lame cows from both farmlets were grazed together in a 'sick' cow mob that rotated between paddocks allocated to each farmlet to reduce any bias. In-line water dispensing of zinc sulphate, and paddock spraying of Sporeguard® (Ravensdown, active ingredient carbendazim) between February and April was used to control facial eczema. Prior to calving, dry cows received magnesium oxide dusted onto pasture and magnesium chloride dissolved into their water trough. After calving, lactating cows received magnesium oxide and limeflour in their in-shed supplementary feed. Colostrum cows (1 - 4 days post calving) also received limeflour dusted onto their pasture.

Maintenance fertiliser was applied to farmlets based on two-yearly soil nutrient tests. Nitrogen was applied independently to each farmlet as required based on feed-budget forecasts and soil-moisture conditions. During June – August 2018 and 2019, gibberellins (Progibb®, Nufarm) were applied to the AUT farmlet paddocks following a grazing event.

Both farmlets grew ~6 ha of maize *(Zea mays)* for maize silage on the milking platform each year. Approximately 4 ha of turnips *(Brassica rapa)* were grown on both farmlets in 2017/18, and then just on the SPR farmlet in 2018/19 and 2019/20. Pasture silage and hay were harvested from conserved pasture independently on each farmlet, based on the farmlet feed budget. Meal and palm kernel expeller (PKE), stored in one silo, were offered to both farmlets, via in-shed feeding, as determined by the feed budget.

Measurements

Bulk-milk supply data could not be used for MS production analysis because milk from both farmlets was collected into one vat during the 2017/18 season. Instead, monthly herd testing of individual cows, commenced August 2017 and was provided by Livestock Improvement Corporation (LIC) qualified technicians, recording individual cow milk yield, and fat, protein and MS percentage. Herd test data were used before and after the herd test date, either from the date halfway between the current test date and the previous test date, or between the current test date and the subsequent test date. Exceptions were for the first and last herd test data, which were used from the start of lactation and end of lactation, respectively. Rectangles were formed based on the height of the herd test record and the width of the base between the two dates, such that individual cow performance was calculated as the sum of the rectangles, as per the rectangular sum approach (Johnson 1996). Individual cow production was accumulated within lactation to calculate farmlet-level production. Individual cow LWT and BCS [1-10 scale, 0.5 increments; Roche et al. (2009)] were recorded monthly by electronic walk-over scales and visually by the same trained assessor, respectively. Reproductive performance was extracted from LIC InCalf Fertility Focus reports as defined by Hemming et al. (2018).

Pasture herbage mass (kg DM/ha) was measured fortnightly in both farmlets during 2017/18 and then weekly during 2018/19 and 2019/20, using a combination of a tow-behind C-Dax Pasture Meter©, rising-plate meter, or visual assessment for each paddock. Pasture growth rate (kg DM/ha/day) was calculated by dividing the increase in pasture mass by the days between observations, excluding grazing events. Seasonal (winter, June to August inclusive; spring, September to November inclusive; summer, December to February inclusive; autumn, March to May inclusive) PGR were calculated as the average growth rate for each paddock during each season multiplied by the number of days within that season. Yearly pasture growth was calculated as the mean of the seasonal sum for each paddock for the dairy season [i.e., June 1st – May 31st. Year one (Y1), 2017/18; year two (Y2), 2018/19]. Due to the timeline of the experiment, year three (Y3) cannot be calculated. Except for turnips, farm staff recorded daily supplementary feed offered (kg DM/cow/day) by recording the wet weight on electronic scales and multiplying by a DM% calculated from either oven drying of a sample or density calculation of the feed bunker (DairyNZ 2016). Turnips fed was estimated as 90% of the visually assessed turnip yield, assuming 10% wastage (Harris et al. 1998). Supplementary feed offered between June 2017 – January 2018 in L1 was not recorded, so L1 results are less than those of other lactations. However relative differences between farmlets are valid as both farmlets were managed equally during this period.

Statistical analysis

During the experimental period, the cows in the AUT farmlet completed two lactations (one extended, 20-month CI; and one normal, 12-month CI), whereas, cows in the SPR farmlet completed two and a half lactations (all 12-month CI). Milk production, LWT, BCS and supplementary feed data were divided into respective lactations, and farmlet means are presented accordingly. Pasture growth data were divided into respective dairy season (i.e., 1st June-31st May), and least-squares means presented accordingly. Data manipulation and analysis was completed using R software (R Core Team 2019; Wickham et al. 2019). Due to the nature of the experiment, replication by herd or by year was not possible. Either individual cow or individual paddock was the experimental unit and was compared within lactations. A Student's t-test was used to determine difference of means. Significance was declared at $P \leq 0.05$.

Results

Cows in the AUT farmlet produced 299 kg MS (67%; $P<0.001$) and 105 kg MS (25%; $P<0.001$) more MS compared with cows in the SPR farmlet during L1 and L2, respectively (Table 1). However, as cows in the SPR farmlet underwent an additional lactation (i.e., L3; Figure 1), total MS production per cow was similar between farmlets across the total experimental period (AUT, 1,194 *vs.* SPR, 1,174 kg MS). Cows in the AUT farmlet were offered 147%, 32% and 22% (625, 320, 420 kg DM/cow) more supplementary feed during L1, L2 and the total experimental period than were cows in the SPR farmlet, respectively. The additional supplementary feed was mainly offered during the winter months to these cows. Pasture growth was similar between farmlets in both Y1 and Y2 ($P>0.05$ for both; Table 1).

During L1, AUT farmlet cows had greater DIM (488 *vs.* 261; $P<0.001$), and produced milk containing greater fat and protein percentages ($P<0.05$) compared with that of SPR farmlet cows (Table 1). During L1, 92%, 86%, 67% and 52% of the AUT farmlet cows were still lactating at 300, 400, 500 DIM and final dry off (January 31st 2019), respectively. Average DIM was 488, while maximum DIM was 577. Cows in the AUT farmlet gained greater LWT and BCS ($P<0.001$), and at drying off (January 2019 for AUT, May 2018 for SPR) were heavier and had a greater BCS than cows in the SPR farmlet ($P<0.001$; Table 2).

During L2, AUT farmlet cows had greater DIM (293

Figure 1 Daily milksolids (MS) production per cow (kg MS/cow/day) in autumn-calving (AUT; solid line) and spring-calving (SPR; dotted line) farmlets during the experimental period (June 1st, 2017-January 31st, 2020). Grey shade indicates 95% confidence interval.

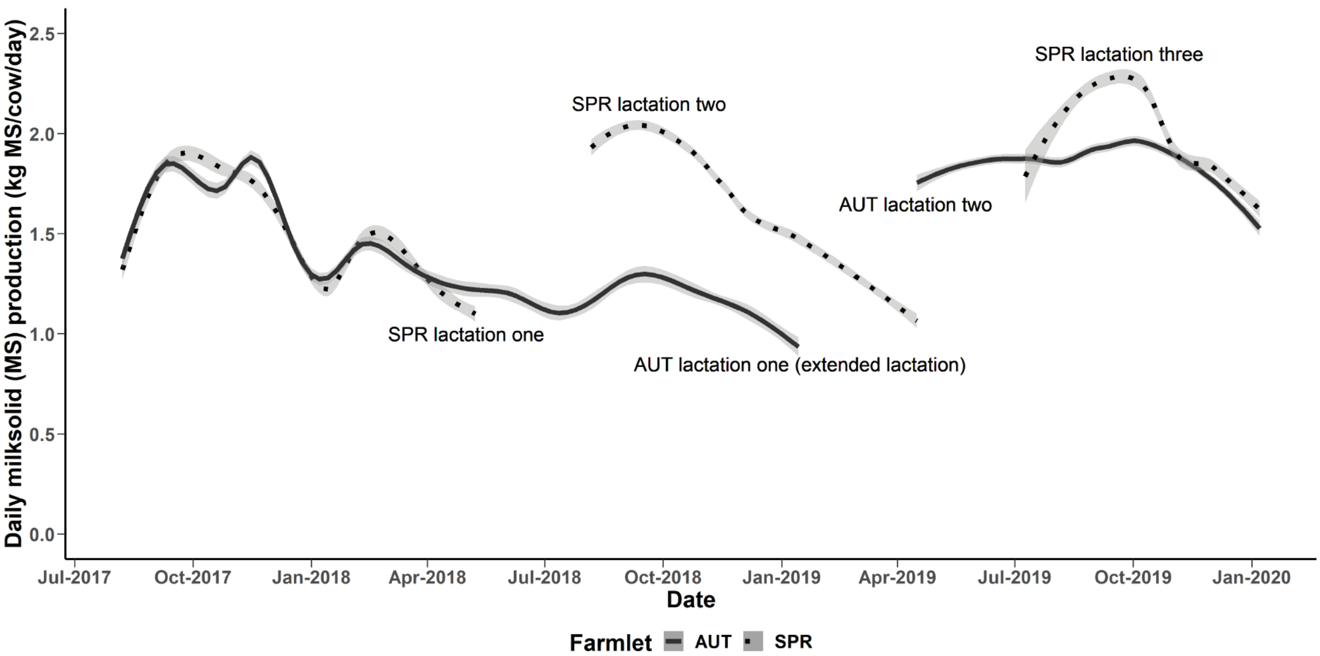

Table 1 Peak numbers of cows milked and least-squares means, standard error of the difference (SED) and significance of the difference between means of days in milk (DIM), total milksolids (MS), MS per day, concentration of fat and protein in milk per cow and supplementary feed offered [kg of dry matter (DM)/cow] during each lactation of the experimental period (June 2017-January 2020), and yearly (June 1st-May 31st) pasture growth in autumn-calving (AUT) and spring-calving (SPR) farmlet herds. Lactation one for the AUT farmlet is an extended lactation. Lactation three for the SPR farmlet is a part lactation, ending January 31st 2020.

	Item	AUT	SPR	SED	P value
Lactation 1	Peak cows milked	301	301		
Production, per cow	DIM	488	261	6.5	<0.001
	MS (kg)	661	395	10.8	<0.001
	MS (kg)/day	1.36	1.51	0.02	<0.001
	Fat (%)	5.21%	5.08%	0.06	0.03
	Protein (%)	4.32%	4.06%	0.03	<0.001
	Supplementary feed (kg DM/cow)[1]	1,049	424		
Lactation 2	Peak cows milked	306	305		
Production, per cow	DIM	293	268	3.0	<0.001
	MS (kg)	533	428	7.4	<0.001
	MS (kg)/day	1.82	1.61	0.02	<0.001
	Fat (%)	5.14%	5.04%	0.05	0.04
	Protein (%)	4.09%	4.15%	0.02	0.02
	Supplementary feed (kg DM/cow)	1,322	1,002		
Lactation 3	Peak cows milked		310		
Production, per cow	DIM		178		
	MS (kg)		351		
	MS (kg)/day		1.98		
	Fat (%)		4.77%		
	Protein (%)		4.05%		
	Supplementary feed (kg DM/cow)		525		
Experimental period[2]					
Production, farmlet total	MS(kg)	362,028	358,869		
Production, per cow	MS (kg)	1,194	1,174		
	DIM	781	707		
	MS (kg)/day	1.53	1.66		
	Supplementary feed (kg DM/cow)	2,371	1,951		
Pasture growth[3]					
Year 1	Pasture growth (kg DM/ha)	11,512	10,878	508	0.22
Year 2	Pasture growth (kg DM/ha)	12,707	13,349	516	0.49

[1] Supplementary feed offered in lactation 1 (L1) between June 2017-January 2018 was not recorded so L1 results are less than other lactations. However relative differences between farmlets are valid as both farmlets were managed equally during this period.
[2] Combined production from all lactations.
[3] Due to the timeline of the experiment, year 3 cannot be presented.

vs. 268; P<0.001), produced milk containing greater fat percentage (P<0.001), and lactated for an additional 25 days (P<0.001), compared with SPR farmlet cows. Cows in the AUT farmlet also displayed greater lactation persistency (Figure 1). AUT farmlet cows begun L2 heavier and with greater BCS, gained greater LWT and BCS, and were heavier and with greater condition at drying-off compared with SPR farmlet cows (all P<0.001).

Compared with the SPR farmlet herd, the AUT farmlet herd had numerically better reproductive performance during L1, while both performed similarly during L2 (Table 3).

There was no difference in the recorded incidence of hypocalcaemia or facial eczema between farmlets. During the dry period between L1 and L2, incidences of ryegrass staggers were recorded for the AUT farmlet cows but not SPR farmlet cows.

Discussion

During L1, MS production from cows in the AUT farmlet followed a similar profile to that in other farm-systems experiments in which cows have undergone an extended lactation (Kolver et al. 2007). Persistency of MS production continued to decline after 305 DIM (typically when cows with 12-month CI are dried off), but there was then an additional MS peak that corresponded to the second spring period. This peak is most probably due to the greater quantity and quality of spring pasture in the diet (Kolver et al. 2007).

During L2 (12-month CI for both herds), cows in the AUT farmlet did not produce as much milk at peak lactation (88 days since PSC), compared with those in the SPR farmlet (106 days since PSC), but MS production did not decline as rapidly following peak (Figure 1). Cows in the AUT farmlet also had greater DIM compared with cows

Table 2 Least-squares means, standard error of the difference (SED) and significance of the difference between means of live weight and body condition score [BCS; 1-10 scale (Roche et al. 2009)] at the start of lactation[1], dry off[2] and change[3] between, of autumn-calving (AUT) and spring-calving (SPR) farmlet herds during each lactation of the experimental period. Lactation one for AUT is an extended lactation. Lactation three for SPR is a part lactation, and end of experiment is presented instead of dry off.

Live weight (kg)		AUT	SPR	SED	P value
Lactation 1	Start of lactation	469	461	4.6	0.09
	Dry off	578	497	4.9	<0.001
	Change	109	36	3.4	<0.001
Lactation 2	Start of lactation	518	476	5.1	<0.001
	Dry off	573	503	5.1	<0.001
	Change	54	27	2.8	<0.001
Lactation 3	Start of lactation		485		
	End of experiment		495		
	Change		9		
Body condition score					
Lactation 1	Start of lactation	4.2	4.1	0.0	0.35
	Dry off	5.4	4.2	0.1	<0.001
	Change	1.3	0.0	0.1	<0.001
Lactation 2	Start of lactation	4.7	4.2	0.1	<0.001
	Dry off	4.6	4.3	0.0	<0.001
	Change	-0.1	0.1	0.1	<0.001
Lactation 3	Start of lactation		4.3		
	End of experiment		4.3		
	Change		0.0		

[1] First recorded observation after calving

[2] Last recorded observation before drying off.

[3] Change in live weight/BCS divided by the number of days between the first and last recorded observation.

Table 3 Three-week submission rate (3wk SbR), six-week in-calf rate (6wk InC) conception rate (CR), not-in-calf rate (NinC) and differences between autumn-calving (AUT) and spring-calving (SPR) farmlet herds for mating periods during each lactation. Lactation one for the AUT farmlet is an extended lactation. Lactation three for the SPR farmlet is a part lactation, ending January 31st, 2020.

		AUT	SPR	Difference
3wk SbR	Lactation one	88%	72%	16%
	Lactation two	80%	81%	-1%
	Lactation three	-	86%	
6wk InC	Lactation one	80%	64%	16%
	Lactation two	65%	66%	-1%
	Lactation three	-	74%	
CR	Lactation one	73%	51%	22%
	Lactation two	54%	57%	-3%
	Lactation three	-	58%	
NinC	Lactation one	8%	16%	-8%
	Lactation two	14%	12%	2%
	Lactation three	-	11%	

in the SPR farmlet, which is consistent with other literature (Garcia & Holmes 2001; Garcia et al. 2000). However, as to whether the increased production is due to different calving season or due to other farm-system changes during this lactation is unknown. Spaans et al. (2019) concluded that there was no difference in DIM or MS production between autumn- and spring-calving herds that were managed the same, stating that differences reported by the former authors were due to farm-system changes such as SR or supplementary feed, and not calving season *per se*. Therefore, as the quantity of supplementary feed offered varied in this current experiment, MS production was also confounded by this factor.

Cows in the AUT farmlet gained excessive LWT and BCS during the extended lactation. This is primarily due to the feed-supply and feed-demand relationship changing in the latter stages of the extended lactation (Auldist et al. 2007; Grainger et al. 2009; Kolver et al. 2007). To maximise DIM and achieve grazing-management targets outlined in the farmlet decision rules, lactating cows were offered pasture diets in which feed supply (i.e., energy input) exceeded herd feed demand (i.e., energy output) during the second spring of the extended lactation. Cows selectively bred for 12-month CI preferentially convert this excess energy to adipose tissue rather than milk production, thus, increasing BCS (Kolver et al. 2007). In response to the increased risk of periparturient metabolic disease with excessive BCS (e.g., hypocalcaemia; Roche et al. 2013a), non-lactating cows in the AUT farmlet were offered a restricted diet by slowing the rotation length. Consistent with reports in the literature, this management strategy improved the metabolic status of cows after calving and there was no difference in incidence of hypocalcaemia between farmlets. However, the restricted pasture allocation was a factor in increasing the incidence of ryegrass staggers during March and April, because cows in the AUT farmlet grazed lower into the sward (Cosgrove

& Edwards 2007), increasing their intake of mycotoxins (di Menna et al. 2012). Therefore, restricting pasture intake in non-lactating cows reduced the BCS gain and the risk of metabolic disease, but exacerbated pasture management issues. This highlights the challenge of achieving greater DIM and revenue from milk production during an extended lactation, while achieving pasture management and BCS targets at calving in NZ dairy cows bred for 12-month CI (Kolver et al. 2007).

Cows in the AUT farmlet had a greater milk-fat percentage compared with that of cows in the SPR farmlet. We postulate that this was due to the greater body tissue mobilisation during L2 because of greater BCS at calving. There is a positive association between calving BCS and milk-fat percentage, potentially due to greater lipolysis providing long chain fatty acids for milk-fat production (Roche et al. 2009; Roche et al. 2013b). Furthermore, recent increases in the farmgate value of fat relative to protein (Edwards et al. 2019) mean that the value of milk produced in L2 by the AUT farmlet may be greater than that of the milk produced by the SPR farmlet.

The improved reproductive performance of AUT farmlet cows during L1 (extended lactation) tends to align with other farm-systems' literature (Butler et al. 2010; Kolver et al. 2007), however, accurate comparisons are confounded by the methods used by the former authors to create an extended lactation (e.g., mating and abortions), and low cow numbers in those experiments. Regardless, a possible explanation may be that increasing the CI allows the cow greater time to regain positive energy balance and clear any uterine infections. A negative energy balance during early lactation, that coincides with the mating period in a 12-month CI system, is an accepted factor involved in poor reproductive performance (Berry et al. 2016). Cows are more likely to have cycled multiple times and be in a positive energy balance later in lactation, which is when mating occurred for the AUT cows in the current experiment. Uterine infections typically occur 1 - 21 days postpartum, but can persist for longer than 70 days, suppressing reproductive performance in the typical mating period for 12-month CI (Sheldon et al. 2009). An implication of greater reproductive performance during the extended lactation is a more-condensed calving pattern at the beginning of L2, which requires greater feed availability and higher peak workload for staff.

Conclusion

As MS production did not differ between farmlets, there was no MS production penalty incurred in this approach to changing calving season within the timeframe considered in this paper. However, there was greater use of supplementary feed in the AUT farmlet and a higher milk price received from the higher fat percentage and winter milk premium, thus, the cost/benefit of this approach to changing to an autumn-calving system still needs to be determined. There are potential farm-system implications if an extended lactation is used to change the season of calving. The implementation of grazing decisions, considered best management practice in spring-calving systems (Macdonald & Penno 1998), in addition to maximising DIM in the latter stages of the extended lactation, led to excessive BCS gain as well as animal-health implications. Future research is required to investigate optimal strategies to alleviate the implications reported in this current experiment. Furthermore, as the increase in BCS and reproductive performance during the extended lactation have carry-over effects on the subsequent lactation, we propose that the first calving in autumn (12-month CI; L2 in the present experiment) is not representative of a steady-state system, and should be considered as part of the system change.

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