Mining Dry Period Data for Insights into Improved Lactation Performance

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Take Home Messages

- Short gestation length is the main contributor to poor performance in the ensuing lactation.
- There is little evidence of negative impacts from moderately short dry periods (e.g. 40 – 50 days)
- Cows with greater production potential (e.g., those with greater previous lactation milk yield) were most negatively impacted by a short gestation.
- Managing for shorter dry periods (e.g., 45 days rather than 60) is feasible.
- Cows with long lactations followed by long dry periods are at greater risk of removal after calving, likely due to poor metabolic health.

Introduction

The dry period of the dairy cow allows time for the mammary gland to undergo involution, proliferation, and differentiation, which in turn allows for maximal production during the following lactation (Capuco et al., 1997). In addition, during the three weeks preceding calving, specific diets are fed to reduce incidence of metabolic disease after calving. These well-established routines for dairy cattle management remain under investigation, but 'no dry period' management strategies are not widely adopted in North America. Nevertheless, nuance remains regarding exactly how long a dry period should be for optimal health and productivity outcomes, along with varying opinions regarding the 'flex' that can be built into the system. For example, many farms dry off cows once per week, meaning there is a 7-day variance in expected dry period length, even if no cows are missed. Is this too wide? Or is there room to allow a 14-day variance in dry period length and benefit from only needing to dry off every 2 weeks? These questions have important implications for optimal dairy herd management.

Decades of Research

Even if dry period management is relatively uniform across North American dairy farms, the consistency and precision with which those protocols are applied can be variable across farms. Dry periods that are substantially shorter or longer than 60 days have been associated with negative effects on dairy cattle productivity in the subsequent lactation. Many retrospective observational studies in the 1970s to 1990s were conducted to identify an optimal dry period length (Schaeffer and Henderson, 1972; Funk et al., 1987); however, these studies are criticized due to the nonrandom assignment of cows to dry period length. As discussed in the review by Bachman and Schalrer (2003), the short dry periods in these studies were unplanned and likely mostly composed of cows that calved early for various reasons. Milk yield of cows following these unplanned short dry periods is often less compared with that of cows that achieve the intended dry period length. In contrast, Smith and Legates (1962) reported that cows with the shortest dry period were those with greatest milk production; however, length of dry period considered short was ≥ 51 days. Milk production was speculated to be lesser for cows with long dry periods in these studies because low milk production is a typical reason for early dry off and therefore extended dry period; again, a biased population calls the result into question. Makuza and McDaniel (1996) were the first to at least account for some of the aforementioned bias by including previous days dry and previous milk yield in the statistical

model when evaluating the effect of days dry on subsequent milk yield.

A retrospective study by Pinedo et al. (2011) incorporated herd records on 12,000 cows from 223 farms and evaluated the associations between dry period length and milk production, milk somatic cell count (indicative of mastitis and mammary infection), reproductive performance, and retention in the herd. Cows were managed according to individual farm target dry period length (60 days for most herds), but were grouped and analyzed by intervals of actual dry period length. Short dry period (0 to 30 days) and extended dry period (143 to 250 days) were associated with increased odds of subclinical mastitis in early lactation, decreased reproductive performance and decreased milk yield. Although these results provided evidence that deviations from the target dry period length can be detrimental, there was no context for the reasons causing the short or long dry periods. Another caution is that the study population represents Chilean dairy herds with a herd size between 37 and 800 cows with average 305-d milk production of 7,429 kg/cow which does not adequately represent our target population in the United States where herd size is continuously increasing and 305-d milk production per cow is up to 10,430 kg (National Agricultural Statistical Service, 2017).

A major factor influencing dry period length is gestation length. A more recent retrospective observation study used records from 2 herds (United States, herd size > 1,500 cows) to investigate the effects of gestation length on productivity (Vieira-Neto et al., 2017). Cows with short (> 1 standard deviation below the mean) or long (> 1 standard deviation above the mean) gestation length had greater incidence of dystocia, stillbirth, retained placenta and metritis. Milk production was greatest for cows with an average gestation length. Interestingly, short gestation length of the dam also affected their offspring; female offspring had a greater rate of removal than heifers from cows that experienced an average gestation length.

The many factors influencing dry period length can be categorized as management or biological. When evaluating the effects of dry period length on cow productivity, observational studies such as those by Makuza and McDaniel (1996) and Pinedo et al. (2011) did not differentiate causes of a short or long dry period. Vieira-Neto et al. (2017) solely addressed the influence of gestation length (biological) on cow productivity. To our knowledge, no previous study evaluated the links between productivity and dry period length due to both biological and management factors simultaneously.

▪ Our Approach: Untangling Gestation Length from Dry Period Length

We hypothesized that cows with a dry period deviating from their intended dry period length (short or long) because of biologically shorter or longer gestation lengths have more severe impacts on cow productivity compared with cows deviating because of management reasons.

We used herd records from 16 U.S. herds in a retrospective cohort study to evaluate the effects of an unintended short or long dry period caused by deviations in gestation length or time of dry off on dairy cattle health and performance in the subsequent lactation (Olagaray et al., 2020). Herd inclusion criteria were as follows: Holstein cows; ≥ 900 cows; use of Dairy Comp 305, PCDART, or DHIA-Provo herd management software; exclusive use of AI breeding; available individual cow milk yields at least every 60 days; and consistent recording of breeding date, dry-off date, and calving date. Data were extracted from the herd records and merged with data obtained from a brief questionnaire for each farm. Herd data were incorporated into a database to allow for analysis of cow-level independent variables while accounting for herd.

In total, after cleaning the dataset, we had 32,182 lactation records to use for testing our hypothesis. These records were separated into nine study groups. For both gestation length and dry period length, populations within a herd were analyzed to determine the mean and standard deviation (SD) for the two variables. Then, cows were categorized as short (1 or more SD below the mean), long (1 or more SD above the mean) or average (within 1 SD of the mean) for both variables. This generated the nine study groups (Figure 1).

		Gestation length		
		Short	Average	Long
Dry period length	Short	S_DS_G n = 2,123	S_DA_G n = 1,418	S_DL_G n = 50
	Average	A_DS_G n = 1,759	A_DA_G n = 19,265	A_DL_G n = 3,325
	Long	L_DS_G n = 310	L_DA_G n = 2,573	L_DL_G n = 1,719

Figure 1. Schematic showing the composition of the nine study groups used to assess independent impacts of short (S), average (A), and long (L) dry periods (D) and gestations (G).

Although in theory nine groups were available, in reality, too few cows had a long dry period and a short gestation, and too few had a short dry period and a long gestation. These two groups were dropped from analyses due to poor sample sizes.

Because distribution analysis of dry period and gestation length occurred within a farm, there was some overlap in the distribution of these variables across the overall dataset. Nonetheless, the differences among groups were clear (Figure 2).

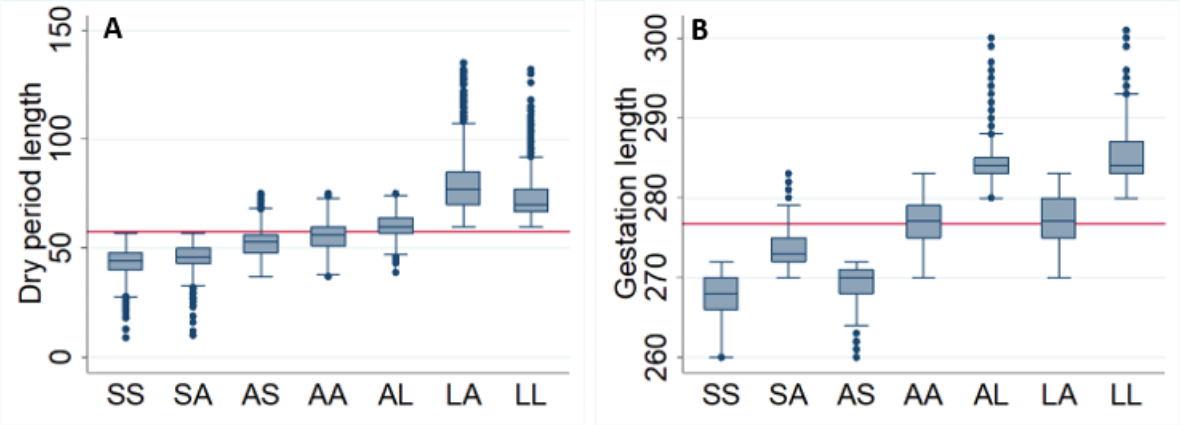


Figure 2. Distribution of (A) dry period length and (B) gestation length across study groups. Cows classified as having short (S), average (A), and long (L) dry periods averaged 45, 56, and 74 day dry periods, while cows classified with short, average, and long gestations averaged 269, 276, and 284 day gestations, respectively.

One simple insight from this study is that modern Holstein cows have an average gestation length of around 276 days, several days shorter than reference tables typically show.

In terms of productivity outcomes, significant differences among study groups were already apparent at first milk test. The most meaningful difference was in milk fat yield, which was decreased in both short-gestation study groups compared to the reference population (average dry period and gestation, Table 1).

Table 1. First-test milk variables for seven study groups varying in dry period and gestation lengths. Means that do not share a superscript are significantly different from one another. LSC: linear somatic cell score; SEM: standard error of the mean.

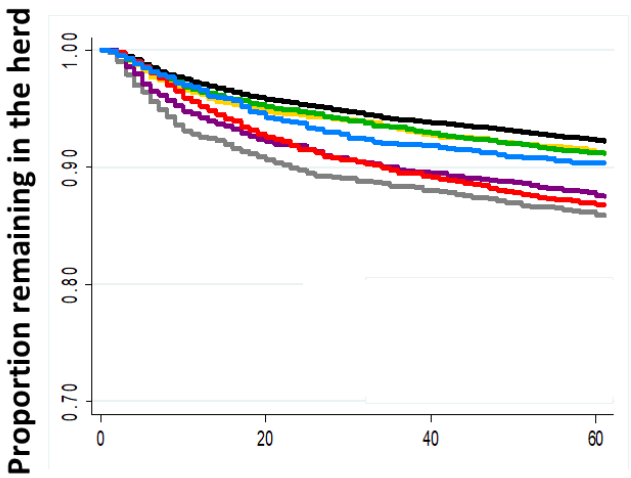
	S_DS_G	S_DA_G	A_DS_G	A_DA_G	A_DL_G	L_DA_G	L_DL_G	SEM	*P*-value
Milk yield, kg	38.72	41.58	39.78	42.37	42.91	42.63	43.11	1.00	0.16
Milk fat concentration, %	4.04	4.10	4.08	4.05	4.07	4.08	4.04	0.10	0.002
Milk fat yield, kg	1.61^{c}	1.72^{ab}	1.69^{b}	1.75^{a}	1.77^{a}	1.74^{ab}	1.75^{ab}	0.06	< 0.001
Milk protein concentration, %	3.17^{a}	3.14^{ab}	3.12^{bc}	3.10^{c}	3.09^{c}	3.05^{d}	3.03^{d}	0.02	< 0.001
Milk protein yield, kg	1.27	1.31	1.29	1.33	1.34	1.34	1.31	0.03	0.65
LSC	2.37	2.59	2.39	2.38	2.47	2.41	2.41	0.18	0.08
Fat:protein concentration	1.29	1.32	1.32	1.32	1.33	1.34	1.34	0.03	0.54

Whole-lactation productivity was also most negatively impacted by short gestation, although a short dry period appeared to exacerbate the negative impacts. This group produced significantly less milk, fat, and protein than the reference group (Table 2).

Table 2. Whole-lactation variables for seven study groups varying in dry period and gestation lengths. Means that do not share a superscript are significantly different from one another. LSC: linear somatic cell score; SEM: standard error of the mean.

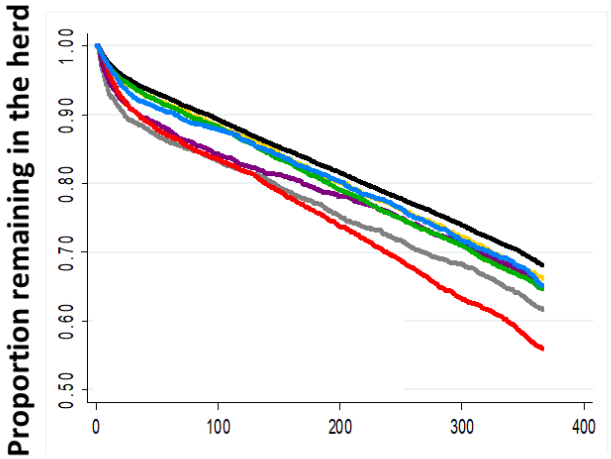
	S_DS_G	S_DA_G	A_DS_G	A_DA_G	A_DL_G	L_DA_G	L_DL_G	SEM	*P*-value
305-ME milk yield, kg	$12{,}204^{b}$	$12{,}526^{a}$	$12{,}408^{a}$	$12{,}537^{a}$	$12{,}505^{a}$	$12{,}296^{a}$	$12{,}542^{a}$	255	< 0.001
Milk fat concentration, %	3.68	3.69	3.66	3.67	3.70	3.65	3.67	0.07	< 0.01
Milk fat yield, kg	436^{b}	451^{a}	446^{ab}	452^{a}	455^{a}	448^{a}	454^{a}	15	0.03
Milk protein concentration, %	3.16	3.13	3.11	3.11	3.10	3.08	3.07	0.03	< 0.001
Milk protein yield, kg	372^{c}	378^{ab}	375^{abc}	379^{a}	380^{c}	372^{c}	373^{bc}	7.9	< 0.001
LSC	2.43	2.29	2.41	2.36	2.39	2.43	2.33	0.17	0.17

The survival analyses were even more interesting. As shown in Figure 3, three groups left herds much more quickly than other groups in the first 60 days of lactation: both groups with short gestation lengths and the long dry period group with average gestation length. Color-coded study groups are graphed to show the rate of removal from herds.



	HR	SE	*P*-value
Study group			0.04
S_DS_G	1.07	0.13	0.57
S_DA_G	0.83	0.14	0.26
A_DS_G	1.34	0.17	0.02
A_DA_G	Ref	Ref	-
A_DL_G	1.13	0.12	0.26
L_DA_G	1.30	0.14	0.03
L_DL_G	1.03	0.16	0.84

Figure 3. Retention in the herd over the first 60 days in milk. Color-coded study groups are graphed to show the rate of removal from herds, while the accompanying table shows the hazard ratio (HR) for the group compared with the reference population, after adjusting for other factors (e.g., parity). An HR of 1.34 indicates a 34% increased risk of removal over this window of time compared that of cows with an average dry period and gestation length.



	HR	SE	*P*-value
Study group			< 0.001
S_DS_G	0.97	0.05	0.50
S_DA_G	0.92	0.05	0.15
A_DS_G	0.99	0.06	0.83
A_DA_G	Ref	Ref	-
A_DL_G	1.07	0.04	0.10
L_DA_G	1.24	0.05	< 0.001
L_DL_G	1.01	0.06	0.93

Figure 4. Retention in the herd over 365 days after calving.

Figure 4 shows the hazard ratio (HR) for the group compared with the reference population, after adjusting for other factors (e.g., parity). An HR of 0.97 indicates a 3% decreased risk of removal over this window of time compared with that of cows with an average dry period and gestation length.

Over nearly the full inter-calving interval (365 days), it was the long dry period group with average gestation length that stood out for having a 24% increased removal rate compared with the reference population. This group also showed greater fat:protein ratios in early lactation, and these relationships were more extreme for cows with a long previous days open (long lactation + long dry period). These results, in our minds, point clearly to a subset of cows that became over-conditioned prior to the calving event evaluated here, resulting in excessive body fat mobilization, poor fertility, and greater culling rate.

Conclusion

What did we learn from this mountain of data (Olagaray et al., 2020)? Short gestation length is the main contributor to poor performance in the ensuing lactation. We know that many physiological stressors, including heat stress, disease, and chronic inflammation, can trigger early calving. It is likely that these stressors are what actually lead to the decreased performance, rather than a short dry period causing these outcomes *per se*.

There was little evidence of negative impacts from moderately short dry periods (e.g., 40 – 50 days), except that cows who also calved early seemed to have more negative outcomes. In this study we were not able to assess days in the close-up pen, and it's possible that shrinking this period (especially) at both the beginning and the end had more negative consequences. In our publication, we demonstrate that cows with greater production potential (e.g., those with greater previous lactation milk yield) were most negatively impacted by a short gestation.

Managing for shorter dry periods (e.g., 45 days rather than 60) seems feasible based on this study, with a few caveats. Cows that dried off with high milk yield seemed to benefit the most from a 'full' dry period, suggesting that delaying dry-off because of concerns about a cow giving too much milk may be counter-productive. Additionally, cows with short dry periods with an average gestation length had, on average, greater somatic cell counts at first test. These results add to the long list of findings that remind us that cows with long lactations followed by long dry periods are at great risk of removal after calving, likely due to poor metabolic health and effects downstream of that. We found few impacts of long gestation length, with the caveat that we did not have consistent data on calving ease across herds.

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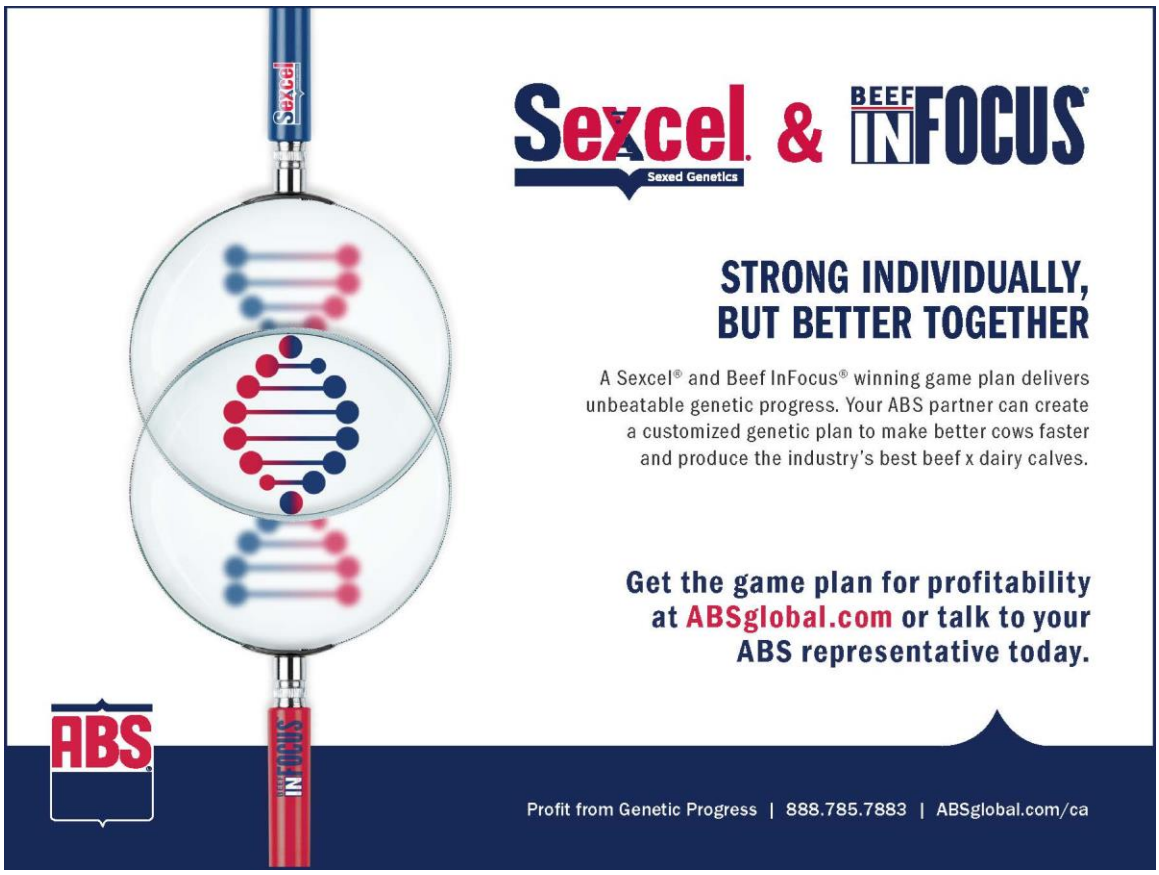
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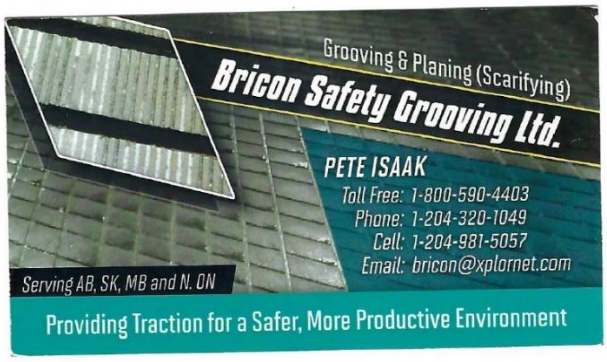
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