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Extending lactation length: consequences for cow, calf, and farmer

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Abstract

Traditionally, a 1-yr calving interval is advised to farmers from an economical point of view, to realize a yearly peak in milk yield. A 1-yr calving interval, however, implies a yearly event of drying-off, calving and start of lactation, which are all associated with an increased risk for diseases and disorders. Deliberately extending the lactation length by extending the voluntary waiting period (VWP) for first insemination reduces the frequency of these challenging events. This reduction in frequency of calvings can be beneficial for cow health and fertility, but also can be of interest to reduce the number of surplus calves and labor associated with drying off, calving, and disease treatments. Current concerns with respect to an extended lactation are that milk yield is too low in late lactation, which might be associated with an increased risk of fattening of cows in late lactation, and compromised economic returns at herd level. In addition, limited knowledge is available with respect to consequences for cow performance in the subsequent lactation and for calves born to cows with an extended lactation. Moreover, response of dairy cows to an extended VWP depends on individual cow characteristics like parity, milk yield level or body condition. A customized strategy based on individual cow characteristics can be a future approach to select high-producing cows with persistent lactation curves for an extended lactation to limit the risk for fattening and milk yield reduction at the end of the lactation while benefitting from a reduction in challenging events around calving.

Lay Summary

Traditionally, a 1-yr calving interval is advised to dairy farmers to realize a yearly peak in milk yield. A 1-yr calving interval, however, implies a yearly event of drying-off, calving, and start of lactation, which are all associated with an increased risk for diseases and disorders. Deliberately extending the lactation length reduces the frequency of these challenging events both for individual cows and at herd level. This reduction in frequency of calvings can be beneficial for cow health and fertility, but also can be of interest to reduce the number of surplus calves and labor associated with drying off, calving, and disease treatments. Current concerns with respect to an extended lactation are that milk yield is too low and cows can get fat in late lactation. Moreover, limited knowledge is available with respect to consequences for cows in the subsequent lactation and for calves born to cows with an extended lactation. Moreover, response of dairy cows to an extended voluntary waiting period depended on individual cow characteristics such as parity, milk yield level, or body condition. A customized strategy based on individual cow characteristics can be a future approach to select suitable cows for an extended lactation.

Key words: cattle, customized lactation length, fertility, health, individual variation, milk production

Abbreviations: AI, artificial insemination; BCS, body condition score; BHB, β-hydroxybutyrate; CInt, calving interval; DIM, days in milk; FPCM, fat-and-protein corrected milk yield; GHG, greenhouse gas; MY/CI, milk yield per day of calving interval; NEFA, non-esterified fatty acids; SCC, somatic cell count; TMR, total mixed ration; VWP, voluntary waiting period

Introduction: Why Re-evaluate Lactation Length?

Traditionally, dairy farmers are recommended to aim for a 1-yr calving interval, as this would maximize milk production and income (Dijkhuizen et al., 1985; Strandberg and Oltenacu, 1989). Longer calving intervals would extend the period in late lactation, when milk production is lower. However, there may be several reasons to re-evaluate the traditional lactation length, including increased productivity of modern dairy cows, and potential benefits of longer lactations for cow health and welfare (Knight, 2005; Sorensen et al., 2008). Moreover, although farmers are advised to aim for a 1-yr calving interval, in practice calving intervals mostly exceed 1 yr (Figure 1; CRV 2021).

A consequence of a 1-yr calving interval is that cows are subjected to a transition period once a year. The transition period is characterized by large changes in cow physiology, including drying-off, calving, and the onset of lactation, as well as changes in ration and management. Especially the onset of lactation, when the cow is recovering from calving and at the same time in a state of negative energy balance, is associated with an increased risk of metabolic disorders and diseases (Friggens et al., 2004; Koeck et al., 2012). Extending lactations of dairy cows would increase calving intervals and thereby reduce the frequency of transition periods for dairy cows (Bertilsson et al., 1997; Knight, 2005; Sehested et al., 2019). Moreover, deliberately extending the lactation

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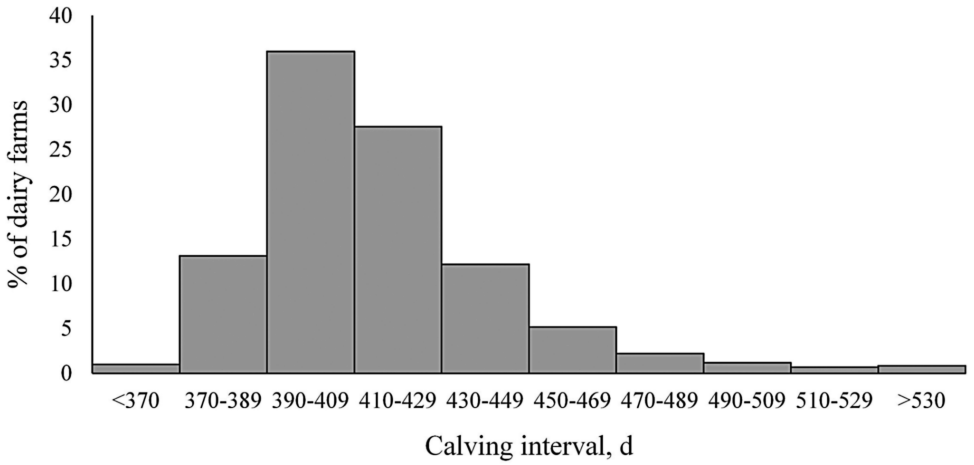

Figure 1. Distribution of Dutch dairy herds by calving interval, based on data from 1 September 2019 to 31 August 2020 (CRV, 2021).

by extending the voluntary waiting period (VWP) may be a strategy to postpone artificial insemination (AI) for cows with compromised fertility in early lactation, to prevent issues with high milk production at dry-off, and to reduce the surplus of calves in the dairy sector.

In this review, experimental studies will be reviewed in which the lactation period of dairy cows was deliberately extended by extending the VWP, with a focus on effects on milk yield, health, fertility and economic and environmental consequences. Next to these studies, modeling studies on retrospective data (where an extended calving interval could be the result of impaired fertility or diseases in early lactation) will be evaluated. Finally, research on customized lactation length strategies based on individual cow characteristics will be reviewed and discussed also in light of practices on commercial farms.

Milk Production and Lactation Persistency

Extending the VWP results in longer lactation lengths and calving intervals (Van Amburgh et al., 1997; Rehn et al., 2000; Arbel et al., 2001; Österman and Bertilsson, 2003; Stangaferro et al., 2018a, b; Niozas et al., 2019a; Burgers et al., 2021b). Longer lactations prolong the period of late lactation, where milk production is generally lower, yet increase the number of lactating days relative to dry days. The overall impact of extended lactations on milk production would therefore be best expressed as milk yield per day of calving interval (**MY/CI**) (Österman and Bertilsson, 2003; Lehmann et al., 2016).

In most of the reviewed studies, a longer VWP resulted in a lower MY/CI for multiparous cows, and [a higher MY/CI] for primiparous cows (Figure 2), while in several studies VWP length had no significant effect (Rehn et al., 2000; Arbel et al., 2001; Österman and Bertilsson, 2003). Within multiparous cows, yield of cows with a VWP of 200 d was lower than that of cows with a VWP of 50 d when expressed as fat-and-protein-corrected milk per day of calving interval (Burgers et al., 2021b), and within primiparous cows, yield of cows with a VWP of 150 d was higher than that of cows with a VWP of 90 d when expressed as value-corrected milk per day of calving interval (Arbel et al., 2001). Niozas et al. (2019b) found a similar production per day in lactation for cows with a VWP of 40, 120, or 180 d, with an increase in lactation length of 106 d and an increase in dry period length of 10 d for a VWP of 180 d, also implying that MY/CI was not affected. Österman and Bertilsson (2003) extended the VWP for multiple lactations, and found similar energy-corrected milk yields per day of calving interval for cows with three 12-mo lactations compared with cows with two 18-mo lactations. Milk fat, protein and lactose content in the first 44 wk of lactation were not affected by a VWP of 50, 125, or 200 d (Burgers et al., 2021b), yet were shown to increase in the extended lactation (Österman and Bertilsson, 2003).

The discrepancies in the impact of VWP on MY/CI among studies may be explained by the VWP lengths applied in the different studies and the lactation curves of the cows in these trials. The dry period, with zero contribution to lactation yield, has a greater impact on MY/CI in the shortest lactations—because the ratio of dry days to lactating days is higher. An increase of CI beyond 330 d is therefore more beneficial for MY/CI than an increase of CI beyond 380 d, which might explain the positive effect of extending lactations in the study by Stangaferro et al (2018a). For the longer CI, MY/CI will only increase with extended lactations if milk yield level relative to peak yield is sufficiently maintained, which is more often the case for moderate compared with extreme extensions of the VWP, and more for primiparous cows compared with multiparous cows (Niozas et al., 2019b, Burgers et al., 2021b).

Extending the VWP also affected lactation persistency. Burgers et al. (2021b) expressed persistency as the decline in milk yield from 100 DIM until dry-off, and found that cows with a VWP of 200 d were more persistent compared with cows with a VWP of 50 d (–0.05 vs. –0.07 kg/d, $P = 0.02$; Figure 3). Similarly, Niozas et al. (2019b), who expressed persistency as the rate of decline in the Wilmink lactation curve, found cows with a VWP of 180 or 120 d were more persistent compared with cows with a VWP of 40 d (–0.061 vs. –0.063 vs. –0.071 kg/d, respectively). The positive effect of VWP on persistency may (at least partially) be explained by the delayed negative effect of pregnancy on the lactation curve (Strandberg and Lundberg, 1991; Rehn et al., 2000). Moreover, independent from the effect of VWP, primiparous cows were more persistent than multiparous cows, with rates of decline of –0.032 vs. –0.082 kg/d (Niozas et al., 2019b) and

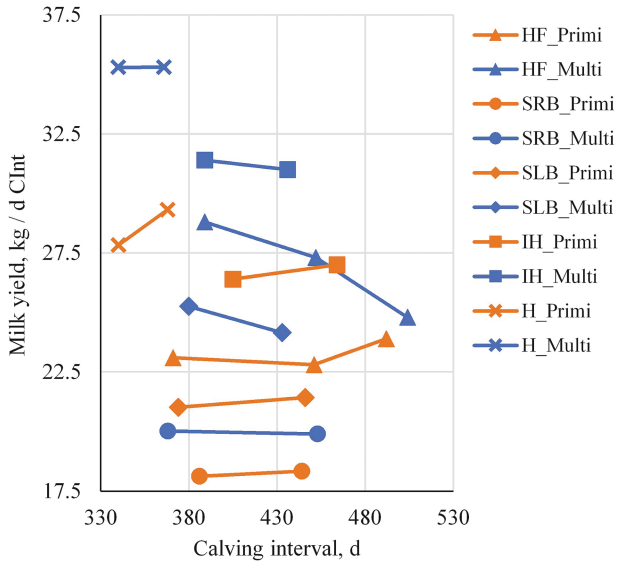

Figure 2. Milk yield per day of calving interval for primiparous and multiparous cows in experimental studies with deliberate extension of VWP; one data point per parity per treatment group. H = Stangaferro et al. 2018a (note: based on cows pregnant at first AI only); HF = Holstein Friesian cows, study of Burgers et al. 2021b; SRB = Swedish Red and White, SLB = Swedish Holstein, study of Rehn et al., 2000; IH = Israeli Holstein, study of Arbel et al. 2001.

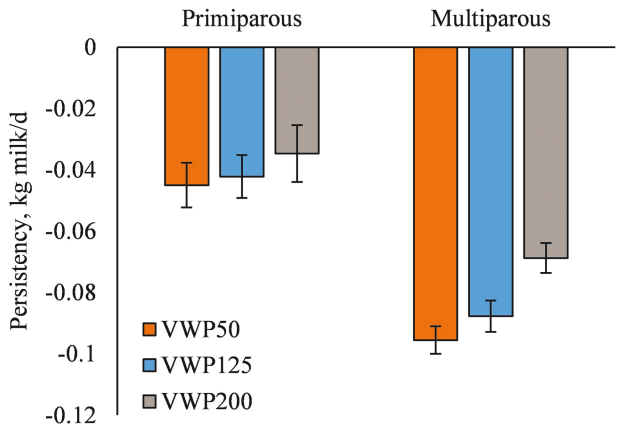

Figure 3. Lactation persistency (kg milk/d) from 100 DIM until dry-off of primiparous and multiparous cows with a voluntary waiting period of 50, 125, or 200 d (VWP50, VWP125, or VWP200) (based on Burgers et al., 2021b).

slopes from 100 DIM until dry-off of –0.04 vs. –0.08 kg/d (Burgers et al., 2021b).

Body Condition and Body Weight

Fattening of cows at the end of the extended lactation is a risk of extending the VWP, when cows are managed for a longer period at a relatively lower milk production. Niozas et al. (2019b) found that cows with a VWP of 180 d had a 0.25-point greater BCS at dry-off than cows with a VWP of 40 or a VWP of 120 d, with 14% to 16% more cows having a BCS greater than 3.5 (on a 5-point scale). Similarly, yet dependent on parity, multiparous cows with a VWP of 200 d had a greater BCS in the last 3 mo before dry off, compared with multiparous cows with a VWP of 125 or 50 d (Figure 4; Burgers et al., 2021b). In grazing cows, where breeding was postponed by 8 mo to change from a spring-calving to an autumn-calving herd, BCS at dry-off was 1.2 points (on a 10-point scale) greater at dry-off for cows with an extended VWP (Jarman et al., 2020). Van Amburgh et al. (1997) did not report BCS in their comparison of VWP of 60 and 150 d, but state that BCS throughout lactation and at dry-off were similar between VWP groups. Based on these experiments with a randomized controlled design, it could be concluded that fattening at the end of lactation is a risk of extended lactations, especially for multiparous cows and when VWP was extended to at least 180 or 200 d.

Fattening in late lactation may be prevented by adjusting the diet and energy intake of cows with extended lactations, either to improve persistency of milk production, or to reduce energy intake in late lactation. When managed for 2-yr lactations, cows in pasture-based systems had a smaller body weight change and BCS change than cows with a total mixed ration, and more cows were able to sustain milk production >30 kg/wk until 600 d in milk in the pasture-based systems (Grainger et al., 2009). Gaillard et al. (2016) attempted to increase milk production during an extended lactation by providing a high-energy density diet in early lactation, compared with a lower-energy density diet throughout lactation, but found that this had a negative carryover effect on lactation persistency. In addition, changing the lipogenic to glucogenic ratio in the diet might affect lactation persistency; and lower (expected) milk production may be matched with a lower energy-density in the diet (Van Hoeij et al., 2017).

Health and Welfare

A major driver for deliberately extending the VWP and lactation length for high-producing dairy cows is the reduction in frequency of transition periods per cow and per herd, with potential beneficial effects for cow health and welfare (Knight et al., 2005). Especially the onset of lactation, when the cow is recovering from calving and in a state of negative energy balance, is associated with an increased risk of metabolic disorders and diseases (Friggens et al., 2004; Koeck et al., 2012). As a consequence, both disease incidence and culling risk are highest in early lactation (Ingvartsen, 2006; Pinedo et al., 2014). An extended lactation reduces the frequency of transition periods and associated ration and group changes, and likely reduces the yearly risk of disease and culling, thus potentially increasing the health, welfare, and productive lifespan of dairy cows. Limited studies, however, are available that reported disease incidence or welfare indicators of dairy cows with a deliberately extended lactation. In modeling studies, a reduction in disease events was assumed, but not measured (Van Amburgh et al., 1997). In our recent experimental study, disease treatments were measured and used as input for calculating the economic consequences of an extended VWP (Burgers et al., 2022). In that study, the period from 6 wk after calving until 6 wk after the next calving was analyzed, to include the transition around calving after an extended lactation. In that period, there was no effect of VWP on disease treatments (Burgers et al., 2022). Numerically, cows with a VWP of 125 or 200 d had more disease treatments than cows with a VWP of 50 d (Table 1A). Per year, however, the number of disease treatments was numerically lower when the VWP was extended (Table 1B). Considering the limited size of the study these results should be interpreted with caution.

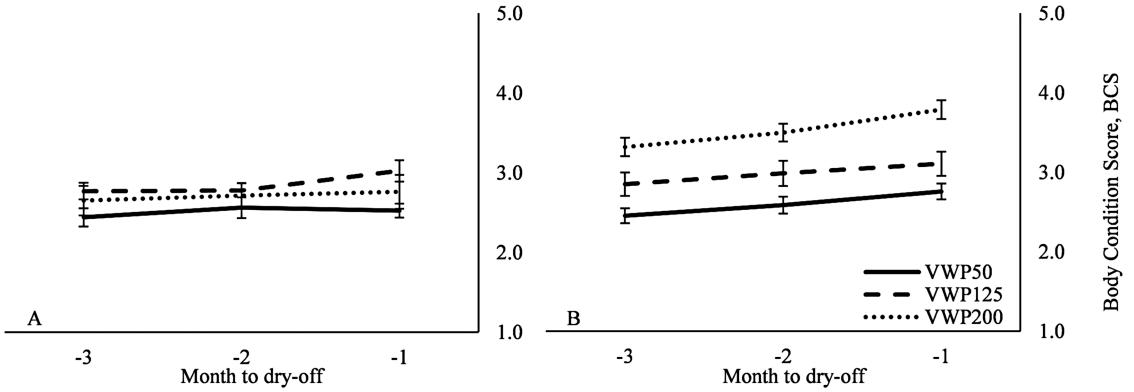

Figure 4. Body condition score in the last 3 mo before dry-off of primiparous (a), and multiparous (b) cows with a voluntary waiting period of 50, 125, or 200 d (based on Burgers et al., 2021b).

Table 1. Disease treatments for a complete lactation (6 wk after calving until 6 wk after next calving) (a) and disease treatments per year (b) per treatment group of cows with a voluntary waiting period (VWP) of 50, 125, or 200 d

a.	VWP50	VWP125	VWP200	Total
Number of cows	53	49	51	153
Milk fever	10	17	9	36
Ketosis	1	1	3	5
Clinical mastitis	28	25	31	84
Retained placenta	4	1	4	9
Vaginal discharge	8	8	7	23
Endometritis	5	4	6	15
Cystic ovaries	11	8	19	38
Claw and leg problems	47	67	48	162
Stomach and intestine problems[1]	14	22	15	51
Other[2]	8	14	14	36
Total	136	167	156	459
b.	**VWP50**	**VWP125**	**VWP200**	**Total**
Number of cows	53	49	51	153
Milk fever	10	14	7	31
Ketosis	1	1	2	4
Clinical mastitis	28	21	24	73
Retained placenta	4	1	3	8
Vaginal discharge	8	7	5	20
Endometritis	5	3	5	13
Cystic ovaries	11	7	15	33
Claw and leg problems	47	56	37	140
Stomach and intestine problems[1]	14	18	12	44
Other[2]	8	12	11	31
Total	136	140	121	397

[1]Main stomach and intestine problems: rotavirus, diarrhea, peritonitis.
[2]Main diagnoses in 'other': fever, cobalt deficiency, 3 teats.

Moreover, there are potential risks for health and welfare associated with an extended lactation with respect to udder health and fattening. First of all, the effect of extended lactations on udder health is ambiguous. On the one hand, late lactation is associated with a rise in somatic cell count (SCC; Österman et al., 2005; Sorensen et al., 2008; Niozas et al., 2019b; Ma et al., 2021), which Österman et al. (2005) found to be more pronounced for multiparous cows compared with primiparous cows. The greater SCC toward the end of the extended lactation was, however, in none of these studies related with an increase in mastitis incidence (Sorensen et al., 2008; Niozas et al., 2019b; Ma et al., 2021), indicating that the rise in SCC cannot be related to clinical mastitis. Less milk or a decline in epithelial integrity could be reasons clarifying the greater SCC at the end of lactation. On the other hand, the low milk yield at the end of the extended lactation (Niozas et al., 2019b) can be expected to reduce udder pressure and favor cow welfare at dry off (Bertulat et al., 2013), and limit the risk for new intramammary infections in the subsequent lactation (Rajala-Schultz et al., 2005).

Second, the increase in body condition toward the end of the extended lactation (Niozas et al., 2019b; Burgers et al., 2021b) can be hypothesized to increase the risk for a more severe negative energy balance and associated increased risk for metabolic disorders in the subsequent lactation (Morrow, 1976). Indeed, fattening in multiparous cows after a VWP of 200 d (Figure 4) resulted also in an elevated BCS at calving and in the first 6 wk of the next lactation (Burgers et al., 2021b). This may result in a more negative energy balance during the start of the next lactation, and related increased NEFA and BHB, as well as an increased risk for ketosis (Grummer et al., 2004).

Fertility

Consequences of different VWPs for reproductive performance are ambiguous. Cows with an extended VWP in some studies had higher conception rates at first AI, and fewer days open after the end of the VWP; though other studies found no effect of VWP on these variables (Figure 5). A study that looked at the success of 51,528 first inseminations found that the conception rate at first AI increased with weeks in milk, and was 6% lower when cows were inseminated before peak milk yield (Inchaisri et al., 2011). This might explain findings by Niozas et al. (2019a), where conception rate at first AI was lower for cows with a VWP of 40 d (37%) than for cows with a VWP of 120 (49%) or 180 d (50%).

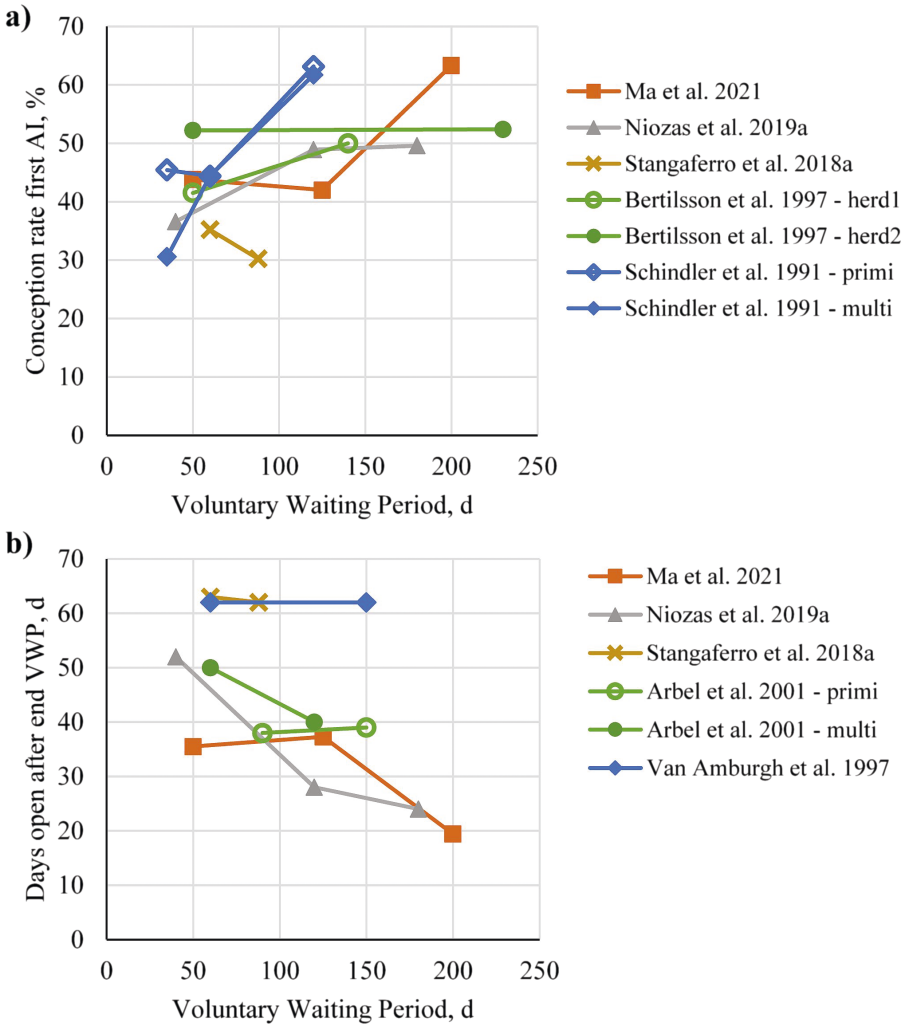

Figure 5. Conception rate first AI (a) and days open (b) after the end of the voluntary waiting period (VWP) for cows that were pregnant per VWP in each experiment.

An improved reproductive performance of cows with an extended VWP might be related to more time to recover from calving, more time to recover from NEB, and a lower milk yield of cows at start of the breeding period. Extending the VWP from 60 to 88 d resulted in a lower percentage of polymorphonuclear cells in uterine samples and tendency for a lower concentration of haptoglobulin in plasma during the breeding period, indicating a better uterine health status and lower inflammatory status for cows with the extended VWP (Stangaferro et al., 2018a). Moreover, in our recent study (Ma et al., 2020), cows with an extended VWP of 125 or 200 d had a greater percentage of normal ovarian cycles (18-24 d in length) during the 100 d around the end of the VWP. Not all studies, however, report consequences of extending the VWP on body condition, energy status, or milk yield around end of the VWP to enable understanding the effect, or lack thereof, of an extended VWP on fertility. Nevertheless, besides differences in reproduction protocol as discussed above, studies differ in how long the VWP is extended. When the extension of the VWP is small, effects on milk yield, body condition, ovarian cyclicity, or uterine health status at the time of insemination may be limited.

Despite the improved conception rate, culling for fertility reasons may still be higher for cows with an extended VWP (Niozas et al., 2019a; Burgers et al., 2021b). An explanation is that, in these experimental studies, cows with an extended VWP had a shorter period of time to become pregnant compared with cows with a shorter VWP. Commercial dairy farms that deliberately extend the VWP still had cows with longer calving intervals than they may have planned for, when cows required several inseminations before getting pregnant (Burgers et al., 2021a). Of the 12% longest calving intervals in that dataset (CInt ≥532 d), at least 69% concerned cows with multiple inseminations. These long calving intervals also indicate that farmers were willing to inseminate these specific cows for a long time, potentially based on their relatively high milk yield at the time of insemination.

Calves

To our knowledge, there are no studies available that report consequences of an extended VWP or extended lactation on colostrum quality or calf health and development. Nevertheless, it can be hypothesized that extending the VWP affects

energy and metabolic status of dairy cows at the moment of conception and during pregnancy and herewith affects calf health and development either prenatally or postnatally. Energy status of dairy cows progresses from a catabolic metabolism to an anabolic metabolism during the course of lactation (De Vries et al., 1999; Van Knegsel et al., 2014). The period with a catabolic metabolism, the so-called negative energy balance, can range from 4 to 180 DIM for individual cows (De Vries et al., 1999). This implies that with a traditional VWP of 50 d (Inchaisri et al., 2011) a major proportion of the cows is still recovering from the negative energy balance at start of the breeding period. A large number of studies reported the relation between negative energy balance, metabolic status and compromised reproductive function (as reviewed by Butler et al., 2003; Chagas et al., 2007; Wathes et al., 2007). Only a few studies evaluated the consequences of production level of the cow during pregnancy and birth weight, metabolic status or lifespan and production of her calf (Berry et al., 2008; Bossaert et al., 2014; Kamal et al., 2014). In a large epidemiological study (Berry et al., 2008), milk production of the dam during the periconception period was negatively related with milk production and survival of the offspring. Moreover, also fertility of the offspring was negatively related with health status of the dam during pregnancy (Evans et al., 2012). Based on knowledge in other species (as reviewed by Fleming et al., 2018) it can be expected that extending the VWP for dairy cows and breeding her during a lactation phase with a lower production level and different metabolic status affects calf health, metabolism, development and possibly also production during early and later life.

Extending the VWP not only reduces the frequency of calving moments, but also reduces the number of calves born in the herd per time unit. For example, extending the lactations of all cows by 4 mo in a simulation study reduced the number of calving events and calves per year from 114 (SD: 6) to 90 (SD: 7) for farms with 100 cows, with a smaller reduction to 105 (SD: 7) calves per year when only lactations of primiparous cows were extended by 4 mo (Kok et al., 2019). Fewer calving moments and fewer calves to be reared will reduce the labor and change the daily workplan at the farm. In an interview, 13 dairy farmers that applied extended VWP reported they spent 8 to 180 min per calving moment, and 5 to 120 min per calf per day in the first 2 wk of life (Van Dooren, 2019). Though fewer calves would decrease the total labor for calves, farmers mentioned that this could increase the time spent per calf. A reduction in the number of calves per year will also reduce the number of surplus calves which are mostly transferred to the veal industry, with 5.8 million veal calves fattened in Europe in 2008 (Sans and De Fontguyon, 2009). These surplus calves, however, are a rising issue of public concern because of welfare implications of transport at a young age and debated management approaches for these young calves (Bolton and Von Keyserlingk, 2021

Economic and Environmental Consequences of Extended Lactations

Most studies that modeled the effect of a longer calving interval advised a 1-yr calving interval for optimal economic result (Dijkhuizen et al., 1985; Schmidt, 1989, Strandberg and Oltenacu, 1989; Sørensen and Østergaard, 2003; Inchaisri et al., 2011; Steeneveld and Hogeveen, 2012, Kok et al., 2019). This was mostly related with a lower milk production in extended calving interval, reducing the average daily revenues. These modeling studies, however, used retrospective data, where an extended calving interval could be the involuntary result of impaired fertility or impaired health in early lactation. In addition, many of these modeling studies used data before 2010, but mostly before 2000. As the milk production of dairy cows has increased since then, this may affect the economic result of an extended calving interval on milk production. Moreover, it can be hypothesized that the lower milk production might be compensated by an improved fertility, lower costs for disease treatments, and lower feed costs. In modeling studies, values for these variables are usually assumed.

Some studies investigated the effect of a deliberately extended VWP on the economic result (van Amburgh et al., 1997; Arbel et al., 2001; Stangaferro et al., 2018a; Burgers et al., 2022). In one study, where only high-producing cows were included, yearly net return increased with 69$ for primiparous cows when their VWP was extended from 90 to 150 d, and increased with 44$ for multiparous cows when their VWP was extended from 60 to 120 d (Arbel et al., 2001). Moreover, in a study where bST was administered to multiparous cows, profitability increased with 274 $ per cow per year when the VWP was extended from 60 to 150 d (Van Amburgh et al., 1997). These studies could indicate that, as long as cows are high-producing or milk production is stimulated with the use of bST, an extended VWP could result in an improved economic result. Another study reported a numerical increase in yearly cashflow for primiparous cows, and a numerical decrease in yearly cashflow for multiparous cows, when the VWP was extended from 60 to 88 d (Stangaferro et al., 2018a). Possibly, this difference between primiparous and multiparous cows was due to more persistent lactation curves in primiparous cows (Lehmann et al., 2016; Burgers et al. 2021b). In addition, in Stangaferro et al. (2018a), the extension of the VWP was limited (from 60 to 88 d) and might not be directly comparable with studies that investigated longer extensions of the VWP. Recently, the economic result of cows with a VWP of 50, 125, or 200 d was investigated (Burgers et al., 2022). In that study, cows with a VWP of 50 d had greater yearly revenues, but also greater yearly costs, compared with cows with a VWP of 200 d. Moreover, the revenues or costs of cows with a VWP of 125 d were not different from the other 2 groups, indicating that a VWP of 125 d did not affect the economic result. The yearly net partial cashflow was not affected by VWP in this study, possibly due to the partial compensation of the lower revenues by the lower costs for cows with a VWP of 200 d (Burgers et al., 2022). In addition, the great variation among cows in net partial cashflow may also have contributed to the lack of differences in partial cashflow between VWP. Cows with a greater partial cashflow than other cows had a greater production of milk, fat, and protein, and fewer veterinary treatments, irrespective of the length of the VWP or calving interval (Burgers et al., 2022).

The differences among studies could indicate that not only the length of the VWP or calving interval are important for the economic result, but that also individual cow characteristics such as parity and milk production play a role. As such, an extended VWP might be a feasible option for at least some cows, depending on their lactation performance in an extended lactation. Moreover, an extended calving interval can be used as a strategy to maintain high-producing cows that are not able to conceive early in lactation (Rodríguez-Godina et al., 2021). In the specific situation of dairy

systems with seasonal calving, rebreeding subfertile cows in the breeding season next year for an extended lactation resulted in positive economic results, especially for high-producing cows (Butler et al., 2010). As such, keeping cows for an extended lactation rather than culling them due to not conceiving might increase longevity, and improve economic result especially for high-producing cows (Rodríguez-Godina et al., 2021).

The environmental impact of milk production is also affected by extending the VWP, through changes in milk production, the number of calves born per year and the annual replacement rate at the herd level and associated changes in feeding management and youngstock rearing (Kok et al., 2019; Lehmann et al., 2019; Sehested et al., 2019). Greenhouse gas emissions of milk production, which are generally expressed per unit milk, increase when annual milk production of the herd decreases, because the emissions associated with maintenance are diluted to a lesser extent. Whether milk production of the herd increases or decreases in case of extended VWP depends on the lactation curves of the cows and the extent to which the lactation length is increased (as reviewed). Important to consider is that, even when the MY/CI of primiparous cows increases in an extended lactation, their production may still be lower than the production of multiparous cows and thereby increase GHG emissions of milk production (Kok et al., 2019). However, if extending the VWP indeed reduces culling risk and thereby increases productive lifespan of dairy cows, the net result would likely be a reduction of GHG emissions of milk production due to reduced GHG emissions from rearing replacement heifers (Browne et al., 2015; Kok et al., 2019; Lehmann et al., 2019). Extending the VWP may have further benefits for sustainability through the lower amount of concentrates required to sustain milk production later in lactation (Burgers et al., 2022), which would allow for a greater proportion of roughage and less human-edible feed to be included in the diet. The environmental impact of the reduced number of calves born and possibly a lower number of cows culled per year in case of an extended VWP depends on whether beef cows would be used to substitute meat production (Lehmann et al., 2019).

Customizing Lactation Length in Dairy Practice

Despite the general advice to aim for a 1-yr or short calving interval, commercial dairy farmers may deliberately extend the VWP to extend the average lactation length of their herd (Burgers et al., 2021a). The motivation of these farmers to aim for an extended lactation varied among farmers, but a majority of the farmers mentioned reducing the number of calving events and the number of calves itself, better fertility, drying off at a lower milk yield and less labor for calvings and care of fresh cows and young calves (Van Dooren, 2019). The strategy of these farmers to extend the lactation also varied among farmers. In our recent study, some farmers (3/13) worked with a fixed extended VWP for their whole herd. Most farmers (10/13) applied a customized strategy based on individual cow characteristics, like body condition or milk yield level (Burgers et al., 2021a).

At 13 commercial farms with a strategy to extend the VWP and lactation for (part of) their herd, the group of cows with a short calving interval was characterized by a low peak milk yield and a low 305 d milk yield (Figure 6A; adapted from Burgers et al., 2021a). Cows with a longer calving interval were more persistent and had a greater 305-d milk yield. This indicates that these farmers seem to select cows with a greater milk yield for an extended lactation. Nevertheless, also at these commercial farms the extended lactation for each individual cow was not always a deliberate choice. A significant proportion of the cows in the class with an extended calving interval were in this class because of many unsuccessful inseminations earlier in lactation (Burgers et al., 2021a).

The success of these individual strategies to customize lactation length on average MY/CI was not always straightforward at these commercial farms. Despite the fact that in general high-producing cows had the longest calving interval, multiparous cows with the longest calving interval and the greatest 305-d production often did not have the greatest production per day of calving interval (Figure 6B). This may be explained by more days in late lactation where especially for multiparous cows the milk production is decreased.

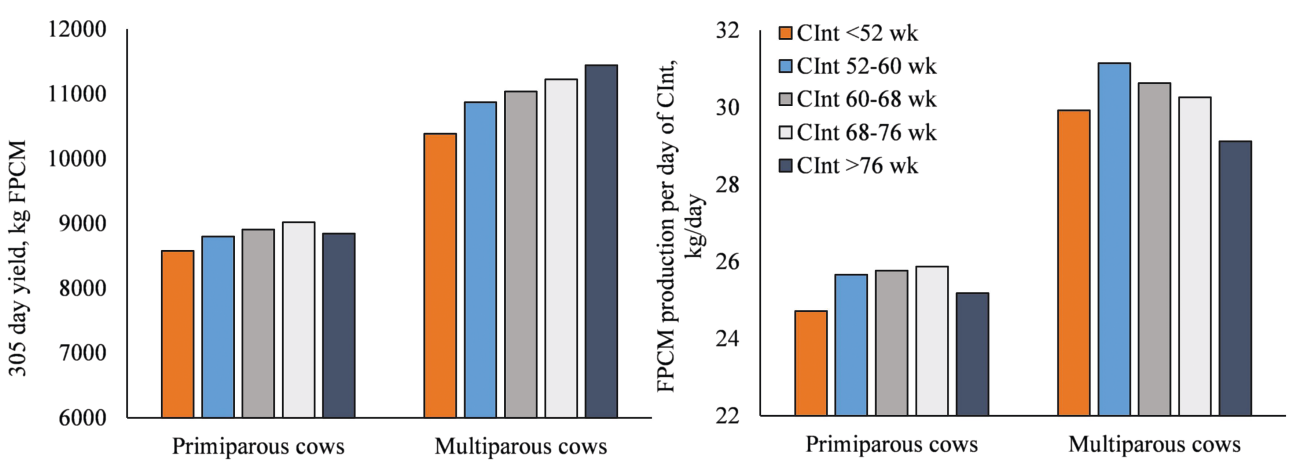

Figure 6. Three hundred and five-day fat-and protein corrected milk production (kg FPCM) (a) and FPCM per day calving interval (CInt) (kg FPCM/d) (b) of cows at commercial dairy farms per CInt class (CInt < 52 wk, CInt 52-60 wk, CInt 60-68 wk, CInt 68-76 wk, CInt > 76 wk) (based on Burgers et al., 2021a).

In line with experimental studies (Niozas et al., 2019b), also commercial farmers recognized the risk of fattening of cows at the end of the extended lactation. They did not consider this as an issue for health of their cows, and mentioned to use ration adjustments and selection of cows for an extended lactation to reduce the risk of fattening end of the lactation (Van Dooren, 2019).

Predicting Lactation Performance of Individual Cows with Extended VWP

An extended VWP may not be suitable for all cows. For some cows, extending the VWP resulted in very low milk production in late lactation, longer dry periods, or a high BCS at dry-off (Rehn et al., 2000; Niozas et al., 2019a; Burgers et al., 2021b). Identification of cows that have the potential to maintain milk production through an extended lactation, and of cows that have an increased risk at fattening in an extended lactation, could help farmers to customize lactation length for individual cows. To this end, associations between cow characteristics available in early lactation and lactation performance in extended lactations were studied using commercial and experimental data (Lehmann et al., 2017; Burgers et al., 2021b).

Especially factors describing the level of milk production, such as peak yield, previous or expected 305 d yield, and previous persistency or breeding value for persistency, and milk yield in early lactation, were positively associated with a greater MY/CI in the extended lactation and at the end of the extended lactation (Lehmann et al., 2017; Burgers et al., 2021b). These factors are in line with risk factors and decision variables used by farmers that deliberately extend VWP of part of their herds (Lehmann et al., 2017; Burgers et al., 2021a): farmers select cows for longer VWP when their milk production in early lactation is higher (Burgers et al., 2021a), and recognize a "low yield" and a "quick yield drop" as risk factors for an extended VWP (Lehmann et al., 2017). Farmers also mentioned "BCS at the end of the previous lactation" as a risk factor for extended lactation for multiparous cows (Lehmann et al., 2017), which matches our finding that a high BCS at calving and in early lactation is a risk factor for a high BCS at dry-off (unpublished results), perhaps especially so in multiparous cows with long extensions of VWP (Niozas et al., 2019b; Burgers et al., 2021b). To move from associations in experimental datasets toward decision support models and management decisions, further research is needed to validate and quantify these relations between early lactation characteristics and lactation performance for commercial farms.

Customizing Lactation Length: Remaining Questions

Dairy farmers who apply a customized approach to extend the VWP each use their own decision support model. Based on these farmers' approaches and experimental data, models were developed to predict milk yield (Burgers et al., 2021b) of cows after an extended VWP using individual cow information available in early lactation. These prediction models are based on a specific dataset and should be validated for other herds to improve applicability in practice. Moreover, the value of other data sources, e.g., sensor data, for the prediction of cow performance after an extended VWP is unknown, but can be expected to advance the development for decision support models for VWP.

Maintaining milk yield and lactation persistency for cows with an extended lactation has been subject of research in a limited number of studies. Increasing milking frequency (Osterman et al., 2005; Sorensen et al., 2008), use of bST (Van Amburgh et al., 1997), or altering dietary energy content (Grainger et al., 2009) were evaluated for their value to maintain milk yield and sometimes also limit body fattening in an extended lactation. Besides these measures, it can be hypothesized that also breeding approaches or feeding strategies such as increasing the lipogenic or glucogenic nutrient availability in the diet (Van Hoeij et al., 2017) have the potential to improve lactation persistency or limit fattening of cows in an extended lactation.

It is known that periconception and prenatal conditions affect development and health of offspring in early but also in later life (Fleming et al., 2018). The consequences of an extended VWP, associated with insemination in a different phase of lactation for the calf are unknown. In addition, when breeding for cows that are successful in an extended lactation, the question arises how to handle the situation when cows most suited for an extended lactation get the lowest number of calves in the herd.

Reduction in critical transition periods and herewith a reduction in disease events in early lactation and potentially an increase in productive lifespan is often mentioned as a major driver to extend the VWP. Data on disease events and culling of cows with different VWPs are, however, limited. Moreover, in several studies, both an extended VWP and culling were confounded with milk yield level. A large and long-term controlled study with accurate monitoring of disease incidence and culling reasons could shed light on the relationships between VWP, disease, and length of productive life in dairy cows.

Conclusion

Extending the lactation length by extending the VWP reduces the frequency of critical transitions such as dry-off, calving, and start of a new lactation both for individual cows and at the herd level. This reduction in the frequency of transitions can be beneficial for cow health and fertility but also can be of interest to reduce the number of surplus calves and labor associated with drying off, calving, and disease treatments. Current concerns with respect to an extended lactation are that milk yield is too low in late lactation, which might be associated with an increased risk of fattening cows in late lactation and compromised economic returns at the herd level. In addition, limited knowledge is available with respect to consequences for cows in the subsequent lactation and for calves born to cows with an extended lactation. Moreover, it can be expected that a customized strategy based on individual cow characteristics is a future approach to select suitable cows for an extended lactation. With such a strategy a herd may benefit from a reduction in challenging transitions like calving and benefit from persistent lactation curves of high-producing dairy cows, while limiting the risk for fattening and milk yield reduction at the end of the lactation. Current studies are ongoing that entangle the associations between individual cow characteristics and the response of cows to an extended lactation. Ultimately, these associations will be input to the development of decision support models to optimize management of lactation length in modern dairy farming.

Conflict of Interest Statement

The authors declare no real or perceived conflicts of interest.

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