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Effect of voluntary waiting period length on milk yield, fertility, and culling in high-yielding, second-parity cows

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ABSTRACT

The substantial increase in milk yield capacity in modern dairy herds has led to growing interest in extending the voluntary waiting period, the time from calving to first insemination, as a strategy to prolong the calving interval. However, the effects of an extended voluntary waiting period on fertility and milk production vary, particularly between primiparous and multiparous cows. This study evaluated the effect of an extended voluntary waiting period, compared with a conventional one, on fertility, milk production, and culling in second-parity cows from 12 high-yielding commercial herds. Cows were distributed, based on odd or even ear tag numbers, and allocated into either a 50- or 140-d voluntary waiting period. Data including calving records, fertility metrics, monthly milk yields, and culling rates were collected from the Swedish official milk recording scheme. Out of 819 cows enrolled, 590 completed a third calving. The protocol extended the interval from calving to first insemination by 60 d, which resulted in a 46-d increase in the calving interval (12.5 mo vs. 14.0 mo). Daily milk yields did not differ between groups and averaged 34 kg ECM per day between 2 consecutive calvings and 40 kg ECM per lactating day. Although average milk yield at the last test milking before dry-off tended to be lower in cows with an extended voluntary waiting period compared with those on a conventional one (LSM 32.5 ± 0.96 kg ECM vs. 33.7 ± 1.01 kg ECM), dry period length remained unaffected. Total milk yield in the first 100 d of the third lactation did not differ between treatments. Fertility outcomes were improved in the extended voluntary waiting period group compared with the conventional group, as indicated by a higher pregnancy proportion at first service (LSM 0.62 ± 0.050 vs. 0.46 ± 0.046), fewer inseminations per born calf (LSM 1.61 ± 0.131 vs. 2.02 ± 0.137), and shorter insemination period (LSM 20.8 ± 4.8 d vs. 35.6 ± 4.3 d). The voluntary waiting period did not influence culling rates. These findings indicate that a voluntary waiting period of 140 d may be a viable alternative to the conventional 50-d duration, without compromising milk production and fertility in second-parity cows from high-yielding herds.
Key words: optimal calving interval, long lactation, delayed first service, customized lactation length, controlled study

INTRODUCTION

In recent decades, advancements in genetics, nutrition, and herd management have substantially increased average milk yield per cow (Crowe et al., 2018). Traditionally, a herd average calving interval (**CInt**) of 12 to 12.5 mo has been regarded economically optimal (Schneider et al., 1981; Strandberg and Oltenacu, 1989). However, as milk yield has increased, several studies have investigated the potential benefits of extending the CInt to further optimize dairy production. Österman and Bertilsson (2003) compared cows milked 3 times per day with CInt of 12 mo versus 18 mo, and found that those with an 18-mo interval produced more milk per day between 2 consecutive calvings. Similarly, Niozas et al. (2019a) evaluated voluntary waiting periods (**VWP**) of 40, 120, and 180 d and concluded that a 120-d VWP could improve fertility and maintain milk yield compared with 40-d VWP. However, multiparous cows with below-average production were less suitable candidates for extended VWP.

Steeneveld and Hogeveen (2012) approached the question from an economic perspective, developing a decision-support tool to determine whether cows detected in estrus from 42 to 105 DIM should be inseminated immediately or have insemination delayed. Decisions were based on individual cow characteristics and economic optimization. Their model showed that immediate insemination was generally the most cost-effective option, except for a small group of cows, typically primiparous

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animals with early estrus and a high persistent milk yield, for whom delayed insemination was economically preferable. Other simulation studies have indicated that the economically optimal VWP ranged from 42 to 70 d, with primiparous cows potentially benefiting from even longer duration due to their more persistent lactation curves (Inchaisri et al., 2011).

In high-yielding herds, extending the VWP by 60 d has been shown to enhance profitability for both primiparous and multiparous cows (Arbel et al., 2001). Overall, research indicates that primiparous cows may be more suitable for extended lactations, as they have more persistent lactation curves compared with multiparous cows (De Vries, 2006; Lehmann et al., 2019; Römer et al., 2020).

Some farmers routinely implemented extended VWP for cows they considered suitable for a prolonged CInt (Lehmann et al., 2016; Burgers et al., 2021a). On these farms, cows with an extended VWP showed increased ECM yield **(MY)** during the first 305 d of lactation, although the effects on average daily MY between consecutive calvings remained inconsistent. As the interest in adjusted VWP strategies increases among farmers, scientific evidence is needed to support decisions regarding optimal VWP and calving intervals. To date, controlled studies evaluating VWP strategies in commercial herds, specifically targeting cows in their second lactation, known for their higher milk yield capacity compared with first-lactation cows, are rare.

A potential negative effect of delayed first insemination and extended CInt relates to the reduced proportion of time spent in peak lactation, which may affect both production and economic outcomes (Strandberg and Oltenacu, 1989). However, the decline in daily milk yield is partly driven by pregnancy (Strandberg and Lundberg, 1991), indicating that delayed conception may sustain daily MY. At dry-off, high MY may increase the risk of udder health problems (Rajala-Schultz et al., 2005). In this context, an extended CInt may help reduce MY at dry-off, potentially offering udder health benefits. Yet, extended lactations are often followed by prolonged dry periods, particularly in higher-parity cows (Rehn et al., 2000; Niozas et al., 2019a; Burgers et al., 2021b).

Recent studies have reported improved fertility outcomes with extended VWP, particularly in high-yielding cows (Larsson and Berglund, 2000; Niozas et al., 2019b; Ma et al., 2022). In contrast, Bertilsson et al. (1997) found no effect of an extended VWP on the conception rate at first insemination, while Schneider et al. (1981), in a randomized study, reported that later-bred cows required more services per conception. Lehmann et al. (2017) reported that among cows with prolonged lactations, those with highest daily MY between consecutive calvings exhibited the poorest fertility outcomes. Together, these findings indicate that extended VWP may allow cows additional time to recover from calving and negative energy balance, thereby potentially improving subsequent fertility.

Previous studies of the effect of extended VWP on culling rate have given inconsistent results. Burgers et al. (2022) compared VWP of 50, 125, and 200 d and Edvardsson Rasmussen et al. (2023) compared 50 and 140 d. In none of these studies, the culling rate was affected by VWP. van Amburgh et al. (1997) observed reduced culling rate and a lower replacement need when comparing a 50-d VWP with a 150-d. Niozas et al. (2019a) reported increased culling with a VWP of 180 d compared with 40 d, while a VWP of 120 d did not differ significantly from either of the other treatments.

The present study aims to investigate the effect of extended versus conventional VWP on milk production, fertility, and culling in second-parity cows in high-yielding commercial dairy herds.

MATERIALS AND METHODS

Study Design and Herd Enrollment

This controlled study was conducted in Swedish commercial dairy herds with more than 100 cows, where second-parity cows were assigned to either a traditional or extended VWP (50 d between calving and start of insemination period vs. 140 d between calving and start of insemination period). Participating herds were affiliated with the Swedish official milk recording scheme (**SOMRS**), with an average MY above the national herd average of 10,400 kg ECM per cow per year (Växa, 2020). To maintain farmers' trust in the study, cows with a 305-d first-lactation MY below 70% of the herd average were excluded. Breeds included were Holstein (**HOL**), Swedish Red (**SR**), and crossbreeds (**CB**). The CB group consisted of the 3-breed ProCROSS, a combination of HOL, SR, and Coopex Montbéliard, as well as SR-HOL crosses. Of the 50 herds invited, 15 accepted to participate. According to Swedish legislation, ethical permission was not required.

Experimental Setup

Within the participating herds, cows were enrolled continuously, with first calving occurring from October 2019 to February 2020 in each respective herd. Allocation to either a 50-d VWP (**VWP50**) or an extended 140-d VWP (**VWP140**) was done based on ear tag numbers (even or odd). Monthly, participating herds received protocol updates for cows entering the study, along with feedback on insemination dates and achieved calving to first insemination (**CFI**) intervals. In December 2020, the enrollment of cows was terminated.

Table 1. Herd size, yearly milk yield (MY) in kilograms of milk and kilograms of ECM, and calving interval (CInt) in the participating herds (n = 12) at the onset of the study[1]

Item	Mean	Minimum	Maximum
Herd size	334	113	756
Yearly MY, kg	11,380	10,270	13,350
Yearly MY, kg ECM	11,740	10,930	13,700
CInt, mo	12.7	11.8	13.6

[1]Data from the Swedish official milk recording scheme, presented as mean and range.

Experimental Cows

Initially, 992 cows entered their second parity during the study period. Cows with a pregnancy duration of less than 215 d (classified as pregnancy loss in SOMRS, n = 6), as well as those without milk records following the second calving (n = 5), were not included in the study. Among the remaining 981 cows, 11 had a 305-d MY that was too low during their first lactation, and 6 were sold during their second parity, leading to their exclusion. Additionally, 3 herds, including 145 cows, were removed from the study due to protocol noncompliance.

The final dataset consisted of 819 cows across 12 herds, with an average of 68 cows per herd (range 25 to 131). The dataset included 601 HOL, 110 SR, and 108 CB cows. At the herd level, the proportions of HOL and CB ranged from 0% to 100%, while the proportion of SR cows ranged from 0% to 62%.

Cows were classified as either inseminated or not. A complete second parity was defined as a cow that lactated and subsequently calved for the third time.

Herd Description

Average herd size, MY, and CInt for the year of study entry are presented in Table 1. The farms either employed automatic milking systems, with herd averages between 2.7 and 3 milkings per cow per day, or parlor milking systems with 2 or 3 milkings per day. Feed was provided as either a partial mixed ration or TMR.

Data Retrieval

Cow data from March 2017 to June 2022 were obtained from SOMRS. Variables included in the analysis were breed, MY, fat and protein percentages, dates for inseminations, calvings, dry-off, and culling, including recorded reason for culling. Where dry-off dates were missing in SOMRS, they were retrieved from the farm management system. If dry-off dates were missing in both systems, the date was set to midway between the last test milking day with reported MY and the first test day with no MY (n = 4).

Data Description: Milk Production, Fertility, and Culling

Individual total MY (kg ECM) between the second and third calving was calculated using SOMRS monthly test milking data, following ICAR (2020) guidelines. Milk yield (kg ECM) for the first 100 d of the third lactation was similarly calculated for cows with at least 3 test milkings. Average daily MY (kg ECM) was expressed as total MY divided either by CInt (days) or by number of lactation days. Dry period length (**DPL**) was defined as the number of days from dry-off to the subsequent calving. Daily MY before dry-off was based on test milk result 10 to 40 d before dry-off.

Fertility was assessed using calving and insemination dates from the second parity, evaluated separately for all inseminated cows and those with a third calving. Calving interval and CFI were calculated in days. Pregnancy was defined as an insemination resulting in a subsequent calving. First service pregnancy (**FSP**) referred to pregnancies resulting from only one insemination. The insemination period length (**IPL**) was the number of days from the first to the last insemination, and the number of inseminations per cow (**NINS**) was recorded. If inseminations occurred within a 6-d interval, only the second date was kept, except for the first estrus, where only the initial date was kept to avoid biasing the CFI. A total of 17 inseminations (less than 1% of all inseminated estruses) were excluded due to duplicate inseminations.

Culling was defined as cows sent to slaughter and on-farm mortality (i.e., cases of unassisted death or euthanasia). Culling was assessed as the total proportion of culled cows, plus the proportion of cows not inseminated, and the proportion culled due to reduced fertility, relative to all cows.

Statistical Analysis and Models

Statistical analysis and visualizations were conducted using R software version 4.2.1 (R Core Team, 2022) within the RStudio environment (R Studio Team, 2023). Linear mixed models were fitted by REML using the lmer function from the lme4 package in R (Bates et al., 2015) to analyze CFI, IPL, DPL, CInt, and the milk yield measures. Hypotheses were tested with type II ANOVA applying Satterthwaite's method. For multiple comparisons, *P*-values were adjusted using Tukey's method for pairwise tests, and the Kenward-Roger method was applied to improve df estimation.

The count variable NINS was analyzed using a Poisson model with a generalized mixed model fitted by maximum likelihood via Laplace approximation, utilizing the glmer function in R (Bates et al., 2015). Hypotheses were

Table 2. Milk yield variables (LSM ± SEM) in cows subjected to a voluntary waiting period of 50 (VWP50) or 140 d (VWP140) in their second parity; n = 590 cows[1]

Item	VWP50	VWP140	*P*-value
kg ECM/d CInt	33.7 ± 0.46	34.2 ± 0.50	0.19
kg ECM/lactating d	40.5 ± 0.52	40.4 ± 0.56	0.94
kg ECM, 305 d	12,064 ± 156	12,785 ± 173	<0.001
Total lactation, kg ECM	12,881 ± 243	14,623 ± 271	<0.001
kg ECM before dry off[2]	33.7 ± 0.96	32.5 ± 1.01	0.02
kg ECM, L3 DIM 100[3]	4,643 ± 129	4,697 ± 141	0.81

[1]Variables include daily milk yield in kilograms of ECM, per day calving interval (CInt), per lactating day, 305-d yield, total lactation yield, yield 10 to 40 d before dry-off in second parity, and milk yield during the first 100 d in the third lactation (L3).

[2]n = 536.

[3]n = 527.

tested using an analysis of deviance with a type II Wald chi-squared test.

Binary variables—including insemination status, FSP, pregnancy status, and culling variables—were analyzed with logistic regression, using the glmer functions with maximum likelihood via Laplace approximation in the lme4 packages. Hypotheses were tested with an analysis of deviance using a type II Wald chi-squared test. A confidence level of 0.95 was applied. For all models, post hoc tests were conducted using the emmean function (Lenth, 2024).

Fixed factors in the models included treatment VWP (with 2 levels), breed (with 3 levels), and the interaction between VWP and breed. Farm (12 levels) was included as a random factor.

The statistical model was

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + c_k + e_{ijkl},$$

where $i = 1, 2$ treatments, VWP50 and VWP140; $j = 1, 2, 3$ breeds, HOL, SR, and CB; $k = 1, 2, \ldots, 12$ herds; μ = the overall mean; α_i = treatment, fixed; β_j = breed, fixed; $(\alpha\beta)_{ij}$ = interaction of fixed factors of treatment and breed; c_k = the random effects of herd; and e_{ijkl} = the residual.

Assume the following:

$$c_k \sim \mathrm{IND}\left(0,\ \sigma_c^2\right),\ e_{ijkl} \sim \mathrm{IND}\left(0,\ \sigma_e^2\right),$$

where IND = independent, and σ^2 = variance.

RESULTS

Of the 819 enrolled cows, 425 were assigned to VWP50 and 394 to VWP140 group. A total of 737 (90%) cows were inseminated, and 590 (72%) completed their second lactation by calving for the third time. The between-herd variation comprised between 3.5% and 8.6% of the total variation.

Milk Production

Average daily MY (kg ECM) between calvings did not differ between treatments. However, both total MY and 305 d MY (kg ECM) were higher in the VWP140 compared with the VWP50 group. Milk yield close to dry-off was lower in VWP140 than VWP50 (Table 2). For all MY variables, a breed effect was observed, with SR cows yielding less than HOL and CB cows ($P < 0.05$). No significant breed × treatment interactions were observed.

Fertility Traits

The extended VWP140 group showed a higher proportion of FSP, fewer NINS, and shorter IPL compared with VWP50 (Table 3). The average CFI differed by 60 d between treatment groups, with the variation illustrated in Figure 1. Notably, a 60-d extension in CFI resulted in a 46-d increase in CInt, with no change in DPL duration (Table 4). No significant breed effects or breed × treatment interactions effect was observed for DPL and CInt.

Among the 388 inseminated cows in VWP50, 318 had a third calving, whereas 272 of the 349 inseminated cows in VWP140 had a third calf, corresponding to 82% and 78% of inseminated cows in the VWP50 and VWP140 groups, respectively. An interaction effect between breed and treatment on CFI was observed for both inseminated cows ($P = 0.03$) and cows with a complete second lactation ($P = 0.04$). Among all inseminated cows within the VWP140 group, CB cows were inseminated 9 d later than HOL and 8 d later than SR cows. No significant breed effects were observed.

Culling

In total, 225 out of 819 cows were culled in their second parity, with 105 of 425 (24.7%) in VWP50 and 120 of 394 (30.5%) in VWP140. Of these, 11 cows were lost due to on-farm mortality. Among the culled cows, 82 were not inseminated: 37 in VWP50 (8.7%) and 45 in VWP140 (11.4%). Culling due to reduced fertility was reported for 17 cows (4%) in VWP50 and 24 cows (6.1%) in VWP140. Treatment did not affect the likelihood of culling ($P = 0.07$), being inseminated ($P = 0.24$), or being culled due to reduced fertility ($P = 0.59$).

DISCUSSION

This study investigated the effect of systematic group allocation of second-parity cows to either a conventional VWP of 50 d or an extended VWP of 140 d. Second-

Table 3. Days from calving to first insemination (CFI), first service pregnancy (FSP) as a proportion, number of inseminations per cow (NINS), and insemination period length (IPL) in days (LSM ± SEM) for all inseminated cows and for cows having a complete second parity ending with a third calving[1]

	All inseminated cows			Complete parity		
	VWP50	VWP140		VWP50	VWP140	
Item	n = 388	n = 349	*P*-value	n = 318	n = 272	*P*-value
CFI[2]	68.6 ± 3.06	128.5 ± 3.22	<0.001	67.6 ± 2.97	127.2 ± 3.27	<0.001
FSP	0.43 ± 0.04	0.58 ± 0.05	<0.001	0.46 ± 0.05	0.62 ± 0.05	0.002
NINS	2.14 ± 0.15	1.79 ± 0.14	0.002	2.02 ± 0.14	1.61 ± 0.13	<0.001
IPL	39.3 ± 5.0	30.6 ± 5.3	0.01	35.6 ± 4.3	20.8 ± 4.8	<0.001

[1]Cows were assigned to voluntary waiting period of 50 d (VWP50) or 140 d (VWP140). Significant treatment × breed interactions are noted in the table footnotes.

[2]A breed × treatment interaction was observed among all inseminated cows (*P* = 0.03) and complete parity cows (*P* = 0.04).

parity cows were selected to represent the higher MY potential compared with primiparous cows, and limiting the effects of varying lactation number by focusing on a single parity group. The cows were enrolled during 1 yr in 12 commercial high-yielding dairy herds in Sweden. The most notable findings were the similar average daily MY (kg ECM) per day CInt and per lactating day between groups, the unaffected DPL, and the higher proportion FSP in cows with extended VWP compared with those with conventional VWP.

As planned, the extended VWP led to a longer CInt and lactation, leading to a higher total MY during the second lactation compared with VWP50. Furthermore, the 305-d MY was higher in the VWP140 group, consistent with findings in both primiparous (Edvardsson Rasmussen et al., 2023) and multiparous cows (Niozas et al., 2019a). This difference in 305-d MY may be attributed to the negative effect of pregnancy on daily MY (Hammond and Sanders, 1923; Strandberg and Lundberg, 1991), as cows in the VWP140 group likely experienced a less pronounced decline in daily MY due to later conception than those in the VWP50 group.

Daily MY per day CInt did not differ between groups in our study, averaging ~34 kg ECM in both the VWP50 and VWP140 groups. This aligns with findings from Arbel et al. (2001), who extended the VWP by 60 d in the highest-yielding half of the cows within each herd, and with van Amburgh et al. (1997), who compared VWP of 60 and 150 d, resulting in CInt of 13.2 and 16.5 mo, respectively. The consistent daily MY observed in our study is likely explained by a higher proportion of DIM and a lower proportion of dry days, which help sustain production levels despite longer CInt. In addition, a delayed conception would be expected to postpone the pregnancy-related decline in daily MY, thereby contributing to a more persistent peak lactation in cows with an extended lactation compared with those managed with a conventional CInt. Together, these dynamics act synergistically to result in similar daily MY across treatments. Although not investigated in the current study, a threshold for VWP may exist beyond which daily MY cannot be maintained. For example, in a research farm study, cows with a VWP of 200 d exhibited lower daily ECM yield between 2 consecutive calvings compared with cows with a VWP of 50 d, while cows with a VWP of 125 d showed intermediate yield, without significant differences from either of the other 2 treatments (Burgers et al., 2021b). However, because lactation persistency varies between farms and among individual cows, this variation may influence the threshold at which further extending the CInt begins to reduce daily MY, both at the herd and individual levels (Steeneveld and Hogeveen, 2012; Lehmann et al., 2017; Niozas et al., 2019a).

In our study, daily MY (kg ECM) per lactating day was not affected by VWP. In contrast, Arbel et al. (2001) reported that multiparous cows with a conventional 60-d VWP produced less ECM per lactating day (39 kg ECM vs. 39.9 kg ECM) compared with cows whose VWP was extended to 120 d. A plausible explanation for this discrepancy is that our study included all cows except the 1% with the lowest 305-d MY in first lactation, whereas Arbel et al. (2001) selected high-yielding cows within herds, defined as those with a 305-d ECM above the herd average in the previous lactation and first-lactation cows exceeding 30 kg of milk in one of the first 3 milk recordings. Our findings indicate that an extended VWP could be a viable strategy for second-parity cows in high-yielding herds, as neither daily MY nor MY per lactating day differed between treatments.

Because DPL did not differ between treatment groups and MY before dry-off was only marginally higher in the VWP50 group, our results indicate that the longer CInt does not increase the risk of an extended dry period due to early dry-off caused by low production. High MY at dry-off has been associated with negative effects on udder health, both during the dry-off and in the subsequent

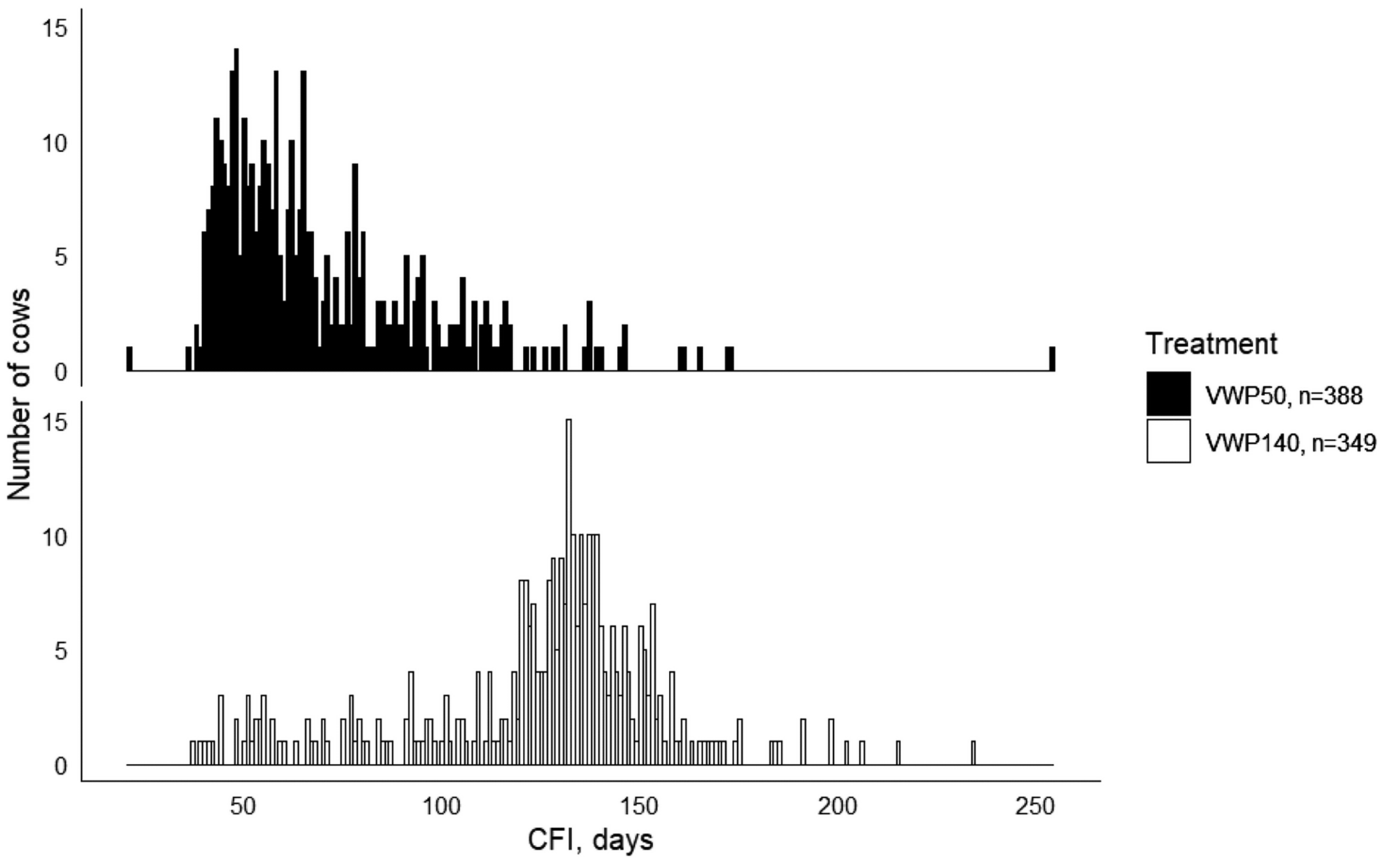

Figure 1. Days from calving to first insemination (CFI) for cows assigned to either a voluntary waiting period of 50 d (VWP50) or a voluntary waiting period of 140 d (VWP140).

lactation (Bates and Dohoo, 2016). In our study, extending the CInt from 381 to 427 d resulted in a moderate reduction in MY near dry-off, from 33.7 to 32.5 kg ECM, based on test-day MY 10 to 40 d before dry-off. This interval was selected to avoid including daily MY potentially affected by management decisions around dry-off. As the reduction in MY was relatively small—and occurred at a high production level—it is unlikely that this difference could have had any meaningful effect on udder health aspects.

In this study, after implementing 2 different VWP regimens during the second parity, we observed no difference between the groups in MY during the first 100 d of the subsequent, third lactation. These findings are consistent with Lehmann et al. (2016), who reported that consecutive lactation MY among multiparous cows was unaffected by the CInt in the previous parity.

In this study, the entire second lactation and the first part of the third lactation were analyzed separately to assess the effect of varying VWP in the second lactation, as well as any potential effect on the onset of the third lactation. No differences were found in daily MY, whether measured per lactating day or calving interval day, during the second lactation, and onset of third lactation did not differ between groups. However, extending the VWP in the second lactation delayed the time from the second calving to peak production in the subsequent lactation. Thus, the estimated long-term effect of an extended lactation on overall milk production may depend on the time frame used for evaluation, whether measured in days from calving or in lactation cycles. Furthermore, milk yield patterns can vary both across and within lactations (Dechow and Goodling, 2008), which may also influence the outcomes depending on the evaluation period used.

The extended VWP resulted in higher FSP, fewer NINS, and a shorter IPL compared with the conventional VWP. These findings align with studies conducted on research farms by Larsson and Berglund (2000) and Ma et al. (2022), as well as Edvardsson Rasmussen et al. (2023) in commercial herds. In Ma et al. (2022), the study's predefined insemination windows—up to 300 DIM—resulted in insemination periods of 250, 175, and 100 d for the VWP treatments of 50, 125, and 200 d, respectively. This design may have contributed to shorter IPL and lower NINS for the cows in the VWP 200 group. Conversely, Ratnayake et al. (1998) found no difference

Table 4. Dry period length and calving interval in days (LSM ± SEM) for cows assigned to a voluntary waiting period of 50 d (VWP50) or 140 d (VWP140) during their second parity

Item	VWP50 n = 318	VWP140 n = 272	*P*-value
Dry period length, d	64 ± 2.9	67 ± 3.1	0.23
Calving interval, d	381 ± 5.6	427 ± 6.1	<0.001

in NINS when comparing CInt of 12, 15, and 18 mo, where cows were allowed up to 5 inseminations within 130 d postfirst service. As study designs in commercial herds rarely dictate whether cows are inseminated during repeated estrus, managerial choices may have influenced NINS and IPL results between VWP groups. For example, daily MY frequently affects whether managers decide to inseminate cows in estrus; higher MY increases the likelihood of insemination. This dynamic may affect differences in CFI, NINS, and IPL between VWP treatments (Eicker et al., 1996; Burgers et al., 2021a).

Reproductive performance is influenced by multiple factors. For instance, negative energy balance during early lactation is a critical factor that can impair fertility, with more severe energy deficits being associated with poorer reproductive outcomes (Butler, 2003). Although energy balance was not measured in this study, we speculate that the improved fertility, reflected by a higher FSP in VWP140 compared with VWP50, may be attributable to a more favorable energy balance at the time of insemination resulting from the extended VWP.

A higher proportion of cows conceived at first service with an extended VWP compared with conventional VWP, both among all inseminated cows and among those that completed their second parity. Larsson and Berglund (2000) demonstrated, using progesterone profiles starting from the second week after calving to monitor ovarian function, that VWP extended to 140 d resulted in fewer ovarian disturbances at insemination and improved fertility outcomes compared with conventional VWP in both first and later parities. However, in a retrospective study on 11 Dutch commercial farms where managers applied either individually tailored or fixed extended VWP variables, generally small effects on FSP were observed. In that study, some managers extended VWP based on daily MY, delaying insemination until daily MY dropped below a certain threshold (Burgers et al., 2021a). It is important to note that results from retrospective studies may be biased due to differing production and fertility potentials in groups compared.

In our study, extending the VWP did not result in a proportional increase of CInt; a 60-d extension of VWP led to only a 46-d increase in CInt. This outcome indicates that improved fertility outcomes, such as higher FSP, reduced the effect of longer VWP on CInt. Notably, shorter VWP may increase the interval between the end of VWP and CFI due to challenges such as anestrus and ovarian disorders in early lactation, as observed in previous studies (Ratnayake et al., 1998). These findings indicate that VWP and CInt are not rigidly correlated, emphasizing the need for adjusting VWP according to individual farm conditions when targeting a specific CInt. Variability in estrus detection rates among farms further influences the relationship between VWP and CInt, underscoring the need for tailored reproductive management strategies.

Our results indicate that an extended VWP can improve reproductive performance, evidenced by higher FSP, shorter IPL, and fewer NINS. These improvements not only reduce resource usage, such as AI equipment and semen, but also lower labor demands for heat detection and insemination routines. Additionally, the reduction in NINS minimizes disruptions to cows' daily routines, contributing to better animal welfare.

In this study, treatment did not affect the likelihood of culling, nor did it influence the proportion of cows that had been inseminated. This aligns with the findings of Arbel et al. (2001) and Edvardsson Rasmussen et al. (2023), who studied 937 and 533 cows, respectively. Overall, no differences in culling patterns were observed in these studies. However, Larsson and Berglund (2000) reported an increased risk of culling due to low fertility, 15% among cows with a VWP of 50 d compared with 4% with a VWP of 140 d, in an experimental setting at the Swedish University of Agriculture, where all cows were offered 5 inseminations over a maximum period of 130 d. Given that insemination and culling decisions were beyond our control in this commercial setting, the results are not directly comparable to those from controlled experimental studies. Furthermore, because culling was a relatively infrequent event in our data, a larger sample size may be required to detect any potential effects on culling patterns in commercial herds. A numerical tendency toward higher culling in the VWP140 group was observed, although the difference was not significant.

Most cows in the VWP50 group were inseminated within a theoretical first cycle length following the 50-d VWP, with only a small proportion experiencing insemination beyond this cycle. Such delays are likely due to postponed onset of cyclicity (Hommeida et al., 2005), although management factors—such as intentionally delayed first service due to high MY, temporary health issues, or missed estrus detection—may also have contributed. In the VWP140 group, deviations from the protocol primarily involved earlier than planned inseminations. While some farmers reported these as unintentional errors, others may have intentionally shortened the VWP in response to moderate daily MY or to prevent injury during intense estrus. Early inseminations in the VWP140 group, particularly in cows with low MY or pronounced estrus behavior, could introduce bias in fertility and milk production results. This is noteworthy, as estrus intensity is positively correlated with conception rate and negatively correlated with MY (Nyman et al., 2016). By including multiple farms in the study, the risk of biases due to management decisions is reduced.

CONCLUSIONS

When comparing conventional (50 d) and extended (140 d) VWP, no differences were observed in daily MY per CInt day, MY per lactating day, or DPL. These results indicate that second-parity cows in high-yielding herds were well suited for an extended CInt of up to 14 mo. Furthermore, there was no adverse effect on MY during the first 100 d of the subsequent third lactation. Fertility, indicated by a higher proportion of conception at first service, improved in cows assigned to VWP140 compared with VWP50. This fertility outcome contributed to a shorter CInt extension than the full difference in CFI interval. Overall, the results indicate that extending the VWP from 50 to 140 d may be a viable fertility management strategy for second-parity cows in high-yielding herds, potentially enhancing fertility without compromising milk production or affecting culling rates.

NOTES

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Nonstandard abbreviations used: CB = crossbreeds; CFI = calving to first insemination interval; CInt = calving interval; DPL = dry period length; FSP = first service pregnancy; HOL = Holstein; IPL = insemination period length; MY = milk yield; NINS = number of inseminations; SOMRS = Swedish official milk recording scheme; SR = Swedish Red breed; VWP = voluntary waiting period; VWP50 = 50-d VWP; VWP140 = extended 140-d VWP.

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