Slutrapport

Projekttitel

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Projekttidsperiod:

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Del 1: Utförlig sammanfattning

Kort beskrivning av syftet, metoder, huvudsakliga resultat och nytta för näringen samt rekommendationer. Sammanfattningen måste skrivas på engelska om rapporten är på svenska, och vice-versa.

Projekt har fått finansiering genom:

Stiftelsen Lantbruksforskning

Del 2: Rapporten (max 10 sidor)

Introduction

Traditionally the optimal length of a lactation has been considered to be 305 days and the dry period 60 days, leading to a 365 days calving interval. The rationale behind this is that it is the part of the lactation with low milk yield that becomes extended, thus leading to feed costs etc. without enough income to compensate these. However, there are several reasons why this might be an oversimplification. Firstly, these calculations were based on the situation about 30 years ago; since then the average milk production has increased with almost 50% which causes a more pronounced metabolic pressure on the cows. Furthermore, health aspects were not accounted for (Strandberg & Oltenacu, 1989; Holmann et al., 1984) and probably more importantly, the assumption was based on that all cows have the same development of milk yield over the lactation, i.e. the same lactation curve shape. If some cows are more prone, for genetic or other reasons, to have a flatter lactation curve, it could be advantageous to delay the inseminations (and thus pregnancy) to allow them to milk longer. But we need to be able to predict this early enough so that one can deliberately delay inseminations for some cows.

The traditional breeding period coincides with the period when cows have high milk yield while the feed intake still is not maximal and therefore many cows are in negative energy balance (NEB), meaning that they cannot consume as much energy as they produce in milk. The number of cows that produce milk longer than 305 days after calving has markedly increased in recent years (Němečková et al., 2015). The expected benefits of extended lactations (EL) include reduced number of dry days per year and lifetime, reduced costs associated with inseminations, calvings and disease due to reduced metabolic stress, exposure to fewer high risk periods of around calvings, and increased longevity (Borman et al., 2004). A traditional lactation (TL) is associated with a markedly increased risk of udder infections and clinical mastitis due to higher yield at dry off (Rajala-Schultz *et al.*, 2005).

There is substantial variation in the lactation persistency among cows subjected to EL. Preplanned calving intervals of 12 and 15 months were compared for Swedish red (SRB) and Swedish Holstein (SH) breeds (Rehn et al., 2000). There was a large individual variation in lactation shape and persistency especially when the cows were subjected to15 months calving interval. Primiparous cows maintained their lactation longer than multiparous cows and SH were more persistent than SRB. This variation limits the benefit of EL as a general management arrangement. However a system where the lactation length is adapted to the characteristics of the individual animal would be beneficial.

Material and Methods

Study I*: Design and herd selection criteria (manuscripts 1 & 2)*

A randomized controlled trial focusing on conventional and extended VWP was carried out on commercial dairy herds in southern Sweden between August 2018 and September 2021 with ethical approval from Uppsala Ethics Committee for Animal Research, Uppsala, Sweden (protocol number 5.8.18-10126/2018). A total of 218 farmers were invited to join the study, based on data from the year 2016/2017 obtained from the Swedish Milk Recording System (SOMRS) managed by Växa Sverige. The inclusion criteria were: herds with >100 dairy cows in production and herd-average milk production of at least 9,000 kg ECM/cow/year, mean CInt less than 14 months, and a system for daily milk recording. Nineteen herds agreed to participate, but one herd dropped off during the study due to miscommunication and two herds were excluded after analysis of insemination data due to poor compliance with the research protocol. Data from the second lactation in 1 herd were excluded because that herd was also involved in another study on extended VWP in multiparous cows.

Herd description
The 16 participating herds had mean herd size of 165 cows (range 102-305), mean yearly milk production, defined as the total produced yield in the herd during the year divided by the mean number of cows during the same year, of 10,623 kg ECM (range 9,000-12,623 kg ECM), and mean CInt of 12.7 months (range 11.8-13.8 months) during the previous year (2016/2017). The herds had either automated milking systems (n = 12) or parlors (n = 4).The cows were categorized as Holstein (HOL), Red Dairy Cattle (RDC, defined as Swedish Red, Danish Red, or Swedish Ayrshire cattle), or Cross/other breeds, with a cow considered purebred if the dam and sire were of the same breed. Based on the SOMRS data for 2017/2018, the breed distribution in the herds was: HOL mean 50% (range 5-97%), RDC mean 41% (range 2-90%), and Cross/other mean 9% (range 0-34%).

Cow inclusion, exclusion, and intervention regarding the voluntary waiting period
The study period started within 1 month of 1 September 2018 in all herds. Only pure-bred HOL and RDC heifers calving within 6 months of the starting date of each herd were recruited for the study. The primiparous cows selected for inclusion were allocated by odd or even ear tag number to either a control group with conventional VWP of 25-95 days or a test group with extended VWP of 145-215 days. No intervention in VWP was made during the second lactation

Data collection, description, and calculation of variables
Data on breed, calvings, inseminations, 305-d lactation yields, test-day yields, and dry-off dates during 2 consecutive lactations were obtained from the SOMRS. Information about daily MY and number of milkings for individual cows was obtained from the herds' milking systems.

Inclusion criteria Manuscript 1
Three inclusion criteria were used, depending on the variable under investigation. These were: "VWP according to plan", "complete lactation", and "sufficient daily MY records".
Voluntary waiting period according to plan and complete lactation
The cows were considered to have VWP according to plan when the instruction regarding number of days from calving to the first insemination interval was followed. Thus for cows in the conventional group, VWP of 25-95 days in milk (DIM) was considered to comply with the plan, while for the cows in the extended VWP group, VWP of 145-215 DIM was considered to be in compliance. Cows that had their second or third calving before the end of data collection in September 2021 were considered to have a complete first or second lactation, respectively. Both these inclusion criteria were applied for all variables studied.
Sufficient daily milk yield records
Daily MY records were considered sufficient if there were less than 50% missing daily yield records in total, no more than the first 40 days of lactation missing, and no more than the last 60 daily yields in the lactation missing. These inclusion criteria were applied for lactation length, dry period length (DPL), DPL category, MY at test milking 50-20 days before dry-off, and lactation curve calculations.

Inclusion criteria Manuscript 2
Data from SOMRS was collected between August 2018 and September 2021, including parentage, breed, calvings, inseminations, estrus intensity, culling dates, and culling reasons. Additionally, if the planned VWP was not followed, the farmers were asked to register a reason for that.
Four different inclusion criteria were used in different combinations for each variable under investigation. A VWP of +/- 10 days from the original plan was considered "according to plan", i.e. 25-95 days for the conventional VWP group and 145 – 215 days for the extended VWP group. This inclusion criterion was applied for all variables except the description of why the VWP was not followed as planned. In addition, culling information are also presented for all cows included. Fertility data was not considered reliable if a cow had a second or third calf without any registered

inseminations or if she had a living calf (defined as a calf that received an ear tag number after calving), but no registered insemination in the interval 280 +/- 14 days before that calving. This was applied to all fertility variables (NINS, insemination period length, FSCR, CFI, estrus intensity and pregnancy loss). A complete first or second lactation was defined as cows that had their second or third calf before September 2021 which was the endpoint of data collection. This criterion was applied for calculating the time for the insemination that led to calving which was used for calculating DIM at insemination leading to calving, insemination period length defined as the calving to last insemination (**CLI**) minus calving to first insemination (**CFI**), number of inseminations per conception (**NINS**) and all somatic cell score (**SCC**) variables. Sufficient daily yields was defined as no more than 10 d of missing milk yields in the beginning of lactation and no more than 50% missing daily yields during the whole lactation. This criterion was applied to the calculation of mean daily yield 4-33 d after calving for cows where the VWP plan was not followed.

Statistical analysis (Manuscript 1)

Initial data handling was performed in Microsoft Excel 2016 and statistical analysis was performed in R software (R core team, 2014), using R studio version R-4.1.2 (RStudio Team, 2021). The confidence level was set at $P<0.05$. All models included the VWP group (2 levels) and breed group (2 levels) as fixed factors, and the random effect of herd (16 and 15 levels in first and second lactation). Interaction between VWP group and breed was also tested as a fixed factor, and was removed from the models if not significant.

For continuous variables with an approximate normal distribution of residuals, i.e., MY variables, CInt, lactation length, and DPL, linear mixed models were fitted by restricted maximum likelihood using the lmer function from the packages lme4 and emmeans in R.The results of the models were analyzed with Type III Analysis of Variance with Satterthwaite's method to obtain P-values, and the results are presented as LSM ± SEM.

For the binary variable, DPL category, a generalized binomial linear mixed model was fitted by Laplace Approximation, using the glmer function in the packages lme4 and emmeans in R. The model was analyzed with Analysis of Deviance using Type II Wald Chi-Square tests for hypothesis testing. Numbers of cows in the short and long DPL subgroups were compared with the number of cows with moderate DPL.

Statistical analysis Manuscript 2

Microsoft Excel 2016 was used for initial data organization. R software (R core team, 2021) and R studio version R-4.1.2, (R studio, 2022) was used for statistical analysis. VWP group (2 levels), Breed (2 levels), and the interaction between VWP group and Breed were included as fixed factors and Farm (16 levels) as a random factor in all models unless otherwise stated. If the interaction was not significant it was removed from the model. The confidence level was set to 0.95.

Linear mixed models were analyzed with the lmer and emmeans functions from the packages lme4 and emmeans in R. for the continuous data; mean MY day 4 – 33 and CFI. The results are presented as LSM +/- SEM.

For the binary variable pregnancy loss, FSCR and Estrus Intensity, a generalized binomial linear mixed model, fit by Laplace Approximation, using the glmer and emmeans functions in R. The results are presented as percent and proportion of cows (n/N, where n is the number of cows that conceived at first insemination, the number of cows with pregnancy loss, or the number of cows with a specific estrus intensity score and N is the total number of animals per group). For hypothesis testing the models were analyzed with an Analysis of Deviance Table using Type II Wald Chi-Square tests. The ordinal data from the estrus intensity score was analyzed with the binomial linear mixed model described above for each score. The scores 0 – 2 were merged due to

low frequency of observations. Results are presented in graphs (percent of cows per VWP or Breed group and score) made in GraphPad Prism version 9.4.0 (GraphPad Prism, 2022) using fraction of total graphs for each VWP and Breed group in both lactations.

For inference regarding the number of inseminations per conception (**NINS**), the total number of inseminations and conceptions was first summarized per farm, breed, and VWP group. If there were no inseminations or conceptions in a group that group was omitted (lact. 1 n =1, lact. 2 n = 4). These grouped results were analyzed with a generalized Poisson linear mixed model, fit by Laplace Approximation, using the glmer and emmeans functions in R.

The insemination period length and DIM at culling were analyzed with Kaplan-Meier survival curves in R using survfit, surv, and ggplot functions from the Hmisc, ggplot2 and ggfortify packages. Only VWP group was included as a fix factor. For the categorical data of reason for culling and reason for not following VWP, the results are only presented descriptively in graphs

Description and definition of variables (Manuscript 2)
Four different inclusion criteria were used in different combinations for each variable under investigation. A VWP of +/- 10 days from the original plan was considered “according to plan”, i.e. 25-95 days for the traditional VWP group and 145 – 215 days for the extended VWP group. This inclusion criterion was applied for all variables except the description of why the VWP was not followed as panned. Fertility data was not considered reliable if a cow had a second or third calf without any registered inseminations or if she had a living calf (defined as a calf that received an ear tag after calving), but no registered insemination in the interval 280 +/- 14 days before that calving. This was applied to all variables except for culling reasons, reasons for not following VWP and milk yield in early lactation for cows not following planned VWP. A complete first or second lactation was defined as cows that had their second or third calf before September 2021 which was the endpoint of data collection. This criterion was applied for calculating the time for the insemination that led to calving which was used for calculating DIM at insemination leading to calving, insemination period length (CLI – CFI), and insemination rate. Sufficient daily yields was defined as no more than 10 d of missing milk yields in the beginning of lactation and no more than 50% missing daily yields during the whole lactation. This criterion was applied to the calculation of main yield 4-33 d after calving for cows where the VWP plan was not followed.

Study II. *Design and herd selection criteria*
In the second study heifers were allocated to conventional and extended VWP according to three selection criteria. Cows assumed to benefit from an extended VWP: 1; cows with 10 % highest genetic index for persistency, 2; all cows with dystocia, twin birth or clinical disease within 28 days after calving were assumed to better fit to extended VWP. 3; all heifers with higher milk yield than the average of heifers in the herd during the period from 4 to 33 days after calving. Fifty percent of the heifers that met the above criteria were subjected to an extended VWP and the other 50 % were subjected to a traditional VWP. All heifers in the study that did not meet the above criteria were subjected to a conventional VWP. The heifers that did not meet the criteria were all subjected to a traditional VWP. Thus the study design generated three groups of heifers. Seventeen herds participated in study 2. Most of the herds (n=13) did also participate in study while four herds were newly recruited according to the same herd criteria an in study 1. The field study was successfully performed and data collected. The data is yet to be analyzed.

Results and Discussion

Study I.

For the cows in the extended VWP group, CInt, lactation length, and DPL were all longer during their first CInt than for the group with conventional VWP (Table 1). On comparing the proportion of cows in different DPL categories (short, moderate, or long dry period), we found that the proportion of cows with a long dry period in their first CInt was higher in the extended than in the conventional VWP group. There was no significant difference between the VWP groups regarding the proportion of cows with short DPL (Table 3). During the second lactation, CInt, lactation length, DPL, and DPL category differed significantly between the 2 VWP groups (Table 1). Effect of voluntary waiting period on milk and ECM yield. The interaction between VWP and breed was not significant and was removed from all models. The results indicate that both dominating breeds are equally well suited for extended VWP from a milk production perspective.
Whole-lactation (WL) yield during the first lactation was 28% greater for the extended VWP group than for the conventional group, and the former group also had higher 305-d yield. However, when yield was calculated per day of CInt, there was no difference between the groups (Table 2). The lactation curves for first-parity cows in the 2 VWP groups are shown in Figure 2. During the second lactation, the extended VWP group had 5-7% higher WL yield, 305-d yield, and yield per CInt day than the conventional VWP group (Table 2). The lactation curves for second-parity cows in the 2 VWP groups are shown in Figure 3. Comparisons of average yield per day during the 2 CInt combined revealed that this did not differ significantly between the 2 VWP groups (Table 2).

In manuscript 1 milk production during the first lactation with conventional or extended VWP and the following full lactation without a VWP intervention was studied. To our knowledge, no random controlled trial has done this before at a large scale in commercial herds. As expected, because lactations were longer, extended VWP resulted in higher WL yield (Table 1). Moreover the 305-d yield was higher during the first lactation, probably due to a delay in the negative effect of pregnancy on MY (Figure 2). Our results for ECM yield per day in the first CInt, which were generally not different between VWP groups, correspond well to previous findings for primiparous cows on ECM per CInt day (Niozas et al., 2019a; Burgers et al., 2021a), or in extended VWP (Arbel et al., 2001; Lehmann et al., 2016).
On comparing MY per day during the second CInt, the cows with extended VWP in their first lactation produced around 1.6 kg more milk per day than the cows with conventional VWP (Table 2). It is possible that the observed higher yield in the second lactation was, at least partly, an artefact related to a higher rate of culling of cows with lower yield potential.
From a farmer's perspective, it is interesting to compare average yield per day during the first and second lactations combined. We found no significant difference between the VWP groups, which suggests that the long dry period for cows with extended VWP in their first lactation was compensated for by higher total yield in both lactations or a lower proportion of dry days.
As a consequence of extended VWP, both CInt and lactation length were prolonged in the first lactation, but there was no difference between the VWP groups in the second lactation. Regarding DPL, we found a higher frequency of extended VWP cows in the "long" dry period class, in line with previous findings. Milk yield at the last test milking before dry-off, which was investigated here as a measure of dry-off yield before the application of dry-off routines, was 1.9 kg lower in the extended VWP group than in the group with conventional VWP in the first lactation, in agreement with findings in Niozas et al. (2019a).
There was no interaction between breed and VWP, which suggests that both breeds are equally suited to extended VWP. The results for CInt and lactation lengths and WL yields were consistent with the lactation curves derived from daily MY in both lactations (Figure 2 and Figure 3),

although the curves were based on fewer animals because only lactations with sufficient daily yield recordings were included. In the first lactation (Figure 2), an effect of pregnancy on daily yield was observed from about 150 DIM for the conventional VWP group, in line with findings by Österman and Bertilsson (2003).

Our results support previous claims that extended VWP in primiparous cows does not have a negative impact on individual milk production (Rehn et al., 2000; Kok et al., 2019; Lehmann et al., 2019). And we found that cows with extended VWP had fewer unproductive days, 13.5% *vs* 15% of the first CInt, than cows with conventional VWP (Table 1). However, when applying extended VWP in practice, consideration has to be given to what this means for

Therefore it may be beneficial to extend VWP, especially when taking account of other advantages such as improved fertility (Paper II), Larsson and Berglund, 2000; Niozas et al., 2019b), and possibly better health due to fewer transition periods with high disease frequency (Ingvartsen et al., 2003), lower MY at dry-off (Rajala-Schultz et al., 2005; Niozas et al., 2019a), and a longer productive life (Gaillard et al., 2016; Römer et al., 2020).

First service conception rate, calculated as the number of cows with a positive pregnancy diagnosis after first insemination divided by all cows with an insemination followed by a pregnancy diagnosis, was higher for cows with an extended VWP than for cows with traditional VWP (table 3). Moreover, the number of services per conception, calculated as total number of inseminations divided by total number of inseminations with positive pregnancy diagnosis per group, was lower in cows with extended VWP than in cows with traditional VWP. The fertility results thus are unanimous, EI, NINS, FSCR and insemination period length were all in favor of the extended compared to the conventional cows. We suggest that the main reason for positive outcome of extended VWP on fertility was negatively affected by negative energy balance when the time point for starting the inseminations was postponed. On the other hand, pregnancy losses tended ($P=0.05$) to be more frequent among cows with extended VWP. We do not have any explanation for this tendency. Only 72% of the cows followed the planned VWP and the compliance to the study protocol varied across the farms, an obvious problem related to random controlled studies in field conditions which may have affected the results. There were fewer cullings in the conventional VWP group than in the extended VWP group of all included cows (17% and 25%, $P < 0.05$). But with the two lactations combined there were no difference in culling rate. There were generally few diseases reported and statistical evaluation of these parameters was not feasible. Never the less, a descriptive presentation of the results (not shown) indicate a higher frequency of diseases among cows with extended VWP, partly due to the fact a longer observation period. The number of somatic cells in milk did not differ between cows subjected to different VWP suggesting that the VWP did not affect udder health.

Table 1. First and second lactation 305-d lactation yield, whole-lactation (WL) yield, and average milk yield (MY) per day in each calving interval (CInt) and during 2 consecutive CInt (kg, LSM ± SEM) for cows with conventional (CONV) or extended (EXT) voluntary waiting period (VWP), and for the 2 breeds Holstein (HOL) and Red Dairy Cattle (RDC)

		VWP					Breed				
	n	CONV		EXT		P-value	HOL		RDC		P-value
First lactation											
305-d ECM	347	9,127[b]	± 228	9,653[a]	± 230	< 0.001	9,488	± 231	9,291	± 244	0.28
305-d MY	347	8,882[b]	± 230	9,492[a]	± 233	< 0.001	9,474[a]	± 234	8,901[b]	± 249	0.003
WL ECM	349	9,578[b]	± 325	12,307[a]	± 329	< 0.001	11,070	± 331	10,816	± 352	0.36
WL MY	349	9,279[b]	± 306	11,872[a]	± 311	< 0.001	10,926[a]	± 312	10,225[b]	± 335	0.01
Daily ECM	349	26.1	± 0.75	26.7	± 0.76	0.15	26.7	± 0.76	26.1	± 0.80	0.30
Daily MY	349	25.3	± 0.73	25.7	± 0.74	0.30	26.3[a]	± 0.74	24.7[b]	± 0.78	0.004
Second lactation											
305-d ECM	219	11,304[b]	± 241	11,957[a]	± 253	0.002	11,973[a]	± 253	11,288[b]	± 281	0.02
305-d MY	219	11,061[b]	± 226	11,778[a]	± 240	0.001	12,115[a]	± 239	10,723[b]	± 268	< 0.001
WL ECM	219	11,986[b]	± 274	12,817[a]	± 294	0.005	12,907[a]	± 289	11,896[b]	± 330	0.008
WL MY	219	11,659[b]	± 253	12,527[a]	± 274	0.003	12,963[a]	± 266	11,223[b]	± 307	< 0.001
Daily ECM	219	31.8[b]	± 0.7	33.3[a]	± 0.7	0.01	33.2	± 0.7	31.9	± 0.8	0.10
Daily MY	219	30.9[b]	± 0.7	32.6[a]	± 0.7	0.007	33.3[a]	± 0.7	30.9[b]	± 0.7	< 0.001
Both lactations											
Daily ECM lact. 1 & 2	219	29.2	± 0.7	30.1	± 0.7	0.07	30.1	± 0.7	29.2	± 0.8	0.21
Daily MY lact. 1 & 2	219	28.4	± 0.7	29.2	± 0.7	0.10	30.0[a]	± 0.7	27.7[b]	± 0.8	< 0.001

[a,b]Mean values within rows with different superscripts differ significantly (P<0.05).

Effect of voluntary waiting period on calving interval, lactation length, and dry period length

Table 2. First and second lactation calving interval, lactation length, dry period length, and milk yield (MY) at test milking 50-20 days before dry-off (TM before DO) (LSM ± SEM) for cows with conventional (CONV) or extended (EXT) voluntary waiting period (VWP), and for the 2 breeds Holstein (HOL) and Red Dairy Cattle (RDC)

		VWP group					Breed				
	n	CONV		EXT		P-value	HOL		RDC		P-value
First lactation											
Calving interval (d)	349	368[b]	± 3.7	462[a]	± 3.9	< 0.001	413	± 3.7	416	± 4.4	0.60
Lactation length (d)	320	311[b]	± 4.2	398[a]	± 4.3	< 0.001	353	± 4.1	355	± 5.0	0.67
Dry period length (d)	320	56.2[b]	± 2.6	62.6[a]	± 2.6	< 0.001	59.8	± 2.6	59.0	± 2.9	0.72
MY TM before DO (kg)	285	25.9[a]	± 0.94	24.0[b]	± 0.95	< 0.001	26.2[a]	± 0.93	23.7[b]	± 1.0	0.003
Second lactation											
Calving interval (d)	219	377	± 6.2	386	± 6.6	0.13	390[a]	± 6.6	373[b]	± 7.4	0.03
Lactation length (d)	127	315	± 7.8	331	± 8.7	0.06	332	± 8.2	314	± 9.3	0.06
Dry period length (d)	127	58.8	± 2.1	58.1	± 2.4	0.75	58.2	± 2.2	58.7	± 2.5	0.84
MY TM before DO (kg)	106	27.3	± 1.0	27.2	± 1.1	0.93	30.1[a]	± 1.0	24.4[b]	± 1.2	< 0.001

[a,b]Mean values within rows with different superscripts differ significantly (P<0.05).

Table 3. Number of inseminations per conception (NINS) in lactation 1 and 2, calculated as the number of inseminations per number of pregnant cows, per farm, breed and voluntary waiting period (VWP) group (number of groups lactation 1, n = 51, and lactation 2, n = 47). The results are presented as least squares means ±SEM, for cows with conventional (CONV) or extended (EXT) VWP, and for the 2 breeds Holstein (HOL) and Red Dairy Cattle (RDC)

		VWP group			Breed		
	n	CONV	EXT	P-value	HOL	RDC	P-value
NINS lactation 1	381	2.0[a] ± 0.1	1.6[b] ± 0.1	0.005[1]	1.9 ± 0.1	1.7 ± 0.1	0.46[1]
NINS lactation 2	290	2.1 ± 0.1	2.0 ± 0.2	0.47[1]	2.2 ± 0.1	1.8 ± 0.2	0.06[1]
CFI lact 2 (days)	288	73.5[b] ± 3.9	86.0[a] ± 4.1	< 0.001	80.5 ± 4.0	79.1 ± 4.5	0.75

[1] For NINS the p-value presented is the chisquare statistic, Pr (> Chisq)

Table 4. Percent and prevalence of cows (n/N) with first service conception rate (FSCR) and pregnancy loss for all inseminated animals with voluntary waiting period (VWP) according to plan in lactation 1, where n is the number of cows with first service conception or pregnancy loss and N is the total number of cows in each VWP group, conventional (CONV) or extended (EXT), and Breed, Holstein (HOL) and Red dairy cattle (RDC)

		VWP group					Breed				
		CONV		EXT			HOL		RDC		
	n_{tot}	%	(n/N)	%	(n/N)	P-value	%	(n/N)	%	(n/N)	P-value
First lactation											
FSCR	382	51[b]	(104/204)	67[a]	(119/178)	0.001	59	(132/233)	61	(91/149)	0.28
Pregnancy loss	382	3	(6/204)	7	(13/178)	0.05	3	(6/233)	9	(13/149)	0.10
Second lactation											
FSCR	253	45	(65/143)	45	(49/110)	0.93	40[b]	(61/152)	52[a]	(53/101)	0.05
Pregnancy loss	253	6	(8/143)	7	(8/110)	0.51	4	(6/152)	10	(10/101)	0.41

[a–b] Mean values in the same row with different superscripts differ (P < 0.05).

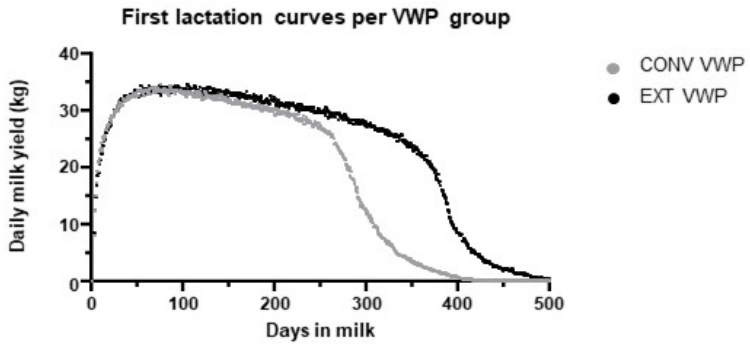

Figure 1. Average daily milk yield per day in milk during the complete first lactation for cows with a conventional (CONV) voluntary waiting period (VWP) (grey, n = 173) or extended (EXT) VWP (black, n = 147) during their first lactation. Based on data from cows with sufficient daily milk yield records, dried-off cows included with 0 kg yield per day.

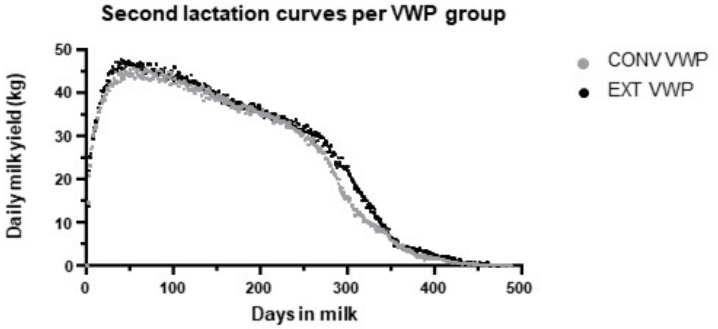

Figure 2. Average daily milk yield per day in milk during the complete second lactation for cows with a conventional (CONV) voluntary waiting period (VWP) (grey, n = 73) or extended (EXT) VWP (black, n = 54) during their first lactation. Based on data from cows with sufficient daily milk yield records, dried-off cows included with 0 kg yield per day.

Conclusions

We hypothesized that extending the VWP of primiparous cows can have a positive impact on fertility, without a negative impact on milk production. Study I was a randomized controlled trial involving > 500 cows in 16 herds followed for two lactations. The cows were randomly allocated to either a traditional or an extended VWP. Information about calvings, milk production, inseminations, and pregnancy outcomes and diseases were collected both from the Swedish milk recording system and from the herd systems. We found no difference between the VWP groups in MY per day during the first calving interval or during the first and second calving interval combined, but MY per day during the second interval was 1.5 kg higher for cows with extended VWP than for cows with conventional VWP. The results further show that first service conception rate was higher for cows with an extended VWP. Moreover, the number of services per conception was lower in cows with extended VWP. On the other hand, there were fewer cullings in the conventional VWP group than in the extended VWP group. In the second study involving 17 herds we did not randomize cows to conventional or extended VWP. Instead cows were allocated to a traditional or an extended VWP according to three selection criteria, developed from study I. This study is not yet finalized.

Benefift for the dairy industry and recommendations

This project was performed in a large number of commercial dairy herds. Thus the conclusions is expected to be applicable on primiparous cows in Swedish herds in general. Extended VWP in primiparous cows as a management routine can be recommended since fertility would be improved without negative impact on milk production. However, not all primiparous cows benefit from an extended VWP. Available individual cow information (early lactation milk yield, genetic persistence index, early lactation stage health status etc) can probably be used to allocate individual cows to favorable VWP.

Referenser

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Del 3: Resultatförmedling

Ange resultatförmedling av projektet, inklusive titel, referens, datum, författare/talare, och länk till presentation eller publikation om tillämpligt. Planerade publiceringar (med preliminära titlar) ska ingå i tabellen. Ytterligare rader kan läggas till i tabellen.

Vetenskapliga publiceringar	A randomized study on the effect of extended voluntary waiting period in primiparous dairy cows on milk yield during first and second lactation. J Dairy Sci (accepted) A. Edvardsson Rasmussen, K. Holtenius, R. Båge, E. Strandberg, M. Åkerlind and C. Kronqvist
	A randomized study of the effect of an extended voluntary waiting period on fertility and culling in primiparous dairy cows during first and second lactation. A. Edvardsson Rasmussen, K. Holtenius, R. Båge, E. Strandberg, M. Åkerlind and C. Kronqvist. Submitted
Övriga publiceringar	Several research communications have been published in the journal "Husdjur".
	Proceedings are available for the oral presentations below
Muntlig kommunikation	International Symposium Ruminant Physiology , Leipzig, September 2019 (Anna E. R. Oral presentation) Correlation between blood analysis of NEFA and BHB and long-chained milk fatty acids - The relationship between blood metabolites and milk fatty acids in early lactating dairy cows.
	European Association of Animal Production, Davos Augusti 2021 (Anna E. R. Oral presentation) Extended voluntary waiting period in primiparous dairy cows Anna E. R.
	European Association of Animal Production, Porto September 2022 (Anna E. R. Oral presentation) Effects of an extended lactation on milk yield in dairy cows - a randomized controlled study
	European Society for Domestic Animal Reproduction, Thessaloniki October 2022 (Anna E. R. Workshop speaker) Extended voluntary waiting period (VWP) in primiparous dairy cows
Studentarbete	Würtz, Mikaela, 2019. Field study of the drought's impact on feeding strategy and biological parameters in early lactation dairy cattle. Mastersarbete baserat på data från O-17-20-957. https://stud.epsilon.slu.se/14549/

	Ronström, Viktor, *2022.* Förlängt kalvningsintervall: stämmer rekommendationerna om att 12 månaders kalvnings-intervall är mest lönsamt*?* Enskilt arbete baserat på data från O-17-20-957 https://stud.epsilon.slu.se/18453/
Övrigt	Två ”lunch till lunch” hybrid-webinars har genomförts inom ramen för projektet. Inbjudna deltagare var bland annat alla lantbrukare som deltagit i projektet, rådgivare och forskare från referensgruppen och forskare från projektgruppen.
	Posterpresentation vid veterinärmötet i Uppsala 2021 Presentatör Anna E. R. ”En kalv per år” Förlängt kalvningsintervall för förstakalvare.
	Anna E. R. will defend her PhD thesis entitled *“Individually adapted lactation length for better performance of dairy cows”* 29 September 2023.