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Fertility in Dairy Cows Managed for Calving Intervals of 12, 15 or 18 Months

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Ratnayake DRTG, Berglund B, Bertilsson J, Forsberg M, Gustafsson H: Fertility in dairy cows managed for calving intervals of 12, 15 or 18 months. Acta vet. scand. 1998, 39, 215-228. – Effects on reproduction in a total of 135 dairy cows managed for calving intervals of 12, 15 or 18 months (72, 38 and 25 cows respectively) were studied. The cows were of the Swedish Red and White Breed (SRB) and the Swedish Freisian Breed (SLB) and were housed in 2 different herds with 3 different management systems (tied, loose, and tied but milked in a milking parlour; mixed). The cows in one of the herds (48 cows) were assigned for milking either 2 times or 3 times a day. When comparing conception rate at 1st insemination (AI) and the percentage of cows finally pregnant, we found no significant differences between the 3 calving interval groups, however, a tendency for a higher conception rate with a 15 months' interval compared with a 12 months' interval was found in one of the herds (50% vs 41.5%). The percentage of finally pregnant animals varied between 81% and 100%, but this variation was mainly attributed to the herd rather than calving interval group. A significantly higher percentage of cows was treated for anoestrous in the 12-month group than in the 15-month group in one of the herds (28.6% vs. 5.3%).
The frequency of ovulations with external heat signs increased with ovulation number up to the 4th ovulation and thereafter remained stable. No significant difference was found in number of AIs required per conception with respect to calving intervals, breeds, or milking frequency groups. However, cows milked 3 times a day had a significantly longer interval from the 1st AI to conception compared with cows milked 2 times a day (45.8 days vs 17.6 days, $p<.01$). Cows kept loose exhibited 1st ovulatory oestrous, approximately 2 weeks earlier (55.9 days vs 69.7 days, $p<.05$) than their herd mates kept tied.
In conclusion, our study shows that lengthening the calving interval to 15 or 18 months may have a positive influence on reproduction in terms of less need for treatments of ovarian disorders and higher conception rates. Our results also indicate that milking 3 times a day may have negative effects, and keeping cows in a loose-housing management system may have positive effects on ovarian function.

reproduction; extended calving intervals; cattle; milking frequency.

Introduction

Close to 12 months is generally regarded as the most profitable length of the calving interval in dairy production (*Zeddies* 1982, *Strandberg & Oltenacu* 1989). This assumption is mainly based on economical calculations on milk production, feeding, housing etc. In most cases, however, costs due to diseases and treatments are not taken into consideration.

In Sweden, the milk production per cow has continuously increased to an average production of 8.000 kg energy corrected milk (ECM) and with individual cows producing more than 16 000 kg ECM (*Anon.* 1996).
A calving interval of around 12 months necessitates an early resumption of the reproductive functions after calving, enabling the 1st insemination at around 50-60 days postpartum and high conception rates leading to pregnancy on an average around day 85 post calving. It has been shown that the risks of silent heat, ovarian cysts and other infertility problems increase with increasing milk production (*Gröhn et al.* 1994) which may make an early conception more difficult. Management for a short calving interval and high milk production may therefore require a close supervision of the reproductive functions and treatment of cows early in the postpartum period, which might be costly for the dairy farmer.
A voluntarily increased calving interval would prolong the time available for control of reproductive functions and probably decrease the need for some treatments. This would also be in line with the Swedish consumers' demand for less use of antibiotics, and hormones and a greater concern for animal welfare. On the other hand, a prolonged open period might lead to ceasing of cyclicity in some cows due to development of ovarian dysfunctions (e.g. unoestrus, cystic ovaries). A common opinion among many dairy farmers is also that heat detection becomes more difficult with time from calving.
In a number of recent studies, negative genetic correlations between milk production and reproduction have been observed (eg. *Emanuelson et al.* 1988, *Lindhé & Philipsson* 1997). How these correlations are expressed is probably to a great extent influenced by management systems. With today's high levels of milk production and calving intervals of 12 months, the demands on the energy supply in the beginning of lactation and thereby at time for insemination of the cow is high, which may cause these negative relationships. One of our hypothesis is therefore that by prolonging the calving interval, these associations might be reduced and eventually taken away.
Data on reproductive effects of pre-planned extended calving intervals are sparse. In an Israelian study, groups of cows were allocated to calving-1st breeding intervals of 35-120 days and investigated regarding fertility (*Schindler et al.* 1990). In a Canadian study, effects of 1st breeding at 50 days versus 80 days postpartum were investigated (*Schneider et al.* 1981). The results of these 2 investigations were, however, not consistent.
In this paper, we present data from one lactation of an ongoing 3 year project. The aim of the present study was to investigate possible effects on reproduction in cows managed for 12, 15 or 18 months' calving intervals by means of milk progesterone profiles, data on clinical examinations, heat detection- and AI-records.

Materials and methods

Cows in 2 dairy herds, belonging to the Swedish University of Agricultural Sciences were used in the study. The investigation period was confined to one calving interval (lactation and dry period) for each cow between September 1994 and December 1995.

Animals

In herd 1, Jälla, 87 cows of Swedish Red and White Breed (SRB) and Swedish Freisian Breed (SLB) in their 1st-5th lactation were included. In herd 2, Kungsängen, 48 SRB cows in their 1st-4th lactation were used. The average production level of cows in both herds were around 9000 kg ECM per lactation with a calving interval between 12 and 13 months before the start of the present study.

Management system
In herd 1, 2 management systems were used; tied cows in a rather new part and a loose-housing system in an older part of the same building. In herd 2, all cows were confined to individual stalls (without tying), but were milked in a milking parlour. This particular system is hereafter referred to as the mixed management system.

Feeding
The cows were fed according to Swedish standards (*Spörndly* 1993). Efforts were made to keep feeding regimes as equivalent as possible in both herds. The main difference between herds was that cows in herd 2 were given free access to a Mixed Ration (MR) during the 1st 24 lactation weeks, but with part of the concentrate given separately. In herd 1, hay, silage and concentrate were given separately from the 1st lactation week and onwards. Cows were individually fed in both herds, and the only exception was that roughage was group-fed in the loose housing system in herd 1. The MR included (on dry matter basis) grass silage 55%, grass hay 5%, concentrate 40%. From lactation week 25 and onwards concentrate, hay, and silage were fed in restricted amounts in both herds according to Swedish standards for metabolizable energy, protein, and minerals. During the summer season, (mid May to the end of August) cows in both herds were allowed to graze in between milking times, but a significant amount of nutrients was in addition fed indoors according to their requirements for milk production.

Milking
In herd 1, all cows were milked twice a day (2X) commencing at 6 AM and 3 PM. Milking was performed in the individual stalls for the tied cows and in a milking parlour for the loose-housing cows.

In herd 2, animals were randomly assigned to milking 2 times or 3 times a day (3X) from onset of lactation throughout the whole lactation. Milking was commenced at 6 AM and 3 PM in 2X cows and at 6 AM, 2 PM and 10 PM in the 3X cows.

Heat detection and insemination
The cows were randomly distributed over the planned calving intervals of 12, 15 or 18 months according to breed, lactation number, and milking frequency (Table 1). The animals were observed for signs of oestrus, 3 times daily at fixed hours, by experienced herdsmen and were inseminated at the 1st oestrus, occurring after 50 days postpartum for the 12-month groups, after 140 days postpartum for the 15-month group and after 230 days postpartum for the 18-month group. All cows were allowed 5 inseminations, and cows not pregnant at 5th insemination, or if ≥ 180, 270 or 360 days had passed since calving, were culled.
Heat records were maintained for each animal and based on the occurrence of different heat signs such as bellowing, mounting behaviour, vulvar swelling, licking, and vulvar discharge observed during heat detection. Based on the recorded heat signs, a final judgement of the strength of the heat was made and scored according to the following: no heat = 0, uncertain = 1, weak = 2, normal = 3 and strong = 4. The inseminations were carried out by experienced AI technicians.

Milk sampling for progesterone analysis
Ovarian function was monitored by analysis of progesterone (P_4) in whole milk samples and for this purpose, milk samples were collected twice weekly starting the 2nd week after parturition until the cows had shown normal cyclicity. Thereafter, the frequency of sampling was reduced to once a week and the samplings were terminated after final confirmation of preg-

Table 1. The distribution of cows in planned calving interval groups (12, 15 and 18 months) by herd, parity, breed, management system and milking frequency.

		Planned calving interval (months)			
		Herd 1		Herd 2	
		12	15	12	18
Parity	1	19	14	12	12
	2	13	12	5	8
	≥3	17	12	6	5
Breed	SRB	32	29	23	25
	SLB	17	9	–	–
Management system	Tied	28	23	–	–
	Loose	21	15	–	–
	Mixed*	–	–	23	25
Milking frequency	2 times	49	38	11	13
	3 times	–	–	12	12
Total		49	38	23	25

* Mixed = Cows confined to individual stalls, but milking was performed in a milking parlour.

nancy. Milk samples (about 5ml. of milk) were collected into tubes containing 100 μl of preservative (Bronopol 2% + MTB 0.05%) and stored at 4 °C until assay. Milk sampling was performed within 60 min after the morning milking in both herds.

Diagnosis and treatment

The reproductive disorders; anoestrous, ovarian cysts and endometritis were diagnosed according to the following criteria: Cows were considered anoestrous, if the P_4 level remained low for more than 10 days and no corpora lutea or cystic structures were found in the ovaries. Cows were considered having ovarian cysts if they had low P_4 values for more than 10 days and if cystic structures of a diameter of at least 25mm were found in the ovaries. Cows were regarded as having endometritis if they showed abnormal discharge (some cloudiness or flakes of pus in the discharge) after day 30 postpartum. In herd 1, cows with abnormal P_4 profiles or with symptoms of genital disorders were subjected to veterinary investigation by rectal palpation, and in herd 2, in addition by ultrasonographic scanning of the ovaries at weekly intervals. The ultrasound examinations were carried out by the same operator and according to procedures described by *Pierson & Ginther* (1987). The ultrasound scanner was a real time, B mode, instrument with a 5 MHz, rectilinear-array transducer. (Aloka echo camera, SSD-210DX II, Aloka Co., Ltd, Japan).

Cystic cows were treated with an intra-muscular injection with 10 μg of Gonadotrophine Releasing Hormone (GnRH: Receptal vet 4.2 μg/ml, Hoechst GmbH, Germany) earliest 42 days after calving regardless of planned calving interval. Anoestrous cows were treated with a progesterone releasing intra vaginal device (EAZI-breed, Cidr B, Smithkline Beecham, Surray, UK) for an 11-day period or with an intramuscular injection with 10 μg of GnRH (Receptal vet 4.2 μg/ml, Hoechst GmbH, Germany). In cows with a planned calving interval of 12 months, treatment for anoestrous was initiated earliest 50 and 60 days after calving for multiparous and primiparous cows, respectively. In the 15-month and 18-month groups, treatments were started by 130 and 230 days post partum, respectively. Cows with endometritis were treated from day 30 postpartum onwards by intramuscular injection with 5 ml of prostaglandin (Dinolytic vet, Dinoprost 5 mg/ml, Upjohn, Belgium).

Pregnancies in herd 1 were diagnosed within 60 days after the last insemination by rectal examination in cows which had not shown any heat sign and had high milk P_4 following the last insemination.

Pregnancies in herd 2 were diagnosed by ultrasonography at approximately 25 days following inseminations in cows with elevated milk P_4 levels through days 20-25 after insemination. Final confirmation of pregnancy was performed at around day 60 after insemination by rectal palpation.

Radioimmunoassay (RIA) of milk progesterone

The P_4 content of milk was determined by RIA technique (Farmose, Orion Diagnostica, Espoo, Finland) which was validated previously (*Ahlin et al.* 1994). During the experimental period, the company stopped supplying kits and launched a new assay (Spectra, Orion Diagnostica, Espoo, Finland). Correlation between the 2 assays was 0.94 for concentrations ranging from 1.0 nmol L^{-1} to 90.0 nmol L^{-1} . The intra-assay variation for both kits was below 10% for 2 control samples (8.3 nmol L^{-1} and 48.0 nmol L^{-1}) and corresponding inter-assay variation was below 16%.

Calculation of fertility parameters

The day of ovulation was estimated by considering one or several of the following criteria: (1) Ovulation had occurred on the day following observed oestrous if milk P_4 was less than basal level (3.1 nmol/L for herd 1 and 1.1 nmol/L for herd 2) on the day of oestrus. (2) When oestrus was not observed, ovulation was estimated to occur 4 days before P_4 increased from basal level to more than 5 nmol/L in herd 1 and 2 nmol/L in herd 2. (3) In cases of recorded post oestrous bleeding, ovulation was considered to have occurred 1-2 days before (4). In cases of inseminations resulting in conception, the day of ovulation was considered as the day after the insemination.

For the analysis of heat strength, only the true heat records (detected heat concomitant with an ovulation) were considered, and cows having only regular cycles (23 cows out of 29 from 15-month interval group and 16 cows out of 25 from 18-month interval group) were used for the analysis. For the comparison of heat strengths, scores of 3 or more were considered as normal heat. Intervals from calving to 1st ovulatory oestrous, from calving to 1st insemination, from 1st insemination to conception, from calving to conception and number of inseminations per conception, conception rate at 1st insemination and percentages of finally pregnant cows were considered for statistical analysis. In the calculation of number of inseminations per conception, any AI repeated within 5 days was excluded and for the interval measures (intervals to insemination and to conception), calculations were based on the last AI out of 2 AIs performed within 5 days. The incidence of treatments of anoestrous, cystic ovaries, and endometritis was also calculated. Only one treatment per cow for the same diagnosis was considered.

In addition to the detailed data on reproductive performance, several other recordings in the herds were also collected on an individual cow basis, such as daily feed intake, milk yield and milk composition on a weekly basis, regular checks of clinical diseases and disease indicators, culling reasons and slaughter data. These data will be published elsewhere.

Statistical analysis

Using milk P_4 values obtained up to day 10 postpartum (before the the first ovulation), a mean value was calculated to which one standard deviation (SD) was added. P_4 values higher than the calculated level were removed and a new calculation of the mean + 1 SD based on the remaining values was performed. The procedure was repeated until the calculated level remained unchanged. This final mean value + 1 SD was assumed as the base level of P_4. The effects of independent factors like calving interval (12, 15 and 18 months), milking frequency (2 and 3 times), herd (1 and 2), parity (1, 2 and 3 or more), breed (SRB and SLB) and management system (tied, loose or mixed) on measures of reproductive performance (interval from calving to 1st insemination and to conception and no. of inseminations per conception) were analysed by least-squares analysis using the General Linear Model (GLM) procedure of a computer package (*SAS Institute Inc.* 1987). Parity number greater than 3 was assigned as the value of 3.

The 2 herds were first analysed separately. In herd 1, effects of calving interval, breed, parity, and management system were considered. In herd 2, effects of calving interval, parity, and milking frequency were considered. To test herd effects, both herds were also analysed jointly in a nested model. The model included effects of herd, calving interval within herd, and parity.

In a preliminary analysis, effect of season (light and dark period) was tested but found to be confounded with calving interval and therefore omitted. Two way interactions were also tested in preliminary analysis but omitted due to low number of cows.

The association between calving interval and conception rate at 1st AI, percentage of finally pregnant cows, and incidence of sterility treatments were analysed by Chi square test (*SAS Institute Inc.* 1987).

Results

Sixteen cows out of 87 in herd 1 were not inseminated due to different reasons (mastitis n = 7, teat injury n = 1, paresis puerperalis n = 1, other diseases n = 4, low production n = 2 and bad temper n = 1). These cows were included for the calculation of interval from calving to 1st ovulatory estrous, but were excluded for further calculations. In herd 2, 4 cows were removed during the study period due to similar reasons (mastitis n = 2, hoof problem n = 1, and teat injury n = 1).

Least-squares (LS) means ± standard errors (s.e.m) for interval from calving to 1st ovulatory oestrous in the 2 herds according to parity, breed, management system and milking frequency are shown in Table 2. The interval from calving to 1st ovulatory oestrus was significantly shorter (55.9 days vs. 69.7 days, $p<.05$) in cows kept in the loose-housing system than in the cows kept tied. A close to significant ($p = .06$) shorter interval was also observed for cows in the mixed management system (55.7 days) compared with cows in the tied-housing system. LS means ± s.e.m. for the other fertility measures, such as interval from calving to 1st AI, interval from calving to conception, number of AIs per conception, conception rate at 1st AI, and percentage of finally pregnant cows in the 2 herds according to the planned calving intervals are presented in the Table 3-5. The interval from calving to 1st insemination and to conception reflects the different voluntary period for the 3 calving intervals. There were no significant differences found in number of AIs per conception, conception rate at 1st AI and proportion of finally pregnant cows, either between the different calving intervals or between the 2 herds. In one of the herds, however, a tendency to a higher conception rate at 1st AI was found for the 15-month group than for the 12-month group (50% vs. 41.5%). No difference was observed between breeds, management

Table 2. Least-squares means (±standard errors of means) for Interval from calving to 1st ovulatory oestrous in two herds by parity, breed, management system and milking frequency.

		Interval to 1st ovulatory oestrous (days)	
		Herd 1 (N = 87)	Herd 2 (N = 48)
Parity	1	71.6 ± 5.2	57.0 ± 5.9
	2	60.9 ± 6.2	41.8 ± 10.0
	3	55.9 ± 6.4	68.4 ± 13.5
Breed	SRB	64.7 ± 4.5	55.7 ± 5.9
	SLB	58.5 ± 6.5	–
Management system	Tied	69.7 ± 4.7[a]	–
	Loose	55.9 ± 5.1[b]	–
	Mixed	–	55.7 ± 5.9
Milking frequency	2 times	62.8 ± 3.6	60.4 ± 7.4
	3 times	–	51.1 ± 7.9

Values with superscripts a and b are significantly different p<.05.

systems, or milking frequency. Regarding the interval from calving to conception, the 2nd calvers conceived, on average, 126 days postpartum, whereas cows with parity order of ≥3 conceived, on an average, 83 days postpartum (p<.05) in the 12-month group of herd 2. There was a tendency for the calving-conception interval to be increased (p = .059) in the 3X milking cows compared to their 2X milking herdmates in the 12-month calving interval group.

As shown in Table 5, some differences in respect to the interval from 1st AI to conception and the number of AIs per conception were found between parity groups within herd and between herd and calving interval group within parity. No differences were found within breeds or management systems. The cows milked 3X a day had a significantly longer interval from the 1st AI to conception compared with the cows in the 2X milking groups (p<.01).

As shown in Table 5, there were no significant differences found between the different calving interval groups in conception rate at 1st AI and percentage of finally pregnant. In the 15-month group, conception rate at 1st AI decreased with parity number and it was significantly different (p<.05) between cows of parity 1 (72.7%) and cows of parity ≥3 (14.3%). Considering management systems, the numerically highest conception rate at 1st AI was achieved by cows kept loose while the lowest rate was recorded for cows kept tied. Similarly in herd 2, the 3X milking frequency group had a numerically lower conception rate at 1st AI compared with their 2X milking herd mates.

Although not significant, there was a trend for the 12-month calving interval cows to have a higher percentage of finally pregnant cows in the loose and mixed housing system (88% and 100% respectively) compared with the tied system (75%).

The number and percentage of sterility treatments in the calving interval groups according to parity, breed, management system and milking frequency are presented in Table 6. In herd 1, there was a significantly higher (p<.05) incidence of treatments for anoestrous (28.6% vs. 5.3%) in the 12-month than in the 15-month group. No differences were found regarding treatment for either cystic ovaries or endometritis between the 2 calving interval groups in herd 1. In herd 2, no cases of either anoestrous or endometritis were found. In herd 1, there was a tendency to a higher incidence of treatment for tied cows compared with loose-housing cows.

The manifestation of strength of heat signs with number of ovulation postpartum in 15- and 18-month calving interval groups are depicted in Fig. 1. The frequency of ovulations with external heat signs increased with ovulation number up to the 4th ovulation postpartum, and thereafter remained stable.

Table 3. Least-squares means ± standard errors of means for Interval from calving to 1st AI and of Interval from calving to conception in cows with planned calving interval 12 , 15 and 18 months.

		Planned calving interval (months)							
		From calving to 1st AI (days)				From calving to conception (days)			
		12		15	18	12		15	18
		Herd 1	Herd 2	Herd 1	Herd 2	Herd 1	Herd 2	Herd 1	Herd 2
Parity	1	73.9±3.5	72.1±4.2	150.0±4.7	247.8±4.2	100.8±8.7	100.2±9.6	159.4±10.8	261.4±9.6
	2	66.6±4.2	69.9±6.5	143.2±4.7	244.7±5.5	105.9±9.7	126.3±15.0[a]	166.2±11.2	248.0±12.6
	≥3	67.9±4.4	72.8±5.9	135.9±6.1	240.5±10.2	74.1±13.9	83.3±13.6[b]	172.2±14.7	262.0±23.6
Breed	SRB	64.8±2.9	71.6±3.2	148.5±3.1	244.3±4.1	94.3±7.8	103.3±7.5	174.2±7.7	257.2±9.5
	SLB	74.2±3.8	–	136.8±6.2	–	92.8±9.7	–	157.7±14.2	–
Management system	Tied	71.1±3.1	–	142.6±4.6	–	99.2±8.9	–	168.2±10.8	–
	Loose	67.8±3.5	–	142.8±4.3	–	88.0±8.7	–	163.7±10.4	–
	Mixed	–	71.6±3.2	–	244.3±4.1	–	103.3±7.5	–	257.2±9.5
Milking frequency	2 times	69.5±2.4	72.3±4.4	142.7±3.4	253.3±5.3	93.6±6.4	89.8±10.1	165.9±8.0	265.5±12.2
	3 times	–	70.9±4.5	–	235.4±5.1	–	116.7±10.3	–	248.8±11.7
Total		69.2±2.3	71.8±3.1	147.1±2.7	245.7±3.2	98.5±5.9	102.0±7.1	170.0±6.4	256.6±7.4

Values with different superscripts differ between parity groups. $p<.05$.

Discussion

The main objective with the present study was to investigate, if a voluntarily increased open period leading to preplanned calving intervals of 15 and 18 months had any effect on the reproductive function of the dairy cows compared with cows managed for a calving interval of 12 months. There are a number of fertility measures that can be used to assess reproductive efficiency in cattle (*Fetrow et al.* 1990, *Esslemont* 1992). In the present study, many of these measures were considered. The interpretation of these measures, however, is sometimes complicated since they reflect fertility in different aspects. In the present study, cows in the 3 groups were assigned to the first AI at the first observed oestrus 50, 140 or 230 days postpartum. The resulting average interval to first AI was 69, 72 (herds 1 and 2, respectively), 147 and 246 days, which is in a good agreement with the preplanned intervals.

Table 4. Least-squares means ± standard errors of means for Interval from 1st AI to conception and No. of AIs per conception in cows with 3 planned calving interval (12, 15 and 18 months) groups.

		Planned calving interval (months)							
		Interval from 1st AI to conception (days)				No: of AI per conception			
		12		15	18	12		15	18
		Herd 1	Herd 2	Herd 1	Herd 2	Herd 1	Herd 2	Herd 1	Herd 2
Parity	1	26.2±8.4	28.1±9.3	10.3±10.4	13.6±9.2	1.6±0.3	1.8±0.3[c]	1.2±0.3[x]	1.6±0.3
	2	39.4±9.3[a]	56.4±14.3[c]	23.9±10.8	3.3±12.1[b]	2.2±0.3[a]	3.3±0.4[b]	1.8±0.3[c]	1.1±0.4[d]
	≥3	8.4±13.4	10.5±13.0[d]	38.9±14.0	21.5±22.6	1.1±0.4[p]	1.5±0.4[c]	2.3±0.4[qy]	2.0±0.7
Breed	SRB	29.1±7.4	31.7±7.1	27.5±7.3	12.8±9.1	1.9±0.2	2.2±0.2	1.8±0.2	1.6±0.3
	SLB	20.1±9.3	–	21.2±13.6	–	1.4±0.3	–	1.7±0.4	–
Management system	Tied	28.7±8.5	–	26.2±10.3	–	1.7±0.3	–	1.9±0.3	–
	Loose	20.6±8.3	–	22.5±10	–	1.6±0.3	–	1.6±0.3	–
	Mixed	–	31.7±7.1	–	12.8±9.1	–	2.2±0.2	–	1.7±0.3
Milking frequency	2 times	24.6±6.1	17.6±9.8[a]	24.4±7.6	12.2±11.7	1.6±0.2	1.7±0.3	1.8±0.2	1.6±0.3
	3 times	–	45.8±9.9[b]	–	13.4±11.3[a]	–	2.6±0.3	–	1.6±0.2
Total		–	–	–	–	1.8±0.2	2.0±0.2	1.7±0.2	1.6±0.2

a,b / a,d / c,d / p,q Values with different superscripts differ along rows (p<.05).
a,b / b,c Values with different superscripts differ within a columns (p<.01).
x,y Values with different superscripts differ within a column (p<.05).
bd Values with different superscripts differ within a row.

The interval from calving to conception can be used as an estimation of the calving interval by adding the time for pregnancy. This leads to an estimated calving interval somewhat longer than the target for the two 12-month groups (12.4 and 12.6 months) and somewhat shorter than planned for the 15- and 18-month groups (14.7 and 17.8 months). This reflects the difficulties in achieving a calving interval of 12 months despite intensive monitoring and management procedures for a short calving interval.

Conception rate at 1st insemination and the percentage of cows finally pregnant were used for comparing fertility in the calving interval groups, but no significant differences were found. However, a trend of higher conception rates were observed in the 15-month group compared with the 12-month group in one of the herds. The conception rates at 1st AI varied between 41% and 52% which is within the range that has been reported elsewhere (e.g. *Williamson et al.* 1980). The percentage of finally pregnant animals varied in this investigation between 81% and 100%, but this variation was

Table 5. Conception rate (%) at 1st insemination and percentage of finally pregnant cows according to parity, breed, management system and milking frequency by calving interval of 12, 15 and 18 months.

		Planned calving interval (months)									
		Conception rate at 1st AI (%)					Finally pregnant rate (%)				
		12			15	18	12			15	18
		Herd 1	Herd 2	Total	Herd 1	Herd 2	Herd 1	Herd 2	Total	Herd 1	Herd 2
Parity	1	44.4	50.0	46.6	72.7[a]	50.0	83.3	100	90.0	100	100
	2	33.3	40.0	35.3	50.0	57.1	100	100	100	91.7	100
	≥3	45.5	66.7	52.9	14.3[b]	50.0	54.6	100	70.6	85.7	100
Breed	SRB	38.5	52.2	44.9	45.8	52.4	76.9	100	87.8	91.7	100
	SLB	46.7	–	46.7	66.7	–	86.7	–	86.7	100	–
Management system	Tied	29.2	–	29.2	50.0	–	75.0	–	75.0	94.4	–
	Loose	58.8	–	58.8	50.0	–	88.2	–	88.2	91.7	–
	Mixed	–	52.2	52.2	–	52.4	–	100	100	–	100
Milking frequency	2 times	41.5	72.7	48.1	50.0	60.0	80.5	100	84.6	93.3	100
	3 times	–	33.3	33.3	–	45.5	–	100	100	–	100
Total		41.5	52.2	52.3	50.0	52.4	80.5	100	87.5	93.3	100

Values with different superscripts ([a] or [b]) differ significantly within column ($p<.05$).

mainly attributed to the herd rather than calving interval group. Regarding the number of AIs per conception, differences in calving interval were found only for the 2nd parity cows. In this group of cows, fewer inseminations were used for 15- and 18-month groups (1.8 and 1.6) compared with the 12-month groups (2.2 and 3.3). However, the low number of cows in each group makes interpretation of this difference uncertain. A significantly higher percentage of cows were treated for anoestrous in the 12-month group than in the 15-month group in one of the herds. It is not surprising that some cows had not resumed the ovarian cyclicity by 50 days postpartum, and these cows belonging to the 12-month group were treated, whereas the cows in the 15-month group to a high extent had resumed ovarian function spontaneously at the start of the insemination period, 140 days after calving. No cases of anoestrous were found in herd 2, and since the cows were genetically similar in the 2 herds, the difference between the 2 herds might be due to management effects. There are a number of factors both managemental and genetical, which influences the resumption of cyclicity after calving (*Fonseca et al.* 1983, *Roche et al.* 1992).

The percentage of cows expressing normal heat signs increased up to the 4th ovulation post-calving and thereafter remained stable during the investigation period up to the 8th ovulation postpartum. Hence we found no support for the opinion among some farmers that the heat signs become weaker as the period after calving increases. It has earlier been shown in several investigations that the expression of heat signs increases by increasing ovulation number in the early postpartum period (*Moorow et al.* 1969, *King et al.* 1976, *Larsson et al.* 1984). From ovulation 4 and up to ovulation 8 postpartum, the percentages of cows expressing normal heat signs were around 50% for the 15-month group and around 75% for the 18-month group. It is most likely that the difference between the groups reflects herd effects, including the herdsmen's skill of observing oestrous signs,

Table 6. Percentage of cows treated for anoestrous, cystic ovaries and endometritis in two herds according to planned calving intervals (12, 15 and 18 months) by parity, breed, management system and milking frequency groups.

		Anoestrous*		Cystic ovaries				Endometritis*	
		Herd 1		Herd 1	Herd 2	Herd 1	Herd 2	Herd 1	
Group		12 month	15 month	12 month	12 month	15 month	18 month	12 month	15 month
Parity	1	7/19(36.8)[a]	1/14(7.1)[b]	1/19(5.3)	2/12(16.7)	1/14(6.7)	1/12(8.3)	0/19(0)	0/4(0)
	2	4/13(30.8)	1/12(8.3)	3/13(23.1)	1/5(20.0)	3/12(25.0)	3/8(37.5)	0/13(0)	2/12(17.0)
	≥3	3/17(17.7)	0/12(0)	3/17(17.7)	3/6(50.0)	1/12(23.1)	1/5(20.0)	2/17(11.8)	0/12(0)
Breed	SRB	8/32(25.0)	2/29(6.7)	3/32(9.4)	6/23(26.1)	5/29(16.7)	5/25(20.0)	2/32(6.3)	2/29(6.7)
	SLB	6/17(35.3)	0/9(0)	4/17(23.6)	-	2/9(20.0)	-	-	-
Management system	Tied	10/28(35.7)	0/23(0)	5/28(17.9)	-	4/23(17.4)	-	1/28(3.6)	1/23(4.4)
	Loose	4/21(19.1)	2/15(11.8)	2/21(9.5)	-	3/15(17.7)	-	1/21(4.8)	1/15(5.9)
	Mixed	-	-	-	6/23(26.1)	-	5/25(20.0)	-	-
Milking frequency	2 times	14/49(28.6)[a]	2/38(5.3)[b]	7/49(14.3)	3/11(27.3)	7/38(18.4)	4/13(30.8)	2/49(6.3)	2/38(6.7)
	3 times	-	-	-	3/12(25.0)	-	1/12(8.3)	-	-
Total	-	14/49(28.6)	2/38(5.3)[b]	7/49(14.3)	6/23(26.1)	7/38(18.4)	5/25(20.0)	2/49(6.3)	2/38(6.7)

Values carrying a and b superscripts differ significantly (Mantel-Haenszel χ^2, $p<.05$).
* There were no treatment cases for anoestrous as well as endometritis in herd 2.

since it is known that the proportion of heats observed varies considerably among Swedish herds (*Gustafsson & Emanuelson* 1996).

To the authors knowledge, there are only 2 studies that have focused on aspects of fertility in cows with different pre-planned calving intervals. In a study by *Schneider et al.* (1981), a total of 125 cows were assigned to be inseminated at 1st heat 50 days or 80 days postpartum. More inseminations were used in the late than in the early breeding group (1.96 vs. 1.50 AIs per conception). Unfortunately, no data on conception rates or other fertility parameters were presented. As affected cows (reproductive problems) in the late-bred group needed significantly more services than the other cows, the authors suggested that the cows in this group had a lower fertility and the best time of insemination had been past 80 days postpartum.

In an Israelian study (*Shindler et al.* 1991), 169 cows were randomly assigned to groups for 1st breeding at postpartum intervals of 35-59, 60-90 and 120-150 days. The conception rate at 1st AI did not differ between groups for primiparous cows, but in multiparous cows the conception rate at 1st AI was significantly higher for cows with 1st breeding 120-150 days postpartum (65.4%) compared with cows with their 1st insemination 35-59 days after calving (35.7%). Genital disorders such as metritis and repeat breeding were regarded as the most important factors influencing the reproductive ef-

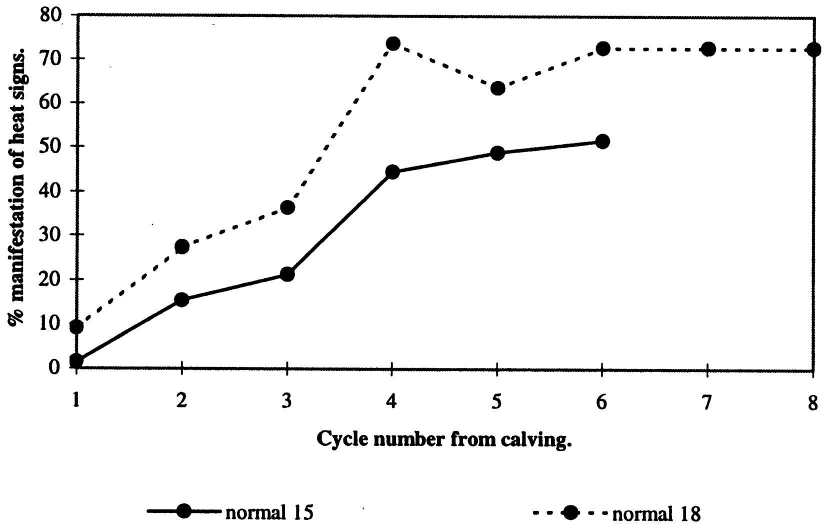

Figure 1. Manifestation of normal heat signs with no. of oestrus cycles from parturition in 15- and 18- month calving interval groups. Cows with regular cycles were selected for comparison. (15-month, n = 23 and 18-month n = 16).

ficiency. In general, the results of these 2 studies are not consistent and are not in agreement with our results. This can be attributed to different ways of measuring fertility and the relatively few cows studied but also to differences regarding management policies and feeding regimes as well as other factors. It is obvious that this topic needs further research.

In herd 1, cows in the loose-housing system had their 1st ovulatory oestrus on average 2 weeks earlier than the cows kept tied ($p<.05$). This trend was also seen in the mixed housing system. There was also a trend towards a higher pregnancy rate and a lower incidence of sterility treatments in the loose-housing system as compared with the tied management system. One reason for this difference can be that cows kept loose may exhibit a stronger behavioural oestrus than tied cows which makes insemination at correct time easier, but a more direct positive effect of exercise on reproductive function is also possible. A positive effect of exercise on reproduction has been found in another Swedish study (*Janson & Ahlin* 1993) in which SRB cows allowed to graze during the summer had an earlier resumption of ovarian cyclicity than cows kept tied all the year round. This differnce was not, however, found in the SLB cows. In a study by *King et al.* (1976), however, no differences were found in ovarian activity between cows kept in stanchions or in loose-housing systems.

When comparing the parity, some differences were seen regarding the number of AIs per conception and interval from calving to conception. However, the small number of cows in each parity group makes it difficult to interpret these results, and it is difficult to find biological reasons for these differences. Regarding effects of milking frequency, the cows milked 3X a day had a significantly longer interval from 1st AI to conception than the cows milked 2X a day in the 12-month group. However, also taking levels of reproductive hormones into concideration (*Ratnayake et al.* 1996), we found no effects of milking frequency on the fertility.

In conclusion, we did not find any significant effects on fertility based on conception rates in cows managed for 12-, 15- or 18-month calving intervals, however, a trend of higher conception rates were oserved in the 15-month group compared with the 12-month group. Cows managed for a 12-month calving interval may require careful supervision and more treatments for ovarian acyclicity than cows managed for longer calving intervals. Our results also indicate, loose-housing management systems may have a positive effect and milking 3 times a day a negative effect on ovarian function.

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Sammanfattning

Fruktsamhet hos mjölkkor med planerat kalvningsintervall på 12, 15 eller 18 månader.

Med gradvis ökande mjölproduktion per ko och ett bibehållet mål på ca 12 månaders kalvningsintervall ökar risken för störningar i kornas hälsa och fruktsamhet. Därmed ökar kraven på intensiv övervakning av kornas könsfunktioner under postpartum perioden samtidigt som man riskerar en ökad behandlingsfrekvens och därmed en ökad användning av exempelvis hormoner. Detta medför kostnader för djurägaren samt negativa effekter på djurens välbefinnande som därmed kan ge negativa konsumentreaktioner. Med en medvetet förlängd period till första inseminition finns möjligheten att en större andel av korna spontant skulle återfå normal cyklicitet efter kalvning, att behovet av vissa behandlingar skulle minska samtidigt som dräktighetsprocenten per insemination (AI) ökar. Samtidigt kan risken öka för andra störningar i form av äggstockscystor och svag brunst. Motivet för föreliggande undersökning var därför att studera effekten på fruktsamheten hos mjölkkor som medvetet styrdes till kalvningsintervall på ca 12, 15 eller 18 månader.

Sammanlagt 135 mjölkkor av SRB- och SLB-ras styrdes medvetet till att insemineras första gången 50, 140 eller 230 dagar efter kalvning. Korna hölls i 2 olika besättningar och i 3 olika uppstallningssytem; uppbundna på båspall, lösdrift eller uppbundna men mjölkade i mjölkgrop. Korna i den ena besättningen var dessutom uppdelade i 2 grupper som mjölkades 2 respektive 3 gånger per dygn. Ingen signifikant skillnad sågs beträffande dräktighetsprocenten vid första AI mellan kalvningsintervallsgrupperna. I en besättning sågs dock en högre dräktighetsprocent i 15-månaders gruppen än i 12-månaders gruppen (50% resp. 41.5%). Andelen slutligt dräktiga varierade mellan 81% och 100%, men denna skillnad var mera kopplad till besättning än till kalvningsintervall. En större andel kor behandlades för anöstrus i 12-månaders gruppen än i 15-månaders gruppen i en av besättningarna (28.6% respektive 5.3%). Inga tendenser sågs till sämre brunstsymtom med ökat avstånd från kalvning. Vid den första ägglossningen efter kalvning var andelen kor som uppfattades som brunstiga låg, (<10%). Andelen kor där brunst registrerades ökade sedan med ovulationsnummer fram till 4:e ovulationen (50%-70%) för att sedan förbli stabil på denna nivå. Korna i lösdriftsystemet visade första brunst i samband med ägglossning ca 14 dagar tidigare än uppbundna kor. Sammantaget sågs således tendenser till gynnsamma effekter på fruktsamheten hos kor med kalvningsintervall på 15 månader jämfört med 12 månader samt hos kor i lösdrift jämfört med bundna kor.

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